SHared automation Operating models for Worldwide adoption

SHOW

Grant Agreement Number: 875530

Deliverable 11.3: Pre-demo evaluation activities

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Legal Disclaimer

Executive Summary

The current Deliverable constitutes the first issue of D11.3: Pre-demo evaluation activities, prepared under A11.3: Pre-demo at sites of WP11: Technical verification & pre-demo evaluation and describes the activities carried out for preparing, implementing, executing and evaluating the results of the pre-demo phase of SHOW – sharing also the first results and lessons learned - for the test sites: **Tampere (Finland), Gothenburg and Linköping (Sweden), Madrid (Spain) and Brainport (the Netherlands).** It also reports a very initial short demonstration that occurred in the **Turin test site of SHOW** at the very beginning of the project. **1945 passengers** in total have tried the different automated mobility services of SHOW during this period across the aforementioned test sites.

As "pre-demo" in SHOW or "1st pilot round", we define the specific phase of the project, where the test sites have completed their **technical verification and validation phase** (in the context of A11.2: Pilot experimental plans, KPIs definition & impact assessment framework for pre-demo evaluation) and, before opening to public and start operating their large scale field trials, they rehearse their intended test cases and services in real life context but without yet transporting passengers from public (or the actual cargo); engaging/ recruiting rather specific test users for this purpose that are aware of the phase specifics and its purpose. This phase intends in the project to serve as the last dry run of the automated mobility services across the sites, and an opportunity also to verify all the evaluation and data collection protocols and mechanisms.

There is no specific duration imposed by the project for this phase; this is left upon the test sites decision making but as a minimum criterion, and as mentioned in D9.2: Pilot experimental plans, KPIs definition & impact assessment framework for pre-demo evaluation, each test case/service has to be run at least 10 times in context before moving to public phase. As it is seen through the content of the current Deliverable, the duration of the pre-demo phase indeed varies a lot across the sites and this is related to their readiness (it is quite different if a test site is research based testing own retrofitted vehicles/ services or commercial based operated by commercial operators that have past experience and validated similar services/ vehicles in the recent past).

The evaluation framework and detailed experimental plans for the pre-demo phase of SHOW have been included in D9.2: Pilot experimental plans, KPIs definition & impact assessment framework for pre-demo evaluation.

The period covered in this deliverable is until **10th of May 2022**. As such, all the reported results in this issue refer up to this period. In the same sense, the (subjective and performance) data analysed are those collected until that point through the project tools, the Netigate, used in SHOW for the subjective responses collection and the Data Management Platform (DMP), used in SHOW for the performance data collection of the sites.

This infers that the following are **not addressed** in this issue:

- The pre-demo period of the following Tampere operational phases 2, 3 and 4 that followed after that period. Thus, the current issue refers only to the pre-demo phase of Tampere executed in December 2021 with 2 L4 vans (Toyota ProAces by Sensible 4).
- The full pre-demo period taking place in Carabanchel (Madrid), that was closed at the end of October 2022. The current issue covers the pre-demo period up to 10th of May 2022.

There will be two upcoming updates of the current issue of D11.3 that will complement the pre-demo phase results for all test sites of SHOW (that are applicable for a pre-demo phase), as follows:

- **The first updated issue of D11.3 will follow in Spring 2023** and will cover the full pre-demo phase of the following SHOW test sites:
    - Full pre-demo period taking place in Carabanchel (Madrid)
    - Karlsruhe (Germany)
    - Pörtschach (Carinthia) & Graz (Austria)
    - Brno (Czech Republic)
    - Tampere pre-demo phases (2 & 3). Each operational phase in Tampere (4 in total within the project) is operated with different types of vehicles (all listed in the test site description in the amended Grant Agreement).

- **The second and last updated issue of D11.3 will follow in Summer 2023** and will cover the pre-demo phase of the following SHOW test sites:
    - Aachen controlled environment test trials (Germany)
    - Trikala (Greece)
    - Villaverde (Madrid, Spain)
    - Salzburg (Austria)
    - Klagenfurt (Carinthia, Austria)
    - Turin (Italy)
    - Tampere pre-demo phase 4 and, in addition, the pre-demo phase that will be conducted (most probably) in Lahti (as part of Amendment 2).
    - Hasselt site that is following up on Brainport site of the Netherlands, expected to be part of Amendment 3 (provisionally; only if Hasselt is accepted in the context of Amendment 3 and at the same time, a formal pre-demo period is deemed applicable).

All the rest test sites of SHOW are moving directly to the public field trials phase as they were deemed by their operators quite mature in order to do so. Those are in specific the following:

- Rouen (France) – to be renamed to Les Mureaux
- Monheim (Germany) – new site entering as part of Amendment 2.
- Frankfurt (Germany) – new site entering as part of Amendment 2.
- Crest Val de Drôme (France) – new site entering as part of Amendment 2.

The reason for all those issues of D11.3, is the inevitable varying timeline of the project test sites operations – affected by a long list of factors – as well as, in some cases, the new sites that entered the project replacing former ones.

Finally, it should be highlighted that D11.3 objective is to report the evaluation results referring **only to the pre-demo phase period and not to the final, open to public large-scale field trials.** The results referring to them will be reported in WP12 Deliverables, as follows:

- D12.2: French CCAV demonstrators
- D12.2: French CCAV demonstrators
- D12.2: French CCAV demonstrators
- D12.5: Swedish CCAV demonstrators
- D12.6: Madrid CCAV demonstrators
- D12.7: Satellite CCAV demonstrators
- D12.8: Follower sites multiplication plans and actions
- D12.9: Real life demonstrations pilot data collection and results consolidation

It should be also noted that D11.3 objective is not to address the follower sites activities at all. Those are expected to be reported in D12.8: Follower sites multiplication plans and actions.

The current issue analyses the results collected through SHOW subjective tools by **69 passengers** who tried the automated mobility services across the test sites addressed in this issue during their pre-demo phase and, in addition, **26 stakeholders** being interviewed representing OEMs, operators, technology providers and authorities. In some cases, more dedicated surveys were conducted from test sites. Also, further to the subjective results, the first performance results collected through the Data Management Platform of SHOW have been aggregated and discussed.

First insights reveal a general positive tendency from both passengers and stakeholders towards shared automated mobility, while at the same time a series of technical, quality of service, acceptance, operational and business wise weaknesses have been recognized. The high frequency of hard-brakings and the reliability/ feasibility of service when a safety driver is not on-board seemed to be the most commonly shared concerns by both passengers and stakeholders. The fulfillment of mobility service gaps and the inclusiveness in mobility are so far the key benefits recognized from SHOW experience regarding shared automated mobility potential.

The results of this phase have been used to optimize features, evaluation protocols and services towards the final large scale field trials of the test sites.

Document Control Sheet

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Work package:	WP11: Technical verification & pre-demo evaluation
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Document Revision History

Version	Date	Reason	Editor
0.1	09.09.2022	First compilation of individual reports (Gothenburg, Tampere)	J. Hülsermann (FEV)
0.2	08.10.2022	Brainport / Linköping added added	J. Hülsermann (FEV)
0.3	08.11.2022	Turin, Karlsruhe added	J. Hülsermann (FEV)
0.4	30.11.2022	All individual reports added	M. Gkemou (CERTH/HIT)
0.5	15.12.2022	All analysis results and cross-cutting sections added – overall full editing of the Del	M. Gemou (CERTH/HIT)
1.0	10.01.2023	Fist complete version for comments and last feedback - overall review of the Del by all	M. Gemou (CERTH/HIT)
2.0/ Final	24.01.2023	Final version towards submission	M. Gemou (CERTH/HIT)

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Abbreviation List

Abbreviation	Definition
3D	Three Dimensional
4K resolution	4,000 pixels resolution
5G NSA	5G non-stand alone
A/C	Air Conditioning
AD	Automated Driving
AEVAC	Spanish Association for the Autonomous and connected vehicle
API	Application Programming Interface
Art.	Article
AV	Autonomous Vehicle
AWG	Accessibility Working Group
BM	Business Model
CAPEX	Capital expenditures
CCAM	Cooperative Connected Automated Mobility
CCAV	Cooperative Connected Autonomous Vehicles
C-ITS	Cooperative Intelligent Transport Systems
CKAN	Comprehensive Knowledge Archive Network
CNG	Compressed Natural Gas
CPM	Collaborative Perception Message
CRTM	Consorcio Regional de Transportes de Madrid
D	Deliverable
DENM	Decentralized Environmental Notification Message
DGT	Dirección General de Tráfico
DMP	Data Management Platform
DMP	Data Management Portal
DPIA	Data Protection Impact Assessment
DPO	Data Protection Officer
DRT	Demand Responsive Transport
EEA	European Economic Area
EIC	Ericsson Innovation Cloud
eMBB	Enhanced mobile broadband
EMC	Electromagnetic Compatibility
ETA	Estimated Time of Arrival
F2F	Face2Face
FAT	Factory Acceptance Test
FMS	Fleet Management System
FOT	Field operational trial
GDPR	General Data Protection Regulation
GLOSA	Green Light Optimal Speed Advisory
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GUI	Graphical User Interface
HB	Hard brakes
HD	High Definition
HIL	Hardware in the Loop
HMI	Human-Machine Interaction
ICT	Information and Communication Technology
ID	Identification
IoT	Internet of Things
IT	Intelligent Transport
ITC-ILO	International Training Centre of the International Labour Organization
JSONs	JavaScript Object Notation
Km/h	kilometres per hour

Abbreviation	Definition
kph	kilometres per hour
KPI	Key Performance Indicator
L	Level
LaaS	Logistics-as-a-Service
LER	Local Ethics Representative
LTE	Long Term Evolution
LTE-A	LTE-Advanced
M3ICA	Multi-Impact, Multi-Criteria, And Multi-Actor Methodology
MaaS	Mobility-as-a-Service
MAMCA	Multi-Actor Multi-Criteria Analysis
MAPEM	Map extended Message
MLDMP	Madrid Local DMP
MOT	Technical Vehicle Inspection
MQTT	Message Queuing Telemetry Transport
N/A	Non Applicable
NOC	Network Operation Centre
ODD	Operational Design Domain
OEM	Original Equipment Manufacturer
OPEX	Operating expenses
PAX	Passengers
PC	Personal Computer
PDI	Physical Digital Infrastructure
PMV	Personal Mobility Vehicle
PT	Public Transport
PTA	Public Transport Authority
PTO	Public Transport Operator
PTZ	Pan Tilt Zoom
R&D	Research & Development
ROS	Robot Operating System
RSU	Road Side Unit
RT	Real time
RTK	Real Time Kinematics.
SAE	Society of Automotive Engineers
SAT	Site Acceptance Test
SDMP	SHOW Data Management Platform
SPATEM	Signal phase and timing extended Message
STA	Swedish Transport Agency
SW	Software
TRL	Technology Readiness Level
UC	Use Case
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
V2x	Vehicle-to-X (X represents any entity capable of receiving C-ITS communications)
vEPC	virtual Evolved Packet Core
VRU	Vulnerable Road User
WP	Work Package

1 Introduction

1.1 Purpose and structure of the document

The current document stands for the first issue of D11.3: Pre-demo evaluation activities and describes the activities carried out for preparing, implementing, executing and evaluating the results of the pre-demo phase of SHOW for the test sites: **Tampere (Finland), Gothenburg and Linköping (Sweden), Madrid (Spain) and Brainport (the Netherlands).** It also reports a very initial short demonstration that occurred in the **Turin test site of SHOW** at the very beginning of the project.

The period covered in this deliverable is until 10th of May 2022. As such, all the reported results in this issue refer up to this period. In the same sense, the (subjective and performance) data analysed are those collected until that point through the project tools, the Netigate, used in SHOW for the subjective responses collection and the Data Management Platform (DMP), used in SHOW for the performance data collection of the sites.

This infers that the following are **not addressed** in this issue:

- The pre-demo period of the following Tampere operational phases 2, 3 and 4 that followed after that period. Thus, the current issue refers only to the pre-demo phase of Tampere executed in December 2021 with 2 L4 vans (Toyota ProAces by Sensible 4).
- The full pre-demo period taking place in Carabanchel (Madrid), that has closed at the end of October 2022. The current issue covers the pre-demo period up to 10th of May 2022.

The content of the Deliverable is spread across its Chapters as follows:

- **Section 2** presents the approach followed for the conduct, monitoring, evaluation and reporting of the pre-demo phase of SHOW test sites.
- **Section 3** presents the status and planning (if applicable) of the pre-demo phase of SHOW test sites (reference date: December 2022).
- **Sections 4 – 9** report the pre-demo phase of the Turin (pre-pre demo), Brainport, Gothenburg/Lindholmen, Linköping, Tampere and Madrid test sites respectively. Each site report is structured in the same way and includes a short introduction, the description of the ecosystem, the site setting, the timing of the pre-demo field trials, the deployed fleet characteristics, the infrastructure supporting them, the users and stakeholders involved, the preparatory processes put in place to allow the field trials happen (permits, development/ customization/ integration, training, ethics & GDPR), the experimental design referring to the test scenarios run referring to the use cases of the project (targeted by each test site), the evaluation methods and tools used and the experimental process followed, the results of this particular phase (subjective from passengers and stakeholders getting involved in each case and for which full responses have been available through SHOW survey tools), the first overall response to the research hypotheses addressed by each test site and, finally, the key lessons learned and recommendations for the coming phase emerging from the current phase as well the final conclusion on the readiness of the site to move indeed to its next phase (real life open to public field trials).
- **Section 10** presents the so far consolidated subjective results.
- **Section 11** presents the so far consolidated performance results across selected KPIs as well as a first study made for the correlation of performance to subjective results.
- **Section 12** concludes the Deliverable, including the lessons learned on evaluation basis and reminding the next steps anticipated.

Appendix 1 provides the monitoring template used in the course of the past period for monitoring the pre-demo phase progress across the test sites, Appendix II lists the Use Cases of the project for the easiness of the reader, whereas Appendix III provides the Turin pre-acceptance study survey template (that is different to the SHOW evaluation tools established later in the project).

1.2 Intended Audience

The current Deliverable is public to all; as such, its main utility is to share real life results from field trials with L4 shared automated vehicles with the general public that is interested in getting evidence of shared CCAM real life demonstration across all aspects (evaluation, operational, regulatory, technical, etc.) as well as to follow the progress made in SHOW project in specific towards its final open to public large scale trials. Different parties (authorities, researchers, operators, OEMs, developers) may find interest in this Deliverable as it touched in a holistic manner upon all aspects that arise for and during automated vehiles in real life.

1.3 Interrelations

The current Deliverable is interrelated to the evaluation framework, experimental plans and tools that have been designed in the context of WP9: Pilot plans, tools & ecosystem engagement (D9.2 latest issue for the pre-demo phase) and have guided the conduct of the pre-demo trials that are presented in this issue. Moreover, it is inevitably related to all the developments related to infrastructure, vehicle demonstrators and cooperative services involving them that have been implemented in the context of WP7: Automated vehicles functions and WP8: Infrastructure functions and system. Another crucial interrelation is to the Data Management Platform and Dashboard of the project that log, process and visualize the project performance data and KPIs (A4.3: SHOW Dashboard & A5.1: Pilot plans, tools & ecosystem engagement). Finally, the lessons learned and readiness conclusion of the test sites are vital towards the final open to public large scale trials which are taking place and reported in WP12: Real – life demonstration.

2 Methodological Approach

The approach followed consists of three phases:

1. **Planning** of the pre-demo phase
2. **Conduct** of the pre-demo phase and its **progress monitoring**
3. **Evaluation** & **reporting**

The **planning** of the pre-demo phase started from the early phases of the project and resulted in the definition of the evaluation framework and the experimental plans, specifically of the pre-demo phase of the test sites. All those are reported in D9.2: Pilot experimental plans, KPIs definition & impact assessment framework for pre-demo evaluation. This included among other the evaluation tools for the collection of subjective views from passengers and stakeholders as well as the KPIs that have to be met and which, in turn, oriented the development of the Data Management Platform that is described in D5.1: SHOW Big Data Collection Platform and Data Management Portal (DMP) and reports all the mechanisms developed to collect – in alternative ways – performance data, already from the pre-demo phase. Thus, in short, participants had to complete for this pre-demo phase and under the supervision and control of the respective test site leaders, three types of surveys, namely **1) user acceptance survey**, **2) 1 question satisfaction survey**, **3) stakeholders** interviews (all annexed in D9.2). Those surveys, as analytically explained in D9.2 were implemented on-line in Netigate tool and translated in all SHOW languages.

In addition, the test sites had to connect their vehicles to the DMP in order to allow performance data collection and, in turn, visualization of their KPIs in the project Dashboard. **One key criterion set for the pre-demo phase conduct later was that each test case had to be run in field for 10 times as a minimum.**

Upon the experimental plans and tools developed, the **conduct** of the trials followed. The test site leaders, activating their ecosystems (as presented in detail in later sections) and alternative/ applicable to the test site recruitment/engagement methods (all described in detail in later sections), conducted the pre-demo phase for their site, after they had completed the technical verification and validation stages (dealt within A11.2: Demos safety, reliability and robustness validation and commissioning) and minding to collect some first subjective and performance data both that would later enable to obtain the first insights and proceed with optimisation across all layers: technical, evaluation, operational.

The **progress of the pre-demo phase trials was overseen** throughout their course with three checkpoint progress reports at different timings, namely at the beginning of the pre-demo preparation, at mid of the pre-demo preparation and close to the end of the pre-demo preparation period. The checklist items for each progress report are provided in Appendix I. Later, and as mandated by the Project Officer, this process was replaced by the Project Monthly Status report that is shared with the Project Officer and reports on the key aspects reflecting the progress of each test site. This process, using both mechanisms, allowed the early recognition of incosistencies, misunderstandings, problems, risks and, thus, their in-time resolution to the most feasible extent possible.

Finally, for the **evaluation and reporting of results** phase, there were two key actions realized:

1. The construct of a template that has been distributed to the **test site leaders**, for **sharing all the preparatory activities, setting of the test site and qualitative lessons learned, as collectively assumed by the test site leaders** and on the basis of the recollection they have had from all different types of participants in this phase. This template accurately follows the structure that sections 4 to 9 follow in

the current Deliverable and has led to a consistent and comparable reporting of the test sites activities, results and lessons learned, upon the revision and consolidation done by CERTH/HIT with the support of FEV.

2. The establishment of a **task force** that worked on a cross-cutting level on the **analysis of the subjective and performance results collected**. The reporting of those results is included in sections 4 to 9 on individual site level and on aggregated level in section 10 and 11, utilizing the logged data in Netigate and the Data Management Portal.

   The subjective data have been statistically analysed and the free and qualitative comments and interviews have been consolidated and discussed according to the provisions described in D9.2 and D9.3. Statistically wise, means, medians, minimum and maximum values and standard deviations have been calculated whenever applicable (by VUB, CTL, EUROMOBILITA, CERTH/HIT and AVL) for each site demographics and each user acceptance aspect raised in the subjective surveys (satisfaction, usefulness, ease of use, ease of learning, reliability, safety, adequacy, comfort, intention to re-use, recommendation intention) and overall (Likert scale 1-9: most positive as a reference).

   The interviews addressing stakeholders other than passengers raised their expectations from the project and shared automated mobility, concerns, potential benefits, potential, level of satisfaction regarding the SHOW services, etc. (see the full form in D9.2). Whenever possible, it has been recognized the level of agreement across the several tangible aspects raised (useful, pleasant, poor, good, effective, irritating, supportive, undesirable) across a Likert scale of 1-5 (most positive).

   Furthermore, there are some cases (i.e. Brainport, Tampere, etc.) that additional test specific surveys have been conducted; results are also provided from them as well.

   In addition, key KPIs have been calculated after processing of the performance data available for the period by the respective task force (CERTH/ITI) and according to the formulas defined in A9.4: Impact assessment framework, tools & KPIs definition and reported in D9.2 and D9.3 and WP13: Impact assessment. In addition, also part of section 11, the first correlation of subjective and performance data has been conducted (IDIADA) to give some first insights. The KPIs calculated are visualized finally and dynamically in the public SHOW project Dashboard (https://show-project.eu/show-dashboard/) for each test site that is running.

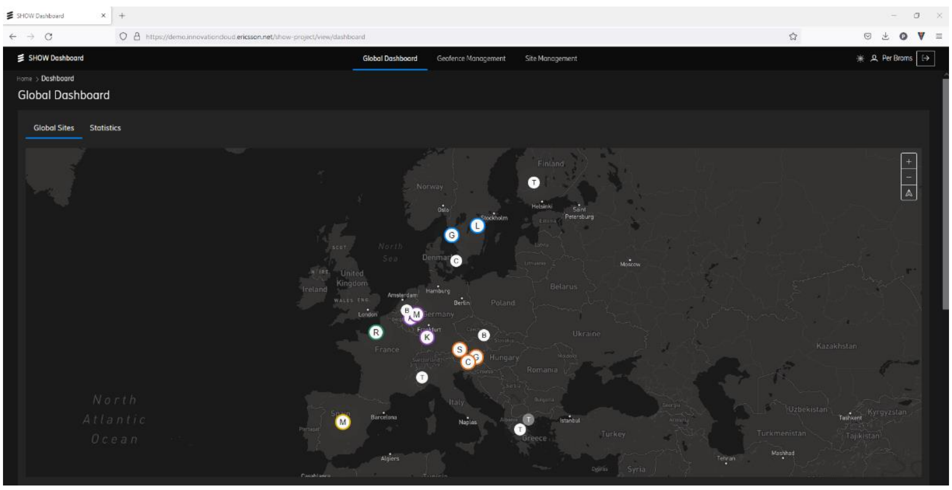


Figure 1: SHOW project dynamic Dashboard – Test sites overview.

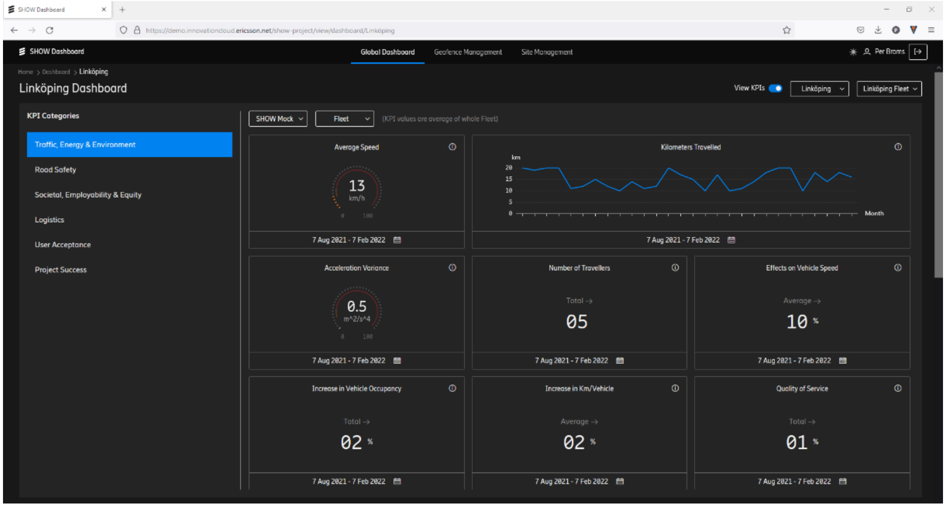


Figure 2: SHOW project dynamic Dashboard - Linköping KPIs example screenshot.

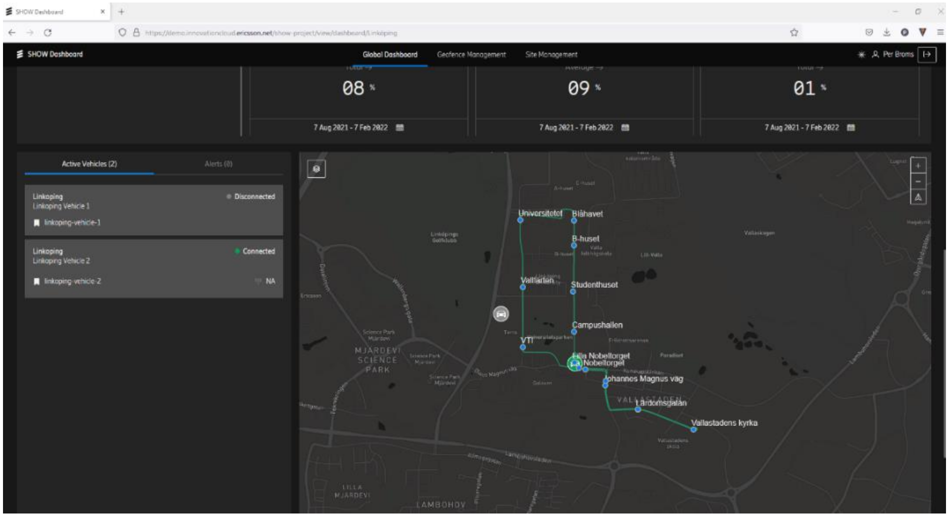


Figure 3: SHOW project dynamic Dashboard - Real time position map of vehicles - Linköping example screenshot.

3 Status & plan of pre-demo pilots

The status and plans of SHOW test sites pre-demo phase or 1st round of pilots at the time of this Deliverable issuing (December 2022) is depicted in the following table. In each case it is denoted in which out of the three issues of D11.3, the respective results will be reported.

Table 1: Status of pre-demo phase of SHOW test sites (when applicable) – December 2022.

SHOW test site	Pilot leader	Vehicles involved in the pre-demo phase	Use Cases addressed in pre-demo (Appendix II)	Pre-demo status - period	Passengers transported during pre-demo	Results reporting – D11.3 issue
Linköping (Swedish Mega test site)	VTI	1 Navya DL4 shuttle L4, 2 EasyMile EZ10 Gen2 shuttles	1.1; 1.3; 1.6; 1.7; 3.1; 3.4;	**Closed** - November – December 2021	401	D11.3 1st issue/ current
Gothenburg (Swedish Mega test site)	RISE	2 NAVYA L4 shuttles	1.1; 1.2; 1.3; 1.6; 1.7; 3.4	**Closed** – Mid of January 2021 - end of May 2021	1500	D11.3 1st issue/ current
Madrid (Spanish Mega test site) (Carabanchel) & Villaverde)	TECNALIA	2 TECNOBUS Gulliver (Electric Microbus L2→L4) by EMT, 2 Renault Twizzy (Passenger car – L2→L4), 1 IRIZAR–-i2eBus – (Electric Bus L3→L4)	UC1.1; 1.2; 1.3; 1.6; 1.10; 1.7; 1.8; 3.3; 3.5	**Closed for Carabanchel** - May to end of October 2022) **Pending for Villaverde** - pre-demo will follow in 2023.	10 until end of May 2022 608 until end of October 2022 (end of pre-demo period)	D11.3 1st issue/ current & D11.3 2nd issue
Graz (Austrian Mega test site)	VIF	1 Ford Fusion (passenger car) & 1 Kia e-Soul (passenger car)	1.2; 1.3; 3.4	**Closed** - August 2022 - early September 2022	70	D11.3 2nd issue
Salzburg (Austrian Mega test site)	SRFG	2 C-ITS vehicles, 1 VW e-Crafter retrofitted (L4) + 1 passenger shuttle (L4) to be deployed in Carinthia.	1.5, 1.2, 1.3, 1.6, 3.1	**Pending** - Pre-Demo Phase planned to start in March 2023	N/A	D11.3 3rd issue

SHOW test site	Pilot leader	Vehicles involved in the pre-demo phase	Use Cases addressed in pre-demo (Appendix II)	Pre-demo status - period	Passengers transported during pre-demo	Results reporting – D11.3 issue
Carinthia (Austrian Mega test site)	PDCP	1 Navya ArmaDL4 shuttle operated in the first pre-demo; 2 more NAVYA shuttles to be added in Klagenfurt demo (one of them mentioned also above in Salzburg).	1.1; 1.2; 1.6; 2.1; 3.6	**Closed** for Pörtschach - September-November 2021 **Pending** for Klagenfurt – Spring 2023	564 passengers in Pörtschach	Pörtschach - D11.3 2nd issue Klagenfurt – D11.3 3rd issue
Karlsruhe (Germany Mega test site)	FZI	2 EasyMile EZ10, gen 2 shuttles, 1 Audi Q5 (AV passenger car), + 1 modular vehicle from DLR	1.1; 1.2; 1.6; 1.7; 1.9; 2.1; 2.2	**Closed** / 1st quarter of 2022 to November 2022	523	D11.3 2nd issue
Turin (Italian Satellite test site)	Links	2 AV Shuttles - NAVYA DL4	1.1; 1.2; 1.3; 1.5; 1.6; 1.7; 1.10	**Pending** - to be conducted in January 2023	N/A	D11.3 3rd issue
Trikala (Greek Satellite test site)	ICCS	2 AV shuttles, 1 Furbot vehicle (REPLACED by 5 YAPES – delivery robots) & 2 passenger retrofitted L4 vehicles	1.1; 1.2; 1.3; 1.5; 1.6; 1.7; 1.8; 1.10 – 1.1 & 1.2 for cargo already in operation	**On-going** – started with logistics – will follow with shuttles and passenger cars in Spring 2023	N/A yet	D11.3 3rd issue
Tampere (Finnish Satellite test site)	SITOWISE (overall leader)	• 2 Sensible 4 Toyota ProAce vans – Phase 1 • 1 AuveTech Iseauto shuttle – Phase 2	1.1; 1.2; 1.4; 1.7	**Closed** – for Phase 1, 2 and 3 (all until end of December 2022) **Pending** – for Phase 4 – In 2023//	12 (Phase 1)	D11.3 2nd & 3rd issue

SHOW test site	Pilot leader	Vehicles involved in the pre-demo phase	Use Cases addressed in pre-demo (Appendix II)	Pre-demo status - period	Passengers transported during pre-demo	Results reporting – D11.3 issue
		• 1 Easymile & 2 Auvetech – Phase 3 • 5 more vehicles – Phase 4 // Amendment 2		also dependent to Amendment 2		
Brno (Czech Republic Satellite test site)	CDV	1 Hyundai i40 Retrofitted (Robo-Taxi), 2 Retro fitted Esagono, Energia, GRIFO shuttles	1.1; 1.2; 1.3; 1.6; 1.7	**Closed -** 13-24 June -31 July 2022	67	D11.3 2nd issue
Brainport (Dutch Satellite test site)	TNO	2 TNO Carlab Renault Scenic passenger vehicles providing SAE Level 4 automated driving functionality	1.1; 1.3; 1.8	**Closed** - November 2021	12	D11.3 1st issue

As it has been mentioned above again, there are some test sites for which pre-demo period is not applicable. Those are mostly the sites that have joined SHOW being operational already; thus they moved directly to open to public large scale field trials.

Those are the following:

- **Rouen** (part of French Mega Site to be renamed to Les Mureaux in the context of Amendment 3), operated by TRANSDEV.
- **Crest Val de Drôme** (part of the French Mega Site- replacing former Rennes), operated by Beti.
- **Monheim** (part of German Mega site), operated by BSM.
- **Frankfurt** (part of German Mega site), operated by RMS.

4 Turin test site (satellite)

4.1 Introduction

Before the start of the SHOW pre-demo and demo phases in Turin, a preliminary experiment was carried out as a preparation step for the main SHOW activities. It took place at the Campus of the International Training Centre of the International Labour Organization (ITC-ILO) from March 2020 to July 2020. During this period, an automated shuttle, provided by Local Motors, circulated on the campus, an area characterized by traffic mixed with pedestrians, bikes and motorized vehicles.

The objectives of this phase were: (1) to assess the users' acceptance of automated mobility, and (2) to assess the drivers/barriers to its implementation. To this aim, LINKS Foundation had on the one hand surveyed potential users of the automated shuttle to assess their acceptance, and on the other hand, had interviewed the stakeholders directly involved in the initiative in order to extract drivers and barriers to the implementation process.

The identified drivers and barriers can be classified into eight categories: **institutional**, **technological**, **financial**, **political**, **cultural**, **spatial**, **communicational and positional**. The experiment also provided some new insights on technological aspects of autonomous driving, its impact on the future of work, reaction of the target community. Despite low attendance caused by covid-19 emergency also some insights into acceptance of the technology were collected.

4.2 General

4.2.1 The ecosystem

The experiment which is addressed in this document was foreseen and defined in the Grant Agreement of the SHOW project. However, it was exceptional in the sense that it is not a part of regular procedure for the pilot sites, since it occurred in 2020 when the evaluation protocols of the project were not available yet and this is the reason the evaluation conducted is not similar to the one of the other test sites following. Still, Turin used its own evaluation measures and tools and it served as an important lesson and input for preparation of the upcoming activities of SHOW.

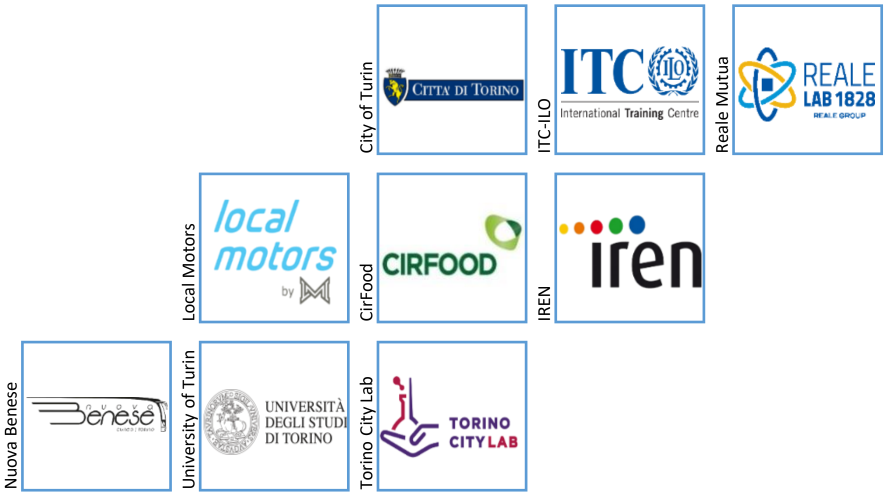


Figure 4: Sponsors of the experiment.

For that reason, also the parties involved in the experiment were different from those participating eventually in all the main activities of SHOW pilot in Turin. The only representative of SHOW consortium involved was **Links Foundation**, responsible for overall management of the experiment.

Apart from Links, a number of entities external to the consortium contributed greatly to bringing Olli shuttle to Turin. **ITC-ILO** played a key role by making available their premises for the shuttle. Moreover, they also supported the initiative with sponsorship, together with other partners (Figure 4), namely **City of Turin** (together with Torino City Lab), **Reale Mutua**, **Local Motors**, **CirFood**, **IREN**, **Nuova Benese** and **University of Turin.**

4.2.2 The setting

The experiment was carried out at The International Training Centre of International Labour Organization (ITC-ILO). ITC-ILO is an advanced technical and vocational training institution in the heart of a riverside park in Turin, Italy (Figure 5). Founded in 1964 by the International Labour Organization and the Government of Italy, the Centre's mission is to achieve decent work for all women and men.

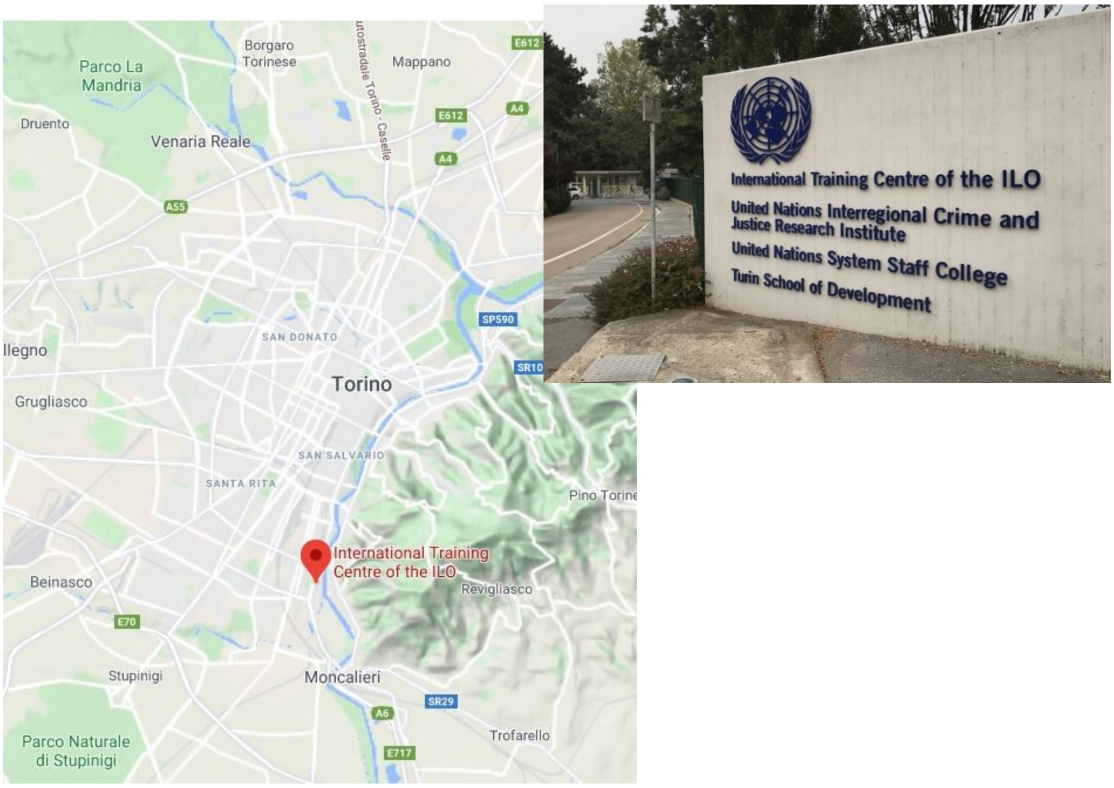


Figure 5: Location of the ITC-ILO campus in Turin.

The Centre is dedicated to the pursuit of learning and training to achieve Sustainable *Development Goal 8: "Promote inclusive and sustainable economic growth, employment, and decent work for all".* The Centre offers learning, knowledge-sharing, and institutional capacity-building programmes for governments, workers' and employers' organizations, and development partners.

The participation of ITC-ILO within Olli experimentation has not only been to provide logistical availability, but overall the strong interest of experimenting with a technology that is fully among those that will design the "**future of work**", a topic widely covered in their training programmes.

Figure 6: Typical street inside the ITC-ILO campus.

The roads inside the ITC-ILO campus (Figure 6) are not public: the entrance is allowed only to employees, students and booked visitors. Still, the campus is an area characterized by traffic mixed with pedestrians, bikes and motorized vehicles (employees are allowed to enter with their own car). The shuttle circulated inside the campus along a selection of internal roads which can be seen in the map below (Figure 7). Total length of the route was 700 meters. 6 stops were foreseen along the route for picking up and dropping off the passengers.

Figure 7: Street network inside the ITC-ILO campus.

Although the traffic is mixed, the traffic intensity is rather low with few vehicles circulating at low speeds and without any major difficulties along the route, such as roundabouts or complex intersections. Overall, the traffic and environmental conditions for the shuttle can be described as normal, without any significant challenges. Weather conditions on the days of experiment were usually favourable, sunny with good visibility (Figure 8).

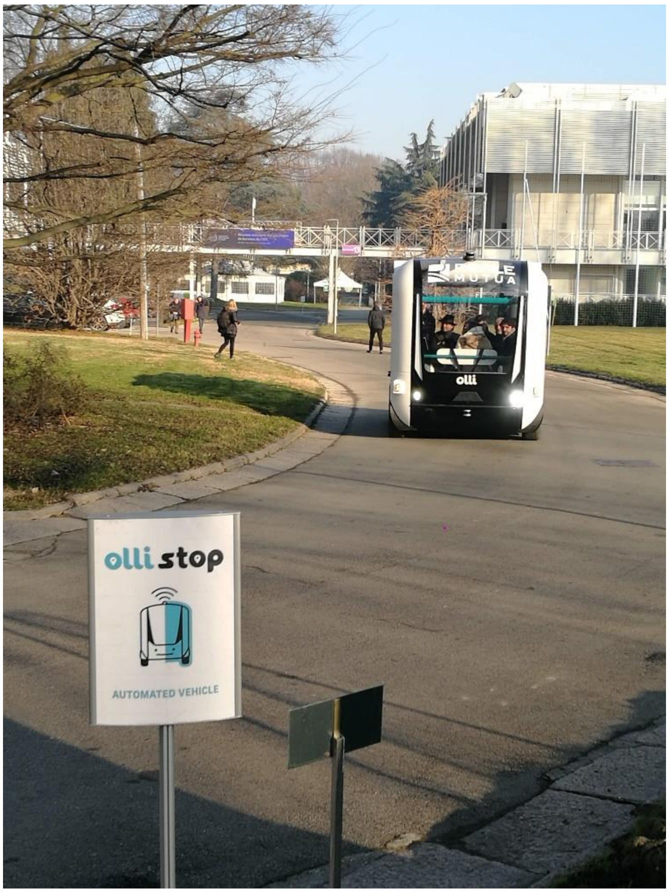


Figure 8: Olli shuttle circulating on the ITC-ILO campus on a typical day of experiment.

4.2.3 Field trials operation timing

Olli was scheduled to remain at the ITC-ILO campus **from mid-February until May 2020,** but the vehicle operations had to be abruptly stopped after 3 weeks due to the sudden lockdown that involved the entire Italian nation during the Covid-19 emergency (from 9 March to 18 May 2020). In this period, nobody was allowed to enter in the campus and - even when the lockdown ended - most students were not able to come to Italy due to the travel restrictions. The following temporal phases can be distinguished (Figure 9):

	2020							
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.
Pre-pilot	Test + training	In progress	Suspended				In progr.	
Covid-19 measures			Total lockdown			Relaxed lockdown		

Figure 9: Timeline of the experiment.

Thanks to the commitment of the sponsors involved in the initiative, it was possible to extend the trial period **for two extra months (until July 2020).** However, even in this additional period, campus users were heavily limited due to both Covid-19 restrictions and the incentive to work remotely for the employees. Table 2 summarises the activities of the shuttle in various time periods, and how they were affected by the Covid-19 emergency.

Table 2: Activities of the shuttle in relation to Covid-19 restrictions.

From	To	Covid-19 measures	What Olli did
16/01/2020	16/02/2020	-	The Olli shuttle circulated only for technical development and steward/safety driver training
17/02/2020	08/03/2020	-	A regular service began in three time slots and two sponsors organised promotional events with their clients or prospects
09/03/2020	14/06/2020	Phase 1 of Covid-19 emergency (total lockdown) + phase 2 (relaxation of containment measures)	The Olli shuttle turned only to keep the batteries active; moreover, there was some technical problem with the antenna, with consequent connectivity problems
15/06/2020	31/07/2020	phase 3 of Covid-19 emergency (further relaxation of Covid-19 containment measures)	
06/07/2020	31/07/2020		Resume of the Olli service at regular times even though attendance was very limited and there were some technical problems. Distribution of the (in-house) developed questionnaire on users' acceptance (both online, also accessible with QR-code, and on paper available on the vehicle).

4.2.4 The Fleet

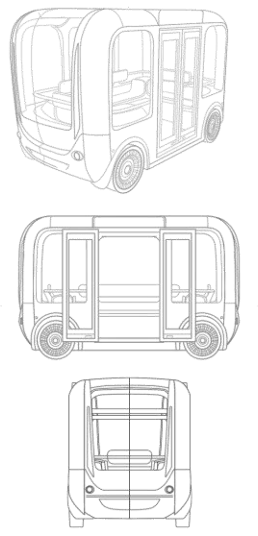
A single vehicle was used in the experiment, namely an Olli shuttle provided by Local Motors. Olli is a self-driving, electric, 3D-printed shuttle, developed for urban mobility and designed with particular attention to accessibility and sustainability (Figure 10). **The shuttle operates in SAE Level 4.**

Figure 10: Olli shuttle provided by Local Motors, parked at the campus.

There are several customization possibilities with an Olli vehicle, but some general specifications are shown in the following table.

Table 3: Olli shuttle technical specification.

Range: 60 km (nominal), 40 km (max load, max A/C)	
Max Speed: 40 km/h	
Max Torque: 240Nm	

Charging Time (440 V): 1.5 hours	
Transmission: 9.59.1 gear ratio	
Curb Weight: 2654 kg	
Capacity: 612 kg	
Length: 3920mm	
Width: 2050mm	
Height: 2500mm	
Wheelbase: 2526mm	

For the purpose of the experiment, the speed of the shuttle was lower than the maximum speed. The registered speed ranges from 10 to 33 km/h.

4.2.5 The Infrastructure

No particular infrastructure had to be installed for the regular operations of the shuttle (such as traffic lights, VRUs detection sensors, etc.). A special space covered by a tent was designated inside the ITC-ILO campus for storing the vehicle outside the hours of operation. For charging the shuttle batteries, a charging station was set up on the campus by Iren, one of the partners of the initiative.

Figure 11: Olli next to the Iren charging station.

4.2.6 Users & Stakeholders

4.2.6.1 Passengers and stakeholders in the loop

It must be noted again that due to Covid lockdown and incentives for smart working the number of people that could experience the vehicle was eventually heavily limited.

On the kick-off day all the participants of the event were allowed onboard to test the vehicle (**around 100 people**), among them representatives of the press and politicians. Also representatives of the sponsors could have a ride on the vehicle. People from outside these groups were not allowed on the shuttle.

In total, besides the passengers of the kick-off day, **about 150 users** boarded the shuttle during the test programme: about 80 campus employees, in addition to about 70 guests and other participants.

24 surveys were completed. The purpose of the surveys was to assess the acceptance of automated mobility. It has to be noted that the target audience for the surveys were not only the people who experienced the shuttle, but also the whole potential pool of users, thus including also those who never boarded the shuttle. Demographics of the respondents is summarised in Table 4.

Table 4: Basic demographic data of survey participants.

Gender			**Age**		
Male:	16	(67%)	18-24:	2	(8%)
Female:	8	(33%)	25-35:	6	(26%)
			36-45:	7	(29%)
			46-60:	7	(29%)
			60+ :	2	(8%)
Education level			**Employment status**		
Primary/Middle school:	1	(4%)	Employed:	18	(75%)
High school:	8	(33%)	Self-employed:	2	(8%)
BSc/MSc/PhD:	15	(63%)	Unemployed:	2	(8%)
			Student:	2	(8%)

In addition to the survey, also interviews were carried out to understand drivers and barriers for automated vehicles implementation. In total **4 interviews** were completed, one with the manager of ITC-ILO campus, and three with safety drivers of the Olli shuttle.

4.2.6.2 Local campaign and strategies for awareness, recruitment & engagement

The experiment received media coverage in the local media, in the press and on the internet. A kick-off event was organized, which attracted prominent representatives of the City of Turin, among them the mayor herself (Figure 12).

Figure 12: Turin kick-off event.

Moreover, flyers encouraging for participation in the experiment and a survey were distributed on the campus (Figure 13).

Figure 13: SHOW flyer for Turin (pre-) pre-demo.

4.3 Preparatory Process

4.3.1 Permits

Under Italian law, no special permit is required for use of automated vehicles inside a closed area, isolated from regular traffic.

4.3.2 Development/ Customisation/ Integration

No special developments were required. The data registered by the shuttle were not automatically uploaded to a database (as the SHOW project Data Management Platform – DMP was not established yet in the project); instead it was manually downloaded on a hard disk after each day of operation.

4.3.3 Training

In total, **10 safety drivers** were trained for the experiment (5 from the campus and 5 sent by the city). The training was conducted by Local Motors and took 8 days: 3 days of theory, 3 days of practice, and 2 days of exams. After successfully passing the exam a 'driving license' for the shuttle was issued to the safety driver.

4.3.4 Ethics & GDPR

No personal data was collected at any point from the passengers, and the surveys distributed were fully anonymous.

4.4 Pre-demonstration study design

4.4.1 Field Trials Research Hypotheses/ Evaluation Objectives

Although some of the SHOW use cases were also examined through the experiment, the main focus, as defined in the Grant Agreement, was to "assess: 1) implementation barriers and impacts and 2) users' acceptance".

Table 5: Turin pre-(pre-demo) response to SHOW research hypotheses and Use Cases (only indicatively- basically out of scope).

Research Questions	Relevant Use cases	Addressed
How will road safety, traffic efficiency, mobility, and user acceptance be affected by AV operation (passenger or cargo) in a real city environment when operated in normal speeds, normal/smooth traffic context, without any traffic or other environmental complexity? Also, interfacing to any of the following modes: PT, DRT, MaaS and LaaS.	UC1.1: Automated passengers/cargo mobility in Cities under normal traffic & environmental conditions	√
How will road safety, traffic efficiency, mobility, and user acceptance be affected by AV operation (passenger or cargo) in a real city environment when interacting with not automated (not connected) vehicles and/or VRUs?	UC1.3: Interfacing non automated vehicles and travellers (including VRUs)	√
How will road safety, traffic efficiency, mobility, and user acceptance be affected by AV operation in a real city environment when operated in mixed flows with AV and non-AV vehicles?	UC1.6: Mixed traffic flows	√

4.4.2 Test Scenarios

4.4.2.1 Use Cases – Test Cases

As indicated in Table 5, three use cases were tested to some extent during the experiment (1.1; 1.3; 1.6). However, it must be highlighted that the trials were not conducted in real traffic conditions and the interaction with other road users was heavily limited. Moreover, as already indicated, **assessment of use cases was not the actual goal of this experiment**. Instead, it focused on assessment of users' acceptance and barriers for automated vehicles implementation. For these reasons, it is not possible to properly elaborate on the related research questions. The main results of the experiment (regarding acceptance and barriers) are covered in sections 4.5 and 4.6.

4.4.2.2 Mobility services & apps

No special mobility services were involved in the experiment. The shuttle circulated along pre-defined route, stopping at each of the 6 predefined stops, where passengers could enter and exit the shuttle, without the need of booking the service. **The shuttle was operating for 6 hours a day, every day of the week.**

4.4.3 Evaluation methods & data collection tools

Different methodologies were used for both assessing the users' acceptance and examining barriers/drivers for AVs implementation. These two different approaches are described below.

A. Assessment of users' acceptance of autonomous mobility

Information had been collected through an online questionnaire available in two languages (Italian and English). The design of the questionnaire was inspired by the survey on the acceptance of automated vehicles built within the Drive2theFuture European project, with appropriate customizations to fit within the specific context of the ITC-ILO campus. The questionnaire (English version) is also available in Appendix III of this document.

The link to fill in the questionnaire was sent by email to the campus employees and - in order to cover occasional users - flyers with the QR code pointing to the link were hung both on the campus streets and inside the Olli shuttle. Furthermore, some printed copies of the survey were available on the shuttle to allow also occasional users not owning a smartphone to fill in the questionnaire.

As noted again, the target audience of the survey was not only the shuttle users, but the entire pool of potential users. To this end, the questionnaire was constructed with a bifurcation (in section B, see Appendix III) between those who had already had the opportunity to board the autonomous shuttle (section C) and those who had never boarded it (section D), in order to analyse for the former also the experience of use and for the latter the degree of acceptance regardless of use.

The survey was structured in four parts, explained in Figure 14.

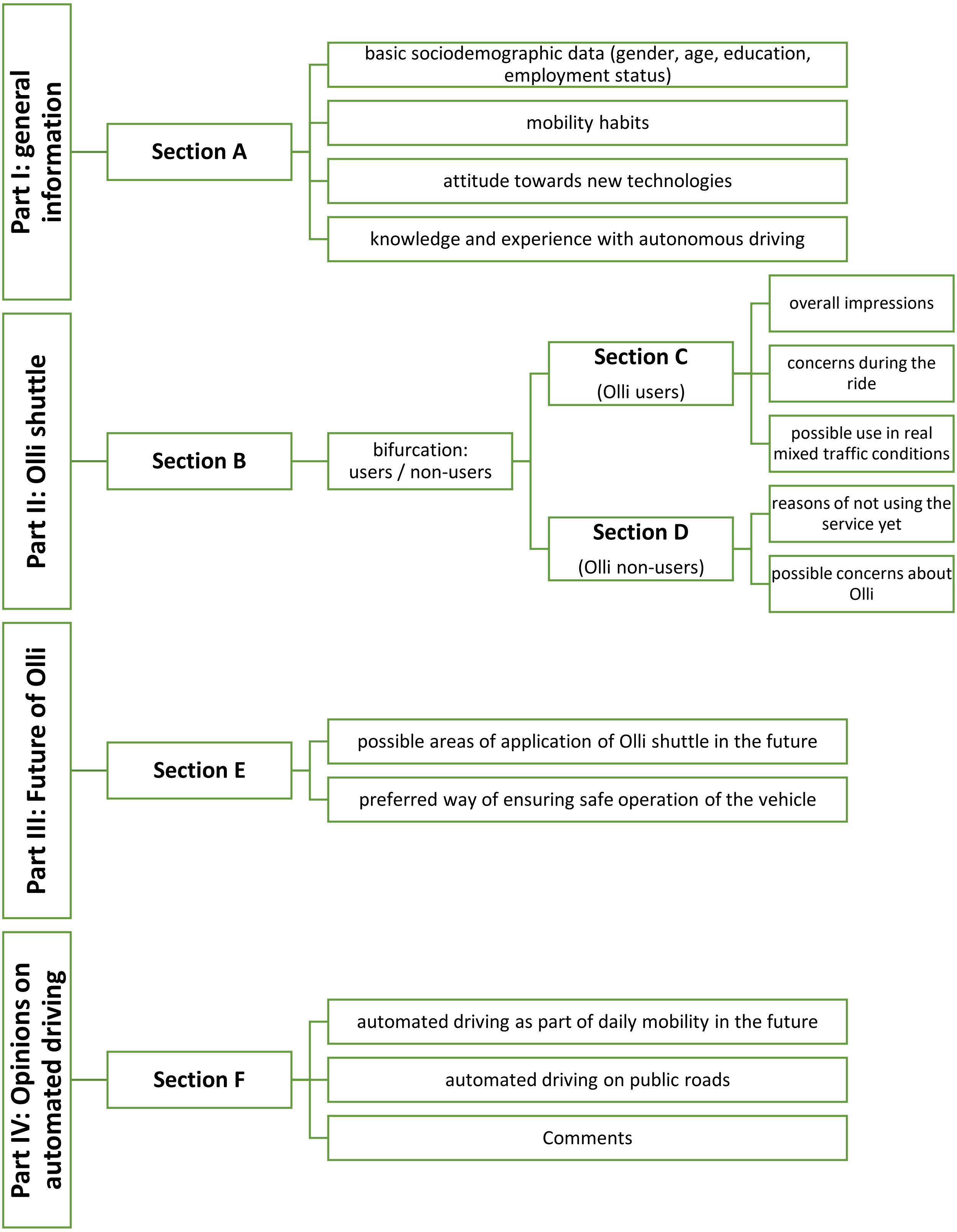


Figure 14: Structure of the users' acceptance survey of Turin (pre)pre-pilot.

B. Assessment of drivers and barriers for automated mobility implementation

The assessment of the drivers/barriers was inspired by the CIVITAS evaluation framework, which was developed within CIVITAS SATELLITE Coordination and Support Action. This framework is aimed at assessing both the process and the impacts of mobility measures, in order to understand what worked (and what did not) in the implementation of a mobility initiative. In particular, through the process evaluation, the evaluators want to answer questions such as: (i) how was the mobility measure implemented? (ii) what are the obstacles and drivers that are detected in the implementation of the measure? (iii) why are certain impacts observed?

For the purposes of the SHOW experiment, some simplifications have been made with respect to the original framework, mainly due to two reasons: (a) the limited duration of the initiative (about 2 months apart from the lockdown period); (b) the objectives of the evaluation (this was a pre-pilot, whose assessment is functional to the actual evaluation of the pilot that will be carried out during the project).

According to CIVITAS framework, drivers and barriers of Turin pre-pilot have been classified following the taxonomy proposed in Table 6 and

Table 7. Furthermore, the guidelines provide some templates as regards the data collection of the whole process evaluation, including: the identification of target groups and stakeholders, the supporting activities and the lessons learned.

Table 6: Classification of drivers in accordance to CIVITAS framework [Source: Engels and G. Van Der Bergh (2017)].

Classification of drivers	
Political / strategic	E.g. commitment of key actors based on political and/or strategic motives, presence of sustainable development agenda or vision, positive impacts of a local election, coalition between key (policy) stakeholders due to converging (shared) believes in directions of solution
Institutional	E.g. facilitating administrative structures, procedures and routines, facilitating laws, rules, regulations and their application, facilitating structure of organizations and programs
Cultural	E.g. facilitating cultural circumstances and life style patterns
Problem related	E.g. pressure of the problem(s) causes great priority, shared sense of urgency among key stakeholders to sustainable mobility
Involvement / communication	E.g. constructive and open involvement of policy key stakeholders, constructive and open consultation and involvement or citizens or users
Positional	E.g. the measure concerned is part of a (city) program and/or a consequence of the implementation of a sustainable vision, exchange of experiences and lessons learned with other measures or cities
Planning	E.g. accurate technical planning and analysis to determine requirements of measure implementation, accurate economic planning and market analysis to determine requirements for measure implementation, thorough user needs analysis and good understanding of user requirements
Organizational	E.g. constructive partnership arrangements, strong and clear leadership, highly motivated key measure persons, key measure persons as ‘local champions’
Financial	E.g. availability of public funds and subsidies, willingness of the business community to contribute financially
Technological	E.g. new potentials offered by technology, new technology available
Spatial	E.g. space for physical projects, experimentation zones

Table 7: Classification of barriers in accordance to CIVITAS framework [Source: Engels and G. Van Der Bergh (2017)].

Classification of barriers	
Political / strategic	E.g. Opposition of key actors based on political and/or strategic motives, lack of sustainable development agenda or vision, impacts of a local election, conflict between key (policy) stakeholders due to diverging believes in directions of solution
Institutional	E.g. Impeding administrative structures, procedures and routines, impeding laws, rules, regulations and their application, hierarchical structure of organizations and programs
Cultural	E.g. Impeding cultural circumstances and life style patterns
Problem related	E.g. Complexity of the problem(s) to be solved, lack of shared sense of urgency among key stakeholders to sustainable mobility
Involvement / communication	E.g. Insufficient involvement or awareness of (policy) key stakeholders, insufficient consultation, involvement or awareness of citizens or users
Positional	E.g. Relative isolation of the measure, lack of exchange with other measures or cities
Planning	E.g. Insufficient technical planning and analysis to determine requirements of measure implementation, insufficient economic planning and market analysis to determine requirements for measure implementation, lack of user needs analysis: limited understanding of user requirements
Organizational	E.g. Failed or insufficient partnership arrangements, lack of leadership, lack of individual motivation or know-how of key measure persons
Financial	E.g. Too much dependency on public funds and subsidies, unwillingness of the business community to contribute financially
Technological	E.g. Additional technological requirements, technology not available yet.
Spatial	E.g. No permission of construction, insufficient space

Vehicle data collection: As mentioned again, regarding collection of data related to the vehicle, there was no automatic data storage (e.g. in cloud). At the end of each working day the safety drivers had to manually connect to the dashboard of the vehicle and download the data on a hard disk – a procedure lasting usually 2-3 hours.

4.4.4 Experimental process

Typical day of trials can be described by the following sequence:

- At the beginning of the day the safety drivers go with the vehicle in a manual mode to the point determined by Local Motors for localization of the shuttle via satellite
- Regular operation of the vehicle, circulating along the route and stopping at the predefined stops
- The passengers of the vehicle are given the survey after using the service, either in a paper version or via QR code
- At the end of the day the vehicle is driven back to its storage area, where the vehicle data is downloaded on hard disk by safety drivers
- The vehicle is connected to charging station to charge the battery overnight for the following day of service

Since use cases were not yet defined and considered during the experiment, testing 10 times each use case, as it was anticipated by D9.2, was not applicable for these trials.

4.5 Pre-demo phase field trials results

In the following two subsections, two main cluster of results from the experiment will be addressed, namely users' acceptance of the automated vehicles and drivers and barriers for their implementation.

4.5.1 Assessment of users' acceptance of autonomous mobility

Since the official SHOW acceptance survey was not available yet, LINKS Foundation has taken as a reference for the design of the questionnaire the 'Drive2TheFuture User Acceptance survey'.

Demographics and general information

As already mentioned, **24 participants answered the survey**. There were twice as many men as women, and the age of the respondents was quite diverse, but mostly evenly distributed in the span of 25-60 years old. Most people had university degree, and were currently employed (Table 4).

Private car is the most popular transport mode among the respondents (Figure 15). The rest is almost equally divided into motorcycle/moped, bicycle and urban public transport. One respondent uses extra-urban public transport for daily travelling.

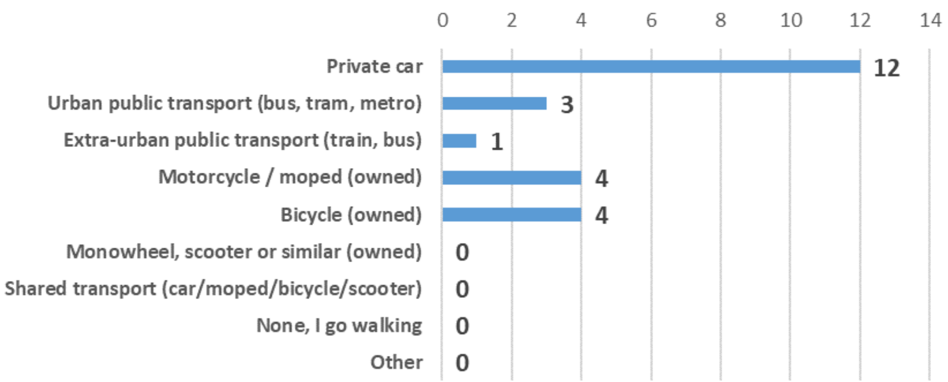


Figure 15: Transport mode used mostly for daily commuting (base: all the respondents).

Regarding the attitude towards new technologies and their adoption, the respondents seem to be quite progressive (Figure 16). 10 of them (42%) declare themselves as early adopters, and 13 (54%) says that they prefer to wait some time before embracing innovative products. Only 1 person (4%) admitted being usually among the late adopters of new technologies. Moreover, the majority of respondents (75%) said that they usually found it easy to learn how to use a new technology.

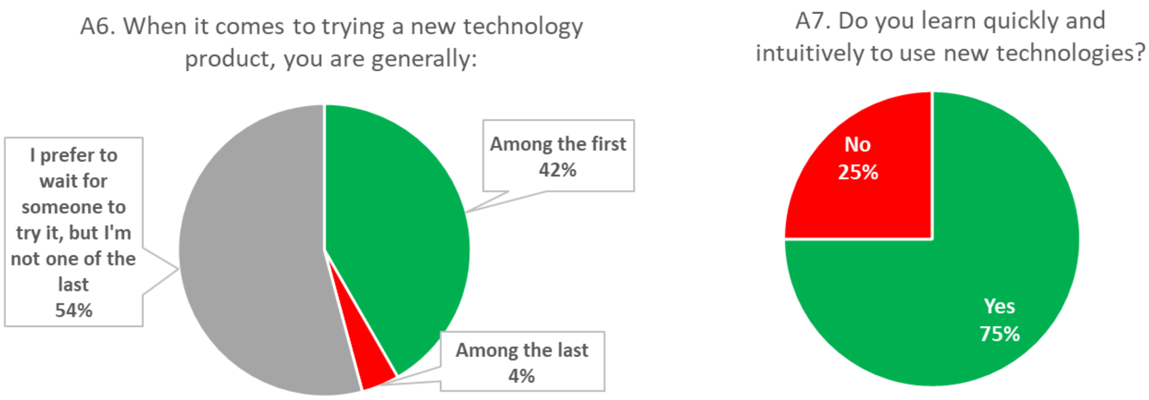


Figure 16: Attitude towards new technology (base: all the respondents).

Regarding the knowledge and experiences with automated vehicles in particular, most of the respondents have at least some theoretical knowledge on the technology, although for the majority of them it is superficial. Moreover, the majority of the participants had no previous practical experiences with autonomous driving (Figure 17).

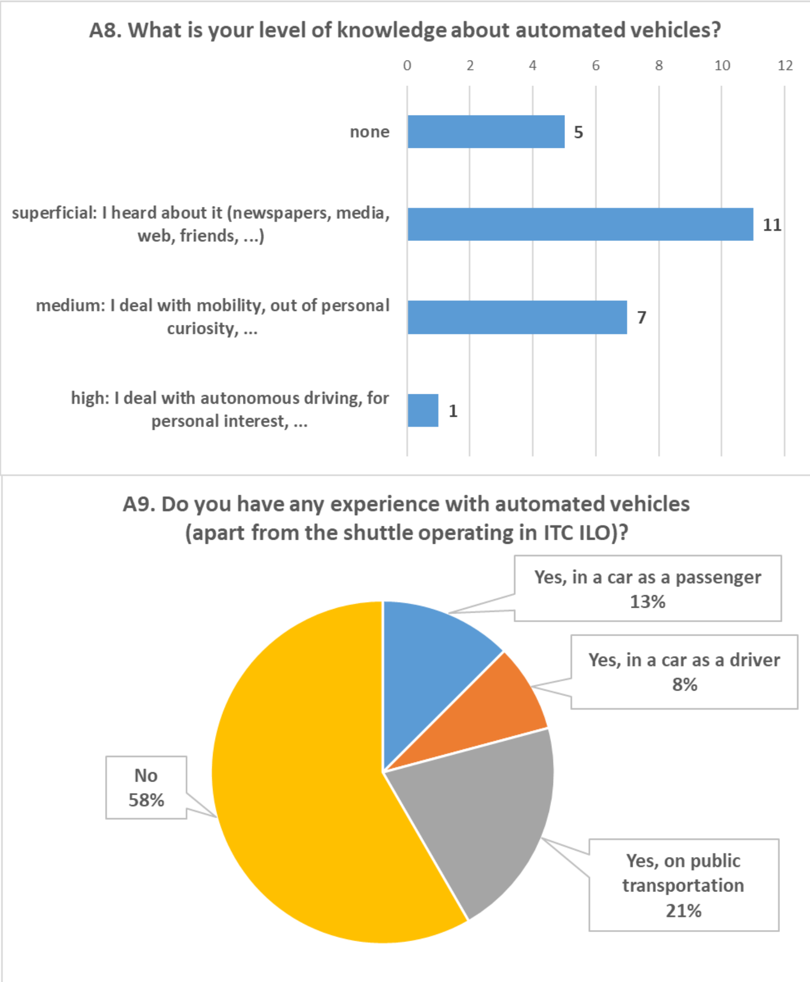


Figure 17: Knowledge and experiences with automated vehicles (base: all the respondents).

4.5.1.1 Opinions on the Olli shuttle

It must be highlighted that not all the respondents did actually use the automated shuttle, and also people who did not do it were surveyed to gather also some insights into possible reasons of not using the vehicle. However, the majority of the respondents were indeed passengers of the shuttle (Figure 18).

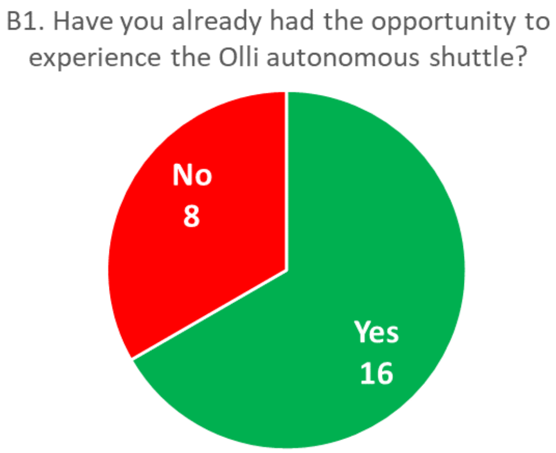


Figure 18: Number of people who experienced Olli autonomous shuttle in Turin (base: all the respondents).

The 16 respondents who actually used the shuttle **were overall satisfied** with the service, with the majority of them giving the experience the rating 4 and 5, on a 5 points scale (Figure 19).

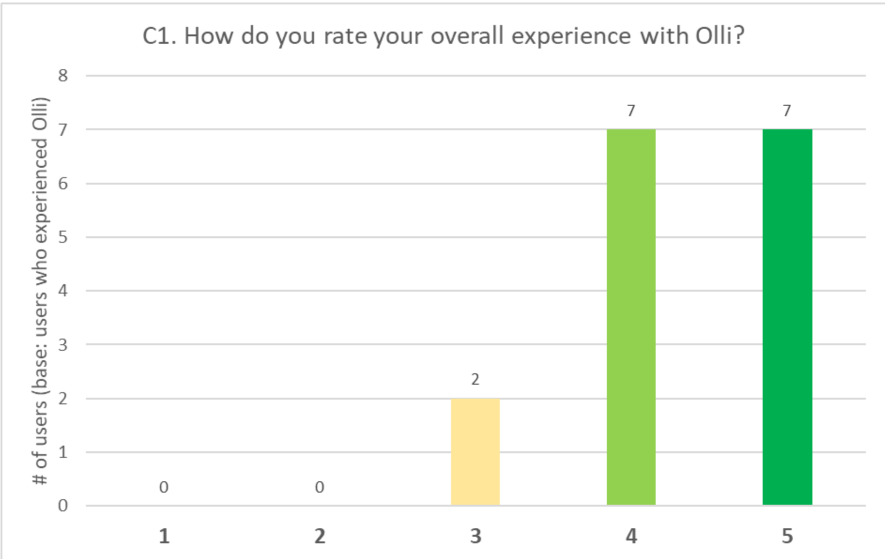


Figure 19: Rating of the overall Olli experience (base: users who experienced Olli).

The passengers of the shuttle were also asked more in detail about their experience and the impressions of the ride. The majority of the users had none or very minor concerns about any of the considered elements (Figure 20). Cybersecurity and data privacy were the factors that caused least concerns, whereas the need to adjust the behaviour in order to use the shuttle (e.g. do a booking) was the element that created certain concerns in a number of passengers. Regarding safety, it seems that although on average the users were not too much concerned about it, they regarded safety of vulnerable road users as being more at stake than their own. The risk of Covid-19 infection also resulted in moderate concerns in some of the passengers.

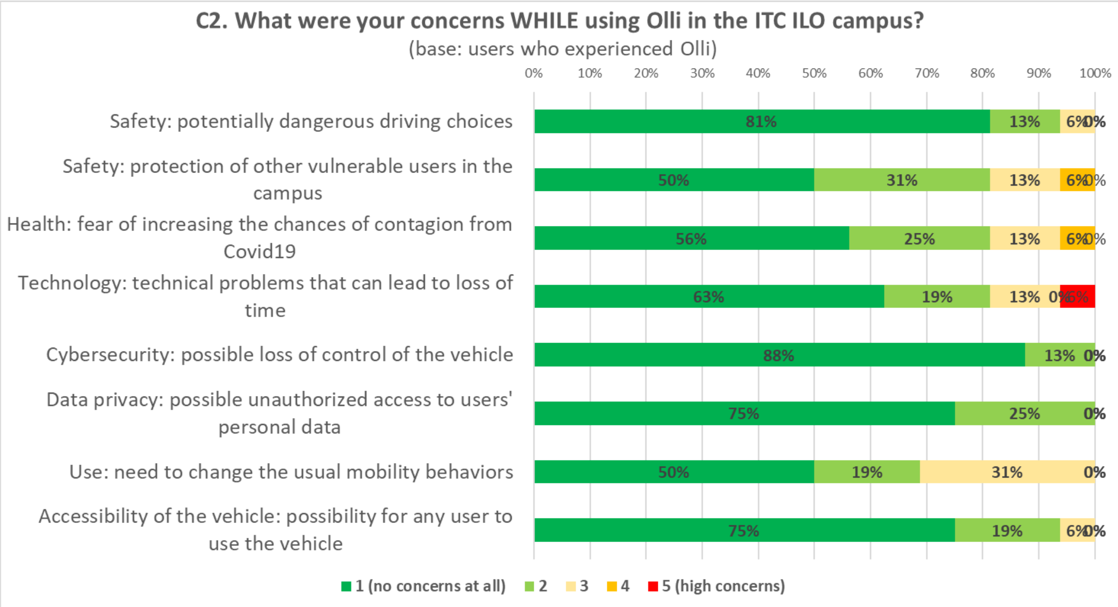


Figure 20: Concerns while using Olli (base: users who experienced Olli).

The people who used the service were also asked if, after their experience, they would use the Olli shuttle in real life conditions with mixed traffic. The majority were positive about this idea, with only two participants being rather negative (Figure 21).

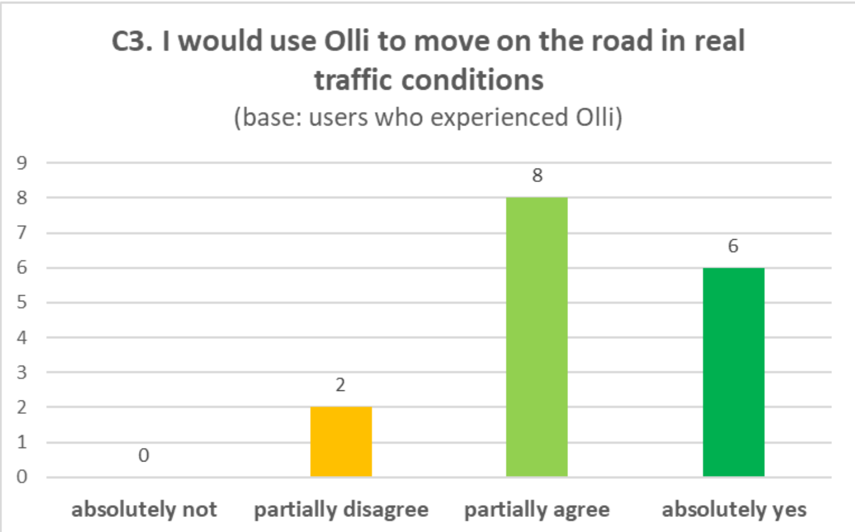


Figure 21. Possible use of Olli in real traffic conditions (base: users who experienced Olli).

To examine possible reasons for being reluctant to use the automated shuttle in mixed traffic conditions, the passengers were also asked about their major concerns in such case (Figure 22). The main indicated issues were safety of vulnerable road users, reliability of technology, possible job losses, and increased cost of public transport. Cybersecurity, data privacy, accessibility of the vehicles and safety of the passengers were of least concern to the respondents.

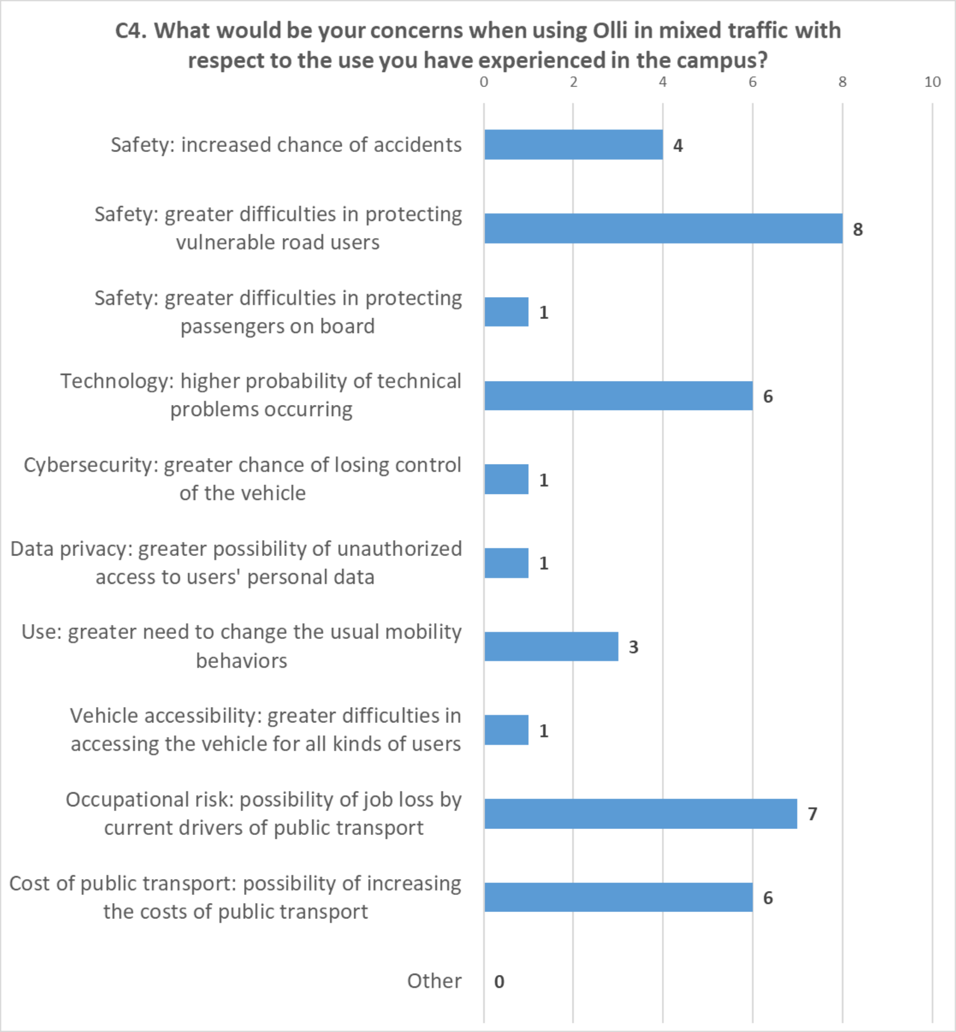


Figure 22: Concerns about the possible use of Olli in real traffic conditions (base: users who already experienced Olli, maximum three answers per respondent).

Out of the people who did not use the shuttle (8 people), the majority declared that the reason for it is because they did not have the opportunity yet (Figure 23). One person declared no interest in the experiment as the reason, and one stated that the service is not useful for his transfers within the campus.

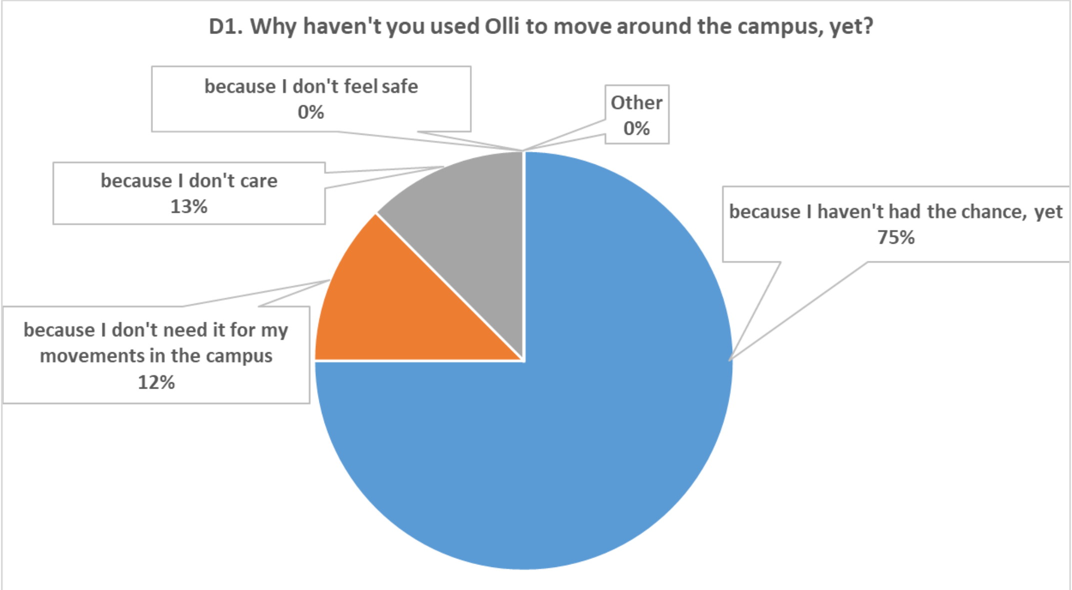


Figure 23: Reasons for not having used Olli (base: people who didn't experience Olli)

These respondents were also asked on their opinions on the specific potential problems with shuttle use. Although the sample is far too small to make any statistically significant observations, it seems that the respondents who did not use the vehicle had more concerns about its operation, in particular regarding safety (Figure 24), with respect to Olli users (Figure 20).

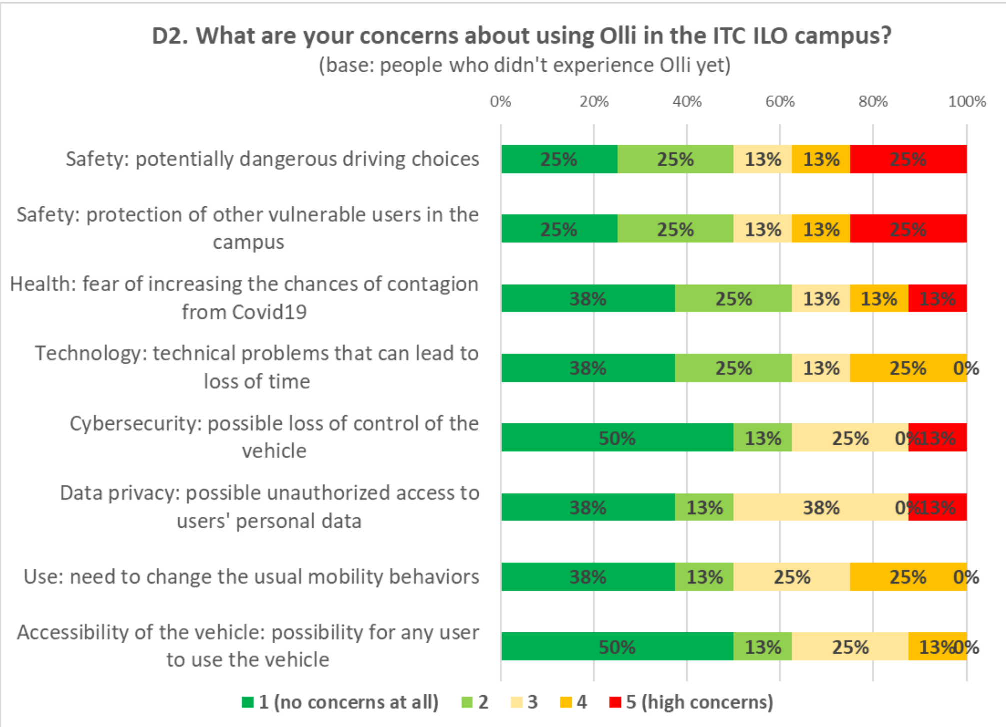


Figure 24: Concerns about the possible use of Olli (base: people who didn't experience Olli).

4.5.1.2 Opinions and expectations about automated driving

In addition to the questions about the Olli shuttle service, all the respondents were also asked on their opinions on automated driving in general (Figure 25). The majority of respondents is not concerned about the use of AVs on public roads in the future, and the highest number of respondents chose the answer in the middle of the scale, which shows that they have at least some concerns. Only one of the respondents declared high concerns.

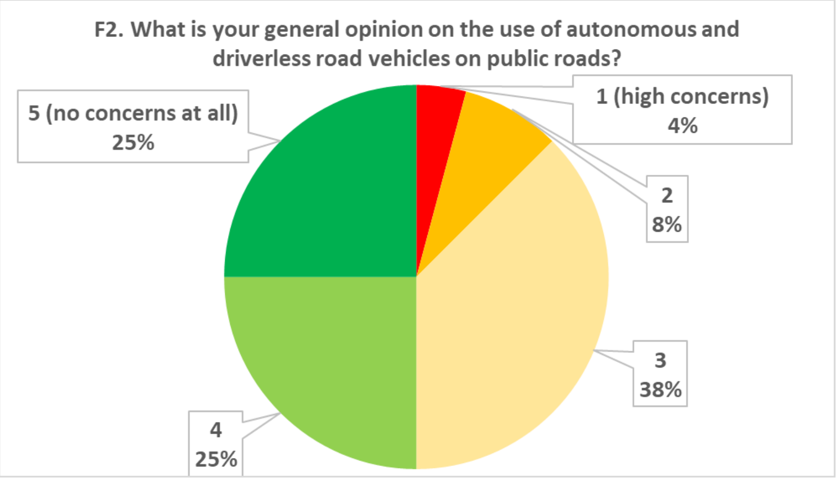


Figure 25: General opinion on the use of AVs in the future (base: all the respondents).

At the same time the majority of participants believe that AVs will be part of daily mobility in the future (Figure 26), regardless of their concerns about their presence on public roads.

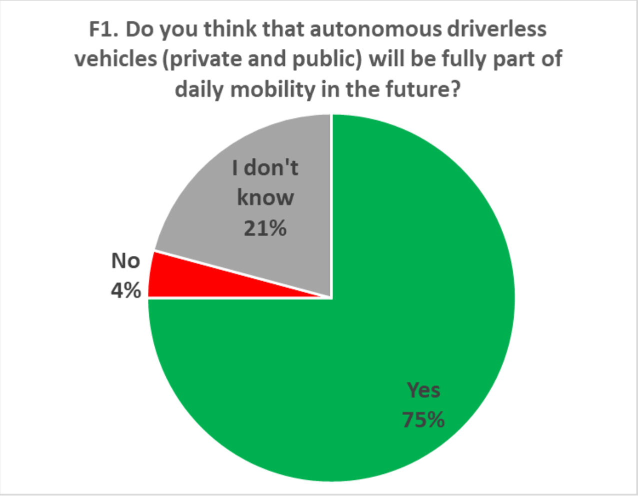


Figure 26: General opinion on the personal safety of AVs users in the future (base: all the respondents).

All the respondents were also asked for which transport applications AVs like Olli could be most useful in the future (Figure 27). Most people see such vehicles as a good solution for congested urban areas. Transport in closed, protected areas was another popular answer, followed by transport of disadvantaged users (e.g. disabled or elderly). The least popular answer was using AVs for mobility in peripheral and rural areas.

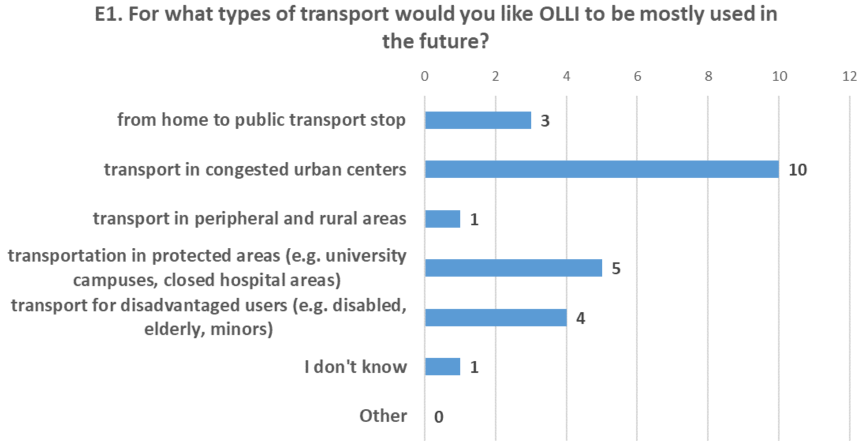


Figure 27: Opinions about the future applications of Olli (base: all the respondents).

The participants were also asked what would be the best way to prevent accidents (Figure 28). Given the three options below, it is clear that the respondents would still prefer to have someone in charge of the vehicle at all times able to monitor the situation, rather than only the possibility of contacting an operator by the passengers in case of emergency. It seems also that there is a preference for a remote operator rather than somebody physically present on board.

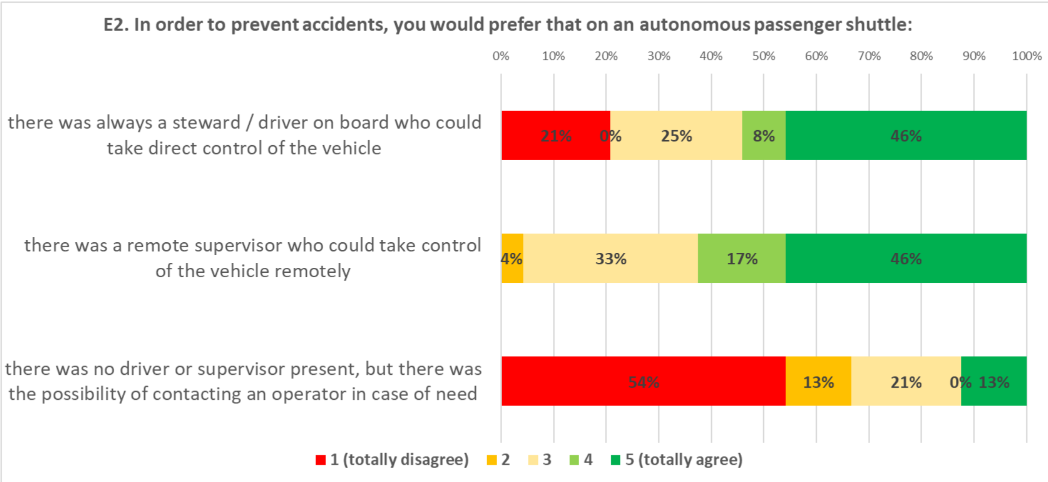


Figure 28: Opinion on the prevention of accidents of AVs in the future (base: all the respondents).

Similar question was also asked to find out what is the preferred way to ensure the safety of the passengers inside the vehicle (Figure 29). Here there was also a preference for an operator available at all times and monitoring the situation on board, although it was less strong than in the case of the previous question. Again, **it seems that a remote operator is slightly more preferred than one present at the vehicle at all times.**

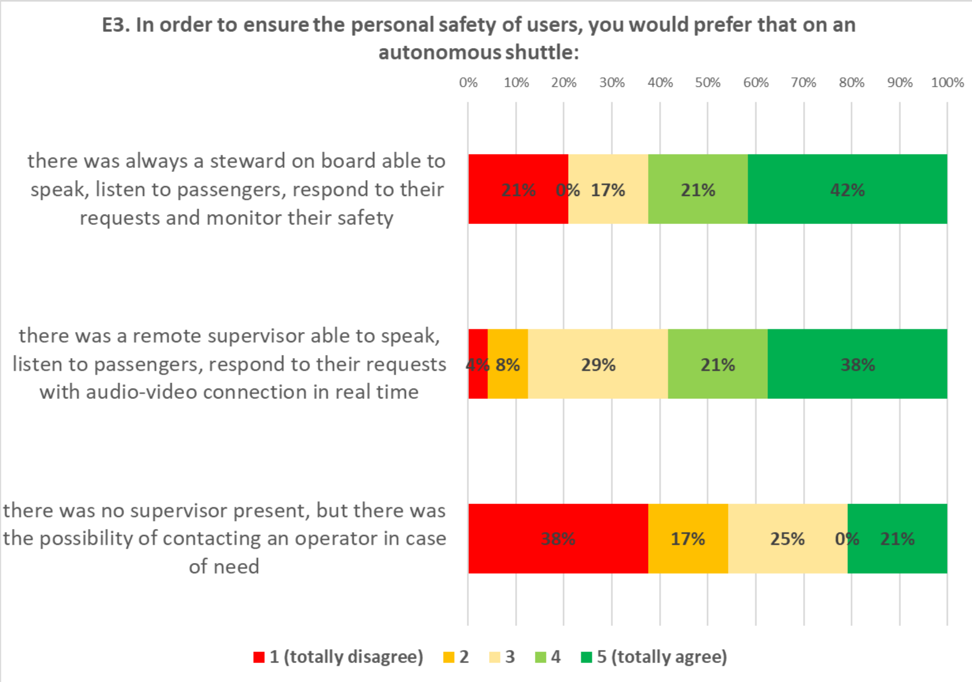


Figure 29: Opinion on the personal safety of AVs users in the future (base: all the respondents).

4.5.2 Assessment of drivers and barriers

The following two tables detail the drivers and barriers to the pre-pilot implementation that emerged during the interview with the ITC-ILO campus contact people. For a further understanding of the first column of these tables (type of drivers and barriers), please refer to the classification introduced in Table 6 and

Table **7.**

Table 8: Drivers of Turin pre-pilot.

Driver field	Description
Political / strategic	The initiative was launched and supported throughout its duration by the Turin City Council's Councilor for Innovation (Paola Pisano, now Minister for Technological Innovation and Digitisation).
Spatial	The nature of the ITC-ILO campus (where pedestrians, cyclists and vehicles are free to circulate) made it possible to test the reaction of the vehicle and stewards even under conditions similar to those of real traffic, still preserving its features of 'protected environment'. The campus was therefore an ideal environment for the implementation of the pre-pilot. Interviewees say that, in post-Covid mode, if Olli rode in a neuralgic city park (such as the Valentino park), the shuttle would probably always be full.
Institutional	The ITC-ILO campus is a closed environment, thus free from the authorisation requirements of the Italian legislature in the case of an autonomous vehicle being put on the public road. This factor has certainly made the implementation more bureaucratically streamlined, speeding up and simplifying the circulation of Olli within the campus.
Cultural	There was a lot of curiosity in the people who came to know Olli: there was a strong desire to experience a strong innovation.
Involvement / communication	There was no need to entice people to try Olli, it's something you don't get to see everywhere. It happened that some citizens of Turin (not users of the campus) came to the campus and - having heard about the

Driver field	Description
	initiative - asked to board on the automated shuttle. Many people even outside of campus knew that an automated shuttle was running in the ITC-ILO. Surely the media campaign around the launch day helped in spreading the news on different channels (press, social, etc.).
Positional	There was great support both from the Municipality and from Torino City Lab, the body that promotes co-development and testing of autonomous mobility services and innovative urban services.
Technological	The new potentials offered by automated vehicle technology constitute a driver for this experimentation. Quoting the interviewee: - "Olli is not a vehicle, but a tablet with wheels" - "Olli is a travelling lab"

Table 9: Barriers of Turin pre-pilot.

Barrier field	Description
Institutional	As detailed in the previous sections, the lockdown period due to the Covid-19 emergency and the subsequent containment actions imposed by the Italian government certainly constituted the main barrier to the use of the automated shuttle. In addition to the total lockdown period (during which no movement was allowed, except for reasons of extreme necessity and during which, therefore, experimentation was suspended), the pandemic also had an impact on the movement of potential Olli users during phases 2 and 3 (relaxation of restrictive measures by Covid-19), with a consequent very low number of responses to the questionnaire on users' acceptance of autonomous mobility. If there had been the usual turnout on campus, Olli would have become a real means of transport. Moreover, the obligation to wear the mask did not encourage the few campus users to board the shuttle.
Technological	Automated vehicle technology is not yet a mature technology: it has often happened during the experimental period that the satellite was disconnected, data unloading has been very cumbersome, and other technological difficulties have led to numerous losses of time (for example, Olli had difficulties in locating the vehicle in certain weather conditions). Quoting the interviewee: "If I had to use everyday a vehicle like this, I would not use it". From a mechanical point of view, the shuttle was a bit abrupt in starting and stopping.
Financial	The cost of Olli's experimentation at the ITC-ILO campus in Turin was very high, as the monthly shuttle operational costs. Such an initiative would not be economically viable in the long term. Action to overcome this barrier: sponsorship.

4.6 Conclusion & lessons learned

The Turin (pre-)pre pilot, being the very first pilot that took place in SHOW project, constitutes as a whole a pool for lessons learned that were conveyed to the rest test sites of the project to guide them for their own trials. The key conclusions and lessons learned are summarised below.

4.6.1 Users' acceptance in Turin (pre)pre-pilot

People who used the Olli shuttle had in general positive opinion about the experience (average score: 4.3 on 5), and expressed willingness to try such service in real traffic conditions (87.5%). In general, the attitude towards autonomous driving is rather positive. People with no or few concerns prevail, however there is still a considerable share having at least some concerns. It seems however that they are still open to the technology, as the majority (75%) believes that it will still be a part of our daily lives in the future.

Main concerns are safety of vulnerable road users and reliability of the technology. Due to these issues, the majority still believes that a supervisor should be available in the vehicle at all times, either in person or via immediate audio-video connection. Other frequently mentioned fears are the possibility of job losses due to automation and increase of public transport cost.

Among the possible applications, the most attractive seems to be mobility in congested city centres (41.7%). Quite some respondents (20.8%) also see the advantage of using automated shuttle in closed areas, similar to the one in the experiment.

4.6.2 Drivers and barriers of SHOW Turin (pre)pre-pilot

The implementation of the Turin pre-pilot was facilitated by a series of **drivers that can serve as a gained know-how for later pilots in SHOW and beyond**. The main factor that facilitated the implementation was of a **political** nature: the initiative had the full support of the Municipality of Turin from the very beginning, with a substantial involvement of the Department for Digital Innovation and Torino City Lab. Another very important driver was **communication**: the media campaign around Olli attracted potential users with great interest and curiosity, so much that people were eager to get on board to experience this great innovation. Last but not least, other factors that positively influenced the implementation of the experimentation were **spatial** and **institutional**: the ITC-ILO campus is a closed environment, thus free from the authorisation requirements of the Italian legislature in the case of an autonomous vehicle being put on the public road. This factor has certainly made the implementation more bureaucratically streamlined, speeding up and simplifying the circulation of Olli within the campus. At the same time, the nature of the ITC-ILO campus (where pedestrians, cyclists and vehicles are free to circulate) made it possible to test the reaction of the vehicle and stewards even under conditions similar to those of real traffic. The campus was therefore an ideal environment for the pre-pilot experimentation.

As repeated several times in this report, the main **barrier** to implementation was the arrival of the **Covid-19 pandemic** and the consequent restrictive measures adopted by the Italian government. In addition to the total lockdown period (during which no movement was allowed, except for reasons of extreme necessity and during which, therefore, experimentation was suspended), the pandemic also had an impact on the movement of potential Olli users during phases 2 and 3 (relaxation of restrictive measures by Covid-19), with a consequent very low number of responses to the questionnaire on users' acceptance of autonomous mobility. The resumption of the experimentation was only successful thanks to the outstanding commitment of ITC-ILO and the other stakeholders involved in the initiative (first of all Local Motors and Reale Mutua), which allowed the vehicle to continue to circulate on campus even beyond the period initially planned. Stakeholder involvement has been a key element in overcoming another type of barrier: the **financial** one. In fact, the cost of the Turin pre-pilot would have been too high to be carried only by the ITC-ILO campus. If the monthly shuttle operational costs are added to this, the initiative would not be economically viable in the long term. Only thanks to the sponsorships established with some of the involved stakeholders it was possible to implement the initiative. Another barrier to implementation has been **technological**: automated vehicles technology is at the forefront, but not yet mature. There have been numerous technical unforeseen events during the experimentation (e.g. disconnected satellite, complexity of data unloading, difficulties in locating the vehicle in adverse weather conditions), which have led to numerous time losses. It is likely that, as technological maturity progresses, this barrier will be definitely broken down.

4.6.3 Lessons learned of SHOW Turin (pre)pre-pilot

The analysis of drivers and barriers led to some 'lessons learned' as listed below:

- **Technological aspects**. "Olli is not a vehicle with driver assistance systems, it is a computer system mounted on wheels" (quot. interviewee). The mechanical component is in fact quite simple and the manual operation proves it. **Autonomous driving**, on the other hand, **requires continuous connectivity with remote systems and considerable processing power on board the vehicle**. All the elements of this 'travelling ICT system' are present and tested, their smooth operation to govern a self-propelled vehicle is sometimes critical. Local Motors' remote assistance is effective. In general, it seems that the distance between the autonomy level of the prototype (level 4 - man on board) and the next one (level 5 - totally remote control) is still considerable.
- **Future of work**. The steward's "job" has very little to do with that of a traditional driver. Apart from a certain aptitude for manual driving using a joystick instead of a steering wheel, the vehicle is mechanically 'simple'. The real skills, on the other hand, are of an IT type, linked to start-up procedures, continuous verification of the alignment of the various processing and telecommunications systems, restart procedures in the event of unexpected events, and data backup at the end of service (quoting the interviewee: "Driving an autonomous shuttle is an 'engineering' profession"). Given the mission of the ITC-ILO Campus, this aspect has proved to be particularly significant, **a concrete example of how technology can require greater professionalization of profiles without necessarily having a devastating impact on employment as a whole**.
- **Community reaction**. In general, community reaction has been extremely positive, mixed with curiosity and interest in the potential of the autonomous technology. It must obviously be taken into account that the campus community, both officials and guests, has a rather high average level of professionalism and training. However, after a few days the presence of Olli in the internal routes has been completely metabolized and the behaviour of the other "road users" (pedestrians, bikes, vehicles) has taken this into account. In this phase, particular attention was paid to safety, so Olli tends to react a bit abruptly when suddenly faced with an obstacle.

5 Brainport test site (satellite)

5.1 Introduction

This section reports the results of the test trials that were conducted for Brainport site on the 11th of November 2021 in the controlled environment at the Aldenhoven Test Centre (proving ground) in Germany with **12 test users**. The Brainport site will follow-up with an operational phase that will be conducted in 2023 and will serve to exploit the technologies tested and the lessons learned acquired in this first pre-demo phase.

5.2 General

5.2.1 The ecosystem

The **only entity that has participated in the pre-demo phase of the Brainport site is TNO**, which has been responsible for the system development, integration, testing and demonstration that was held. Apart from TNO there are no further entities involved in the operation of the demonstration at the Brainport since the activities at that phase have focused on demonstrations at a test track.

For the operational phase that will follow in Spring 2023, a complete ecosystem formulation is underway.

5.2.2 The setting

First pilots have been conducted with users at a test track as depicted in Figure 30 where recruited passengers have experienced different scenarios of automated driving that represent target deployment of automated driving on bus lanes in Brainport.

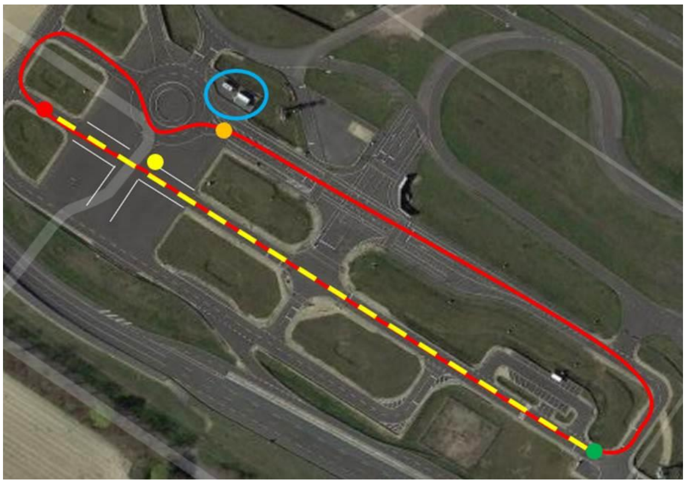


Figure 30: Pilot route of Brainport pre-demo phase.

An overview of the environmental conditions is summarized in the table below.

Table 10: Environmental conditions of pre-demo pilots in Brainport.

Variable Name	Brainport pre-demo conditions
Weather	Road: Dry Weather: Clear (Sun)
Sight conditions	Clear, Glare depending on time-of-day
Road type	2 lane urban road, max 50kph, 2 intersection configurations
Road works	Proving ground
Incidents	0

Variable Name	Brainport pre-demo conditions
Traffic conditions	Controlled environment, including intersections
Traffic composition	Pilots included VRUs intersection crossing.
Traffic control	Pilots included GLOSA – controlled intersection crossing.

5.2.3 Field trials operation timing

Field operational trial (FOT) for in-depth user assessment was carried out on the 11th November 2021 at the Aldenhoven Test Centre (proving ground) in Germany, which was accompanied by a press release on the SHOW project website[i].

5.2.4 The Fleet

Two out of the three TNO Carlab vehicles were used in the pre-demo, all Renault Scenic, that provide SAE Level 4 automated driving functionality. The functionality for crossing intersections has been extended with C-ITS services in the SHOW project. The vehicles are depicted in the following figure.

Figure 31: Vehicles used in Brainport pre-demo phase.

Table 11: Brainport vehicle demonstrators' characteristics.

Test/ Use Case [ID as of D1.2])	Deployed fleet characteristics								
	Vehicle brand & model	Vehicle type	SAE Level reached for the field trials [1-5]	TRL level reached for the field trials [1-9]	Summary of upgrades held during the project (in consistency with D7.1, D7.3 & D7.4)	HMI and Hand-over strategies (in consistency with D7.2)	Maximum speed reached during the trials (km/h)	Average speed during the trials (km/h)	Maximum capacity of vehicle (nr of passengers)
UC1.1; 1.3; 1.8	Renault Scenic	Passenger vehicle	4	6	Implementation of C-ITS services for VRU warning and GLOSA functionalities	N.A.	50	38.16	4

5.2.5 The Infrastructure

The user tests were carried out at the Aldenhoven Test Centre in Germany. At the yellow dot of the Figure 32, an intersection setup has been created with road barriers and a Road Side Unit (RSU). The scenario was controlled, in order to compare and cross validate the user assessment of the developed automated intersection crossing functionalities. For the in-depth user assessment, scenarios have been generated for GLOSA and presence of VRU's provided by CPM.

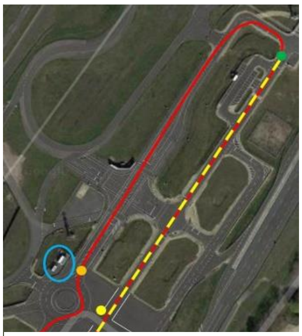


Figure 32: Schematic overview of the Aldenhoven Proving Ground.

The vehicles are equipped with a communication platform supporting ITS-G5, C-V2x and 4G/5G. In the current setup ITS-G5 is used for V2I intersection services (GLOSA and Signal Violation Warning), as well as for V2V vehicle functions (Cooperative Automated Cruise Control).

5.2.6 Users & Stakeholders

5.2.6.1 Passengers and stakeholders in the loop

A priori surveys during the pre-demonstration phase have been carried out during the user tests. During the pre-demonstration phase, the intended/expected users have been invited on an individual basis. In total **12 users** - TNO employees, family and friends, as well as a JRC delegation- joined the pre-demonstration phase. The end-users participating in the trials in Brainport were recruited by TNO and the safety drivers of the vehicles also originated from TNO.

Joining AD vehicles during the pre-demonstration has been free of charge. During the user tests, the focus was on the user acceptance and in-depth assessment of the automated driving functionalities. Each of the two vehicles involved in the pre-demo had one safety driver; thus two safety drivers participated in total.

5.2.6.2 Local campaign and strategies for awareness, recruitment & engagement

Due to the nature of the trials, no campaigns were organized during the pre-demo phase.

5.2.7 Business Models

Due to the nature of the user testing at a closed test track environment, no business models are applicable.

5.3 Preparatory Process

5.3.1 Permits

Permits were not required for the current Brainport activities in the SHOW project since the demonstrations were executed at a closed track.

5.3.2 Development / Customisation / Integration

All of the Brainport SHOW use cases have been realized using internally development actions. This includes developments and modifications to the Road Side Units involved as well as adaptations to TNO Carlab vehicles (which haveretrofit AD hardware and software from earlier projects) by adding functionality for C-ITS services which was done in the context of the SHOW project.

Hard and software have been tested separately and integrated in several steps from development to in-vehicle integration in earlier projects. For the added SHOW functionality first extensive simulation studies and unit tests have been performed, followed by integration tests including communication hardware components in a desk setup (Hardware in the Loop (HIL)). Finally the full software stack has been deployed on the TNO test vehicles to enable the new functionalities.

5.3.3 Training

The safety drivers involved in the Brainport test site have gone through a procedure internal to TNO which enables them to drive the vehicle demonstrators with the added functionality. During this training, safety drivers have been trained in detecting and mitigating vehicle malfunctioning. This includes, but is not limited to, driving with automated functionalities and carrying out take-overs from system to safety driver. This training is maintained up-to-date within the internal procedure.

Prior to the trials, safety drivers are informed and/or reminded of the intended behavior of the vehicle functionalities of the specific demonstrator as well as any applicable functional updates that were realized since last testing/demonstration event. Secondly they are also made aware of any safety procedures that are specific for the driving environment.

5.3.4 Ethics & GDPR

According to TNO's internal policies, a quick scan was carried out checking the need for a DPIA considering the currently foreseen activities in the Brainport. Outcome of this scan is that currently no DPIA is required, due to the nature of the field trials planned by TNO. These activities have been checked and accepted by a TNO internal review committee for GDPR compliance. TNO has been confirming and signing the ethics checklist of the project and asked for informed consent form from the recruited participants (D3.5).

5.3.5 Other

Since March 2020, TNO has maintained a regularly updated protocol regarding regulations and practicalities in the context of COVID19. Among others, this protocol contains a specific appendix regarding supplementary guidelines for work where 1.5 meters distance cannot be maintained. This allowed for continuation of most development and testing work in a safe manner. The participants of demonstration were fully informed of the COVID19 safety procedures, and it was made sure that the participant complied to the requirements of wearing face masks during the demonstrations.

5.4 Pre-demonstration study design

5.4.1 Test Scenarios

5.4.1.1 Use Cases – Test Cases

The specific test cases evaluated in Brainport are as follows:

- **Intersection crossing at normal operational speed/ GLOSA (responding to UC1.1)**
  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 automated vehicle will handle preceding traffic, will pass through intersections and for that it will be capable of handling information that comes from traffic lights. The vehicle adjusts the speed in response to C-ITS services for traffic light status.

- **Safety for VRU at intersections (responding to UC1.3)**
  The vehicle will handle preceding traffic and will pass through intersections on a route. Specifically for this use case it is considered that VRU can violate the traffic light at intersections. The vehicle will be capable to react to that by reducing its speed to ensure sufficient safety levels (via the receipt of a C-ITS message).

- **Vehicle relocation for automated mobility using platooning (responding to UC1.8)**
  At a bus stop or predefined point, empty automated vehicles will form a platoon. The leader of the platoon is a vehicle driven by a human. The platoon of vehicles will drive to a predefined destination, crossing an intersection. The platoon assembly will adjust to situations at intersections (e.g. traffic light status and VRU) that it is crossing.

The relevant research hypotheses addressed for Brainport are discussed in section 5.5.3.

5.4.1.2 Mobility services & apps

Due to the nature of the user testing at a closed test track environment, no mobility services and apps were applicable.

5.4.2 Evaluation methods & data collection tools

During the pre-demonstration phase, loggings were recorded using ROS as middleware platform. Loggings have been converted to depict the KPI applicable to the test site, which have consequently been shared with the SHOW Data Management Team to external sharing and reporting (see section 11). Along with the vehicle dynamic data recorded during the pre-demonstration phase and the SHOW pre-defined questionnaires on user acceptance and satisfaction (see section 2), a set of more elaborate questionnaires focusing on specific aspects of the functionalities addressing the specific Brainport test cases have been answered in addition in the testing procedure of Brainport.

5.4.3 Experimental process

The developed functionalities have been subject to several test cases for the different use cases. The user tests were carried out at the Aldenhoven Test Centre in Germany. The scenario is controlled, in order to compare and cross validate the user assessment of the developed automated intersection crossing functionalities. The 12 users were split into 3 groups of 4. Every group of 4 is consequently split into 2 groups of 2, such that 2 users undergo the same test, at the same moment in time. This results into a total of 6 pairs of users undergoing a test. 25 minutes were devoted to each passenger testing each (applicable) variants of test cases. After every test case, the users answered the SHOW subjective forms and a more specific questionnaire that reflected their assessment of the automated driving functionalities (see section 5.5).

The test cases were carried out at an initial velocity of 50 km/h. The test-cases for the different use-cases are detailed below:

- **Intersection crossing at normal operational speed** (UC1.1). Here the vehicle is considered to be approaching a signalized intersection, where the phase of the traffic light initially is green. The traffic light system is programmed to initiate phase changes to yellow when the vehicle is at a specific distance away from the intersection followed by the Red phase, 3 [s] thereafter. For this use case, 3 different test cases are defined.

    - Far away, phase yellow at 120 [m] and then red, an approach of a red traffic light far away.
    - Close; phase yellow at 50 [m] and then red, just in time for stopping at the red traffic light
    - Too Close; phase yellow at 20 [m] and then red, too late to stop for a red light
- **Safety for VRU at intersections** (UC1.3). Here the vehicle is considered to be approaching a signalized intersection, where the phase of the traffic light is green continuously. When the vehicle is 80 [m] away from the intersection a Collaborative Perception Message (CPM) is received from the Road Side Unit (RSU), indicating the presence of a VRU (represented by a dummy) that may be violating its' red phase. For this use case, 2 different test cases are defined:
    - VRU next to the road (Temporal); The VRU red light violation will be active for 4 [s] from 80 [m]
    - VRU on the road (Persistent); The VRU red light violation will be active continuously through the test case from 80 [m]
- **Vehicle relocation for automated mobility using platooning** (UC1.8). Herein, the test cases are defined as the joined set of test cases detailed for UC1.1 and UC1.3, but driven with 2 platooning vehicles, instead of using single vehicle automation. Note that this functionality is intended for relocation of vehicles without any passengers in the vehicle since the objective is relocation of empty vehicles.

All test cases have been run successfully at least 10 times each.

5.5 Pre-demo phase field trials results

The developed functionalities, for all use-cases involved, **focus basically on automated intersection crossing**. Therefore, the assessment of performance and user acceptance of the different use and test-cases is grouped. As the functionalities are designed to display similar in similar situations, also feedback on the acceptance of particular vehicle behavior is applicable and comparable between the different use cases.

5.5.1 Overall performance results

The test cases that have been carried out during the pre-demonstration phase, have been carried out successfully and without failure. The communication with the roadside and other vehicles involved in the use-cases worked properly and communicated data could be exploited to the full extent. See overview of performance results across the key project KPIs in section 11.

5.5.2 User and stakeholder acceptance

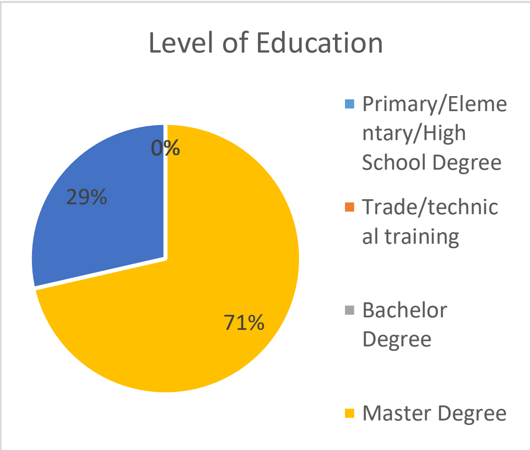
5.5.2.1 End-users results upon SHOW evaluation protocols

Demographics

The sample was relatively small, with 7 completed responses in Netigate tool (out of the 12 in total). It mainly consists of men (86%), with a mean age of 33, a median of 34 and a standard deviation of 4.89. The oldest respondent is 42, while the youngest is 28. Education levels are mostly high, with all respondents having at least a master's degree (71% have a master's degree, 29% a PhD). The geographical distribution of participants is largely focused in urban areas (71%).

Table 12: Distribution of age in Brainport.

Descriptive data	
Mean response	33.29
Standard deviation	4.89
Median	34.00
Minimum	28
Maximum	42
Number of responses	7



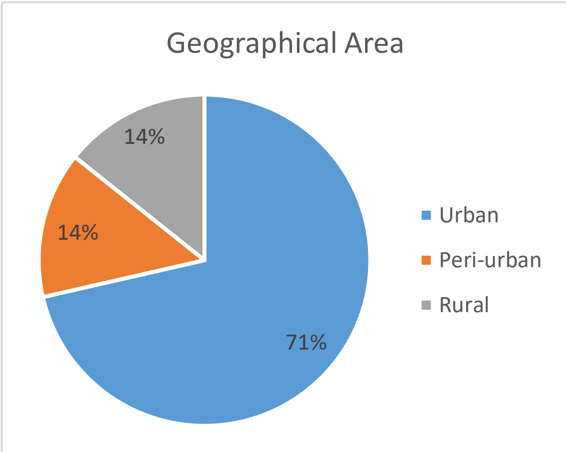


Figure 33: Distribution of the level of education and geographical area origin of respondents in Brainport.

User Acceptance Results

The mean acceptance score is high in the sample (8.01), with a low standard deviation (0.73). This high acceptance is reflected in all the specific metrics of the following table, as no score lower than 6 has been given, and the average scores for each are between 7.5 and 8.

Table 13: Descriptive data of acceptance components of the test cases in Brainport [9-point Likert scale].

Descriptive data	Mean response	Standard deviation	Median	Minimum	Maximum	Number of responses
Satisfaction	8.00	0.82	8.00	7	9	7
Usefulness	8.29	0.49	8.00	8	9	7
Ease of use	8.14	0.69	8.00	7	9	7
Ease of learning	8.00	0.58	8.00	7	9	7
Reliability	7.86	0.69	8.00	7	9	7
Safety	8.57	0.53	9.00	8	9	7
Adequacy	7.43	0.79	8.00	6	8	7
Comfort	7.43	0.98	7.00	6	9	7
Intention to re-use	8.29	0.76	8.00	7	9	7

Descriptive data	Mean response	Standard deviation	Median	Minimum	Maximum	Number of responses
Recommendation Intention	8.14	0.38	8.00	8	9	7

Starting with satisfaction, the mean score is quite high (8) and the range of scores is between 7 and 9. The mean scores are not compared by gender as only one woman filled out the survey completely. **Respondents coming from peri-urban areas give the highest mean score (8) compared to those in urban (7.4) and rural areas (7).** Usefulness, safety, and intention to re-use are scored even higher on average (8.29, 8.57, and 8.29), and we see a similar patter with respondents in peri-urban areas giving the highest scores on average compared to urban and rural areas.

Overall, **we do not see a significant association between the level of education and the average scores**, as the scores are nearly identical or at least comparable for respondents with master's degrees and those with a PhD. Indeed, this is observed with satisfaction (8 and 8 respectively), usefulness (8.4 and 8), ease of learning (8 and 8), safety (8.6 and 8.5), intention to re-use (8.3 and 8) and recommendation intention (8.2 and 8.5). The **most significant difference is seen with adequacy**, with master's degree holders giving a significantly lower score (7.2) than PhD holders (8).

5.5.2.2 End-users results upon additional surveys dedicated to Brainport

In addition to the protocoled SHOW survey, a survey was done during the test program (in between test runs) and in a debriefing session after all the tests were completed.

The user feedback for GLOSA test case (UC 1.1) is summarised in several figures below. Figure 34 provides the feedback on the timing of braking for when the vehicle is approaching a far away traffic light signalling red, and secondly for when the light changes to yellow and red when the vehicle is close. The test users could indicate if the braking was timely ranging from too early to too late. Each scenario was run twice and the results from the first and second run are shown to assess how users may adapt to the vehicle driving and scenario. The most consistent result is that for approaching traffic light that is changing to yellow and red at a close distance, more users indicate that the vehicle is braking too early in the second run. This could indicate that the users in a second run feel more confident if the vehicle stops timely.

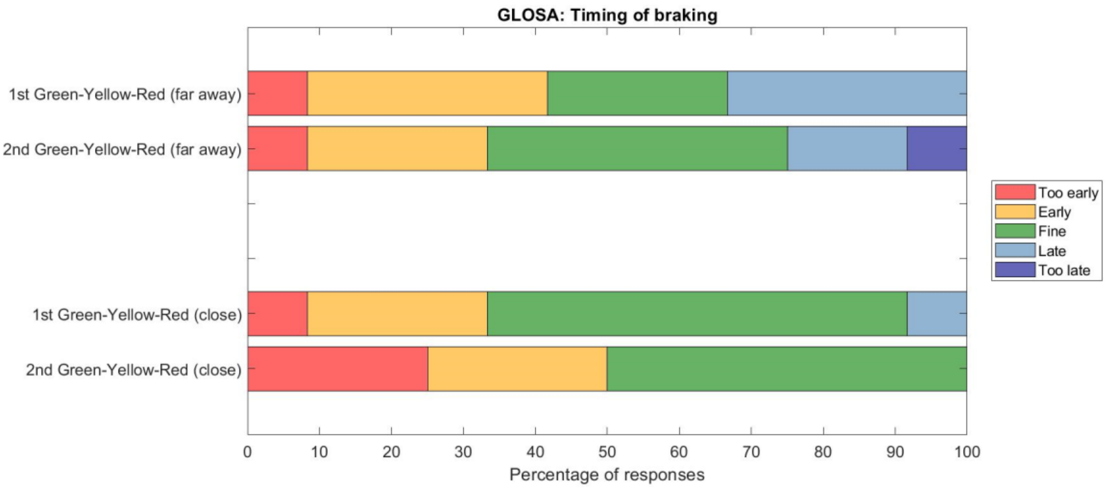


Figure 34: User feedback on timing of braking in a GLOSA scenario.

The feedback on the level of braking is indicated in Figure 35. For the “close” scenario to users indicate that the vehicle is braking harsher than usual. This is however unavoidable (and also happens with manual driving) since otherwise the vehicle will not stop before the traffic light.

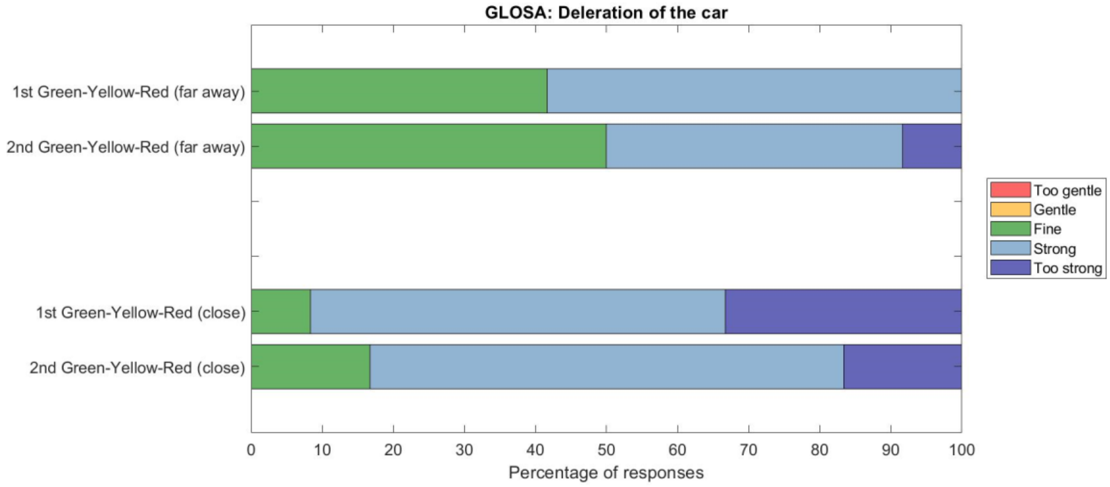


Figure 35: User feedback on the level of braking in a GLOSA scenario

The user feedback on safety perception is shown in Figure 36. A third scenario is displayed, which is when the traffic light switches too yellow when the vehicle is too close for braking. Then the vehicle will pass the traffic light when it is still yellow. The far majority of test users did not feel unsafe. Generally there are more users who feel safe (green bar) in the second run (top 3 lines) compare to the first run (bottom 3 lines), which again could indicate that they develop more confidence in the automated driving behaviour.

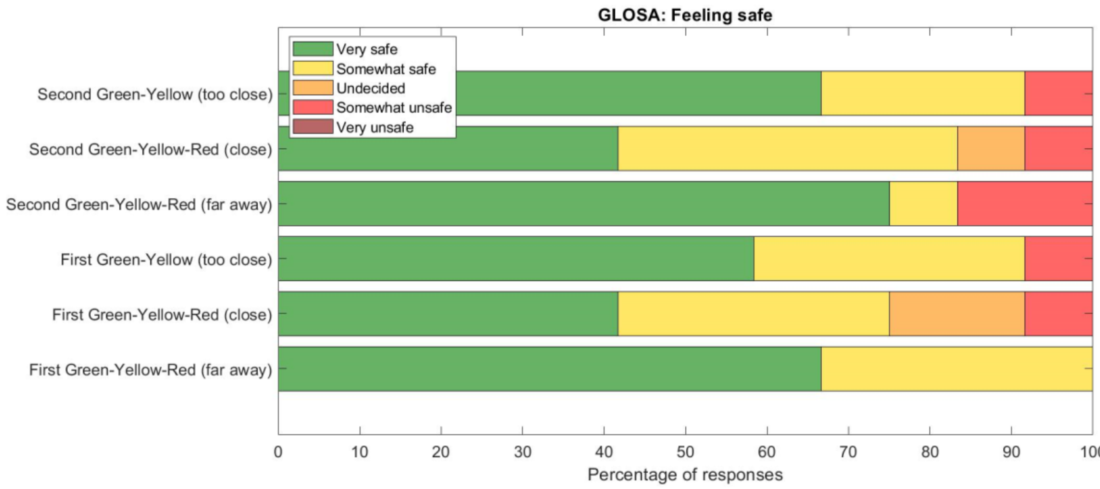


Figure 36: User feedback on safety perception in GLOSA scenario

The second use case concerns the vehicle acting on the presence of a VRU (represented by a test dummy) at the intersection (UC1.3). The presence of VRU is indicated by a C-ITS message, with a clear indication of its’ exact position on the road. A summary of the user feedback is provided in the figures below. Figure 37 indicates the timing of braking for the VRU scenarios. Note that each of the VRU scenarios (VRU on the road, VRU next to the road) has been repeated three times. When the VRU is on the road the vehicle needs to stop, while when the VRU is next to the road the speed is reduced until it is confirmed that the VRU is not on the road. Most clearly it can be seen that in repeated tests with the VRU next to the road (and the vehicle slows down but not to standstill), the users indicate that the vehicle is braking too early. It is assumed that their prior knowledge that the VRU will stay next to the road (and not moving in front of the vehicle) makes the users feel that braking (or too much braking) is not needed.

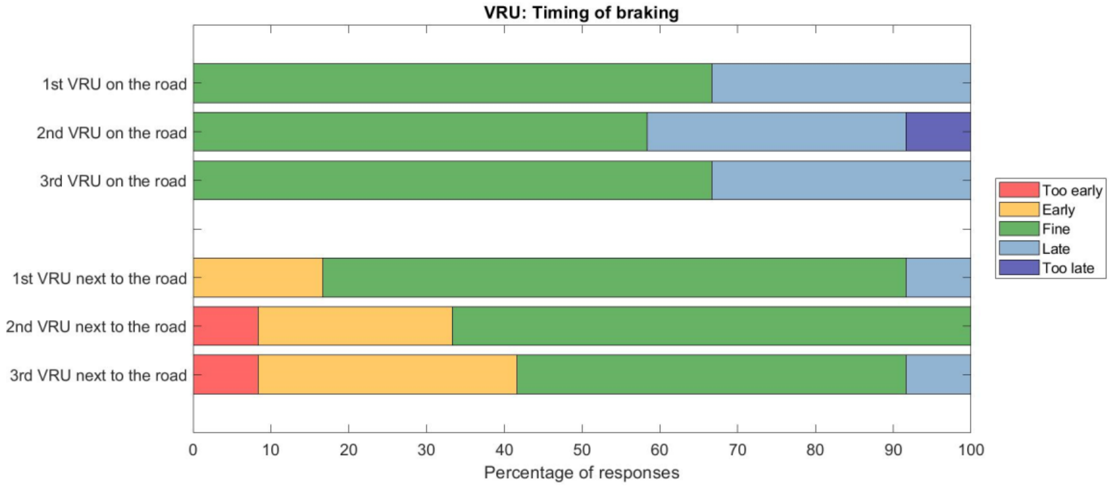


Figure 37: User feedback on timing of braking for VRU scenarios.

Figure 38 shows the user feedback on the decision of having braking for the different scenarios. When the VRU is on the road all users understand that braking is required for the most test runs. It may be that the scenario for some of them was not clear in some test runs with the test dummy VRU, however we can assume that when a real person is on the road this would not be the case. With the VRU next to the road it is clear that a significant share of the users do not fully agree that the vehicle should brake. But again, that may be since they have experienced that the VRU (dummy) will not get more onto the road.

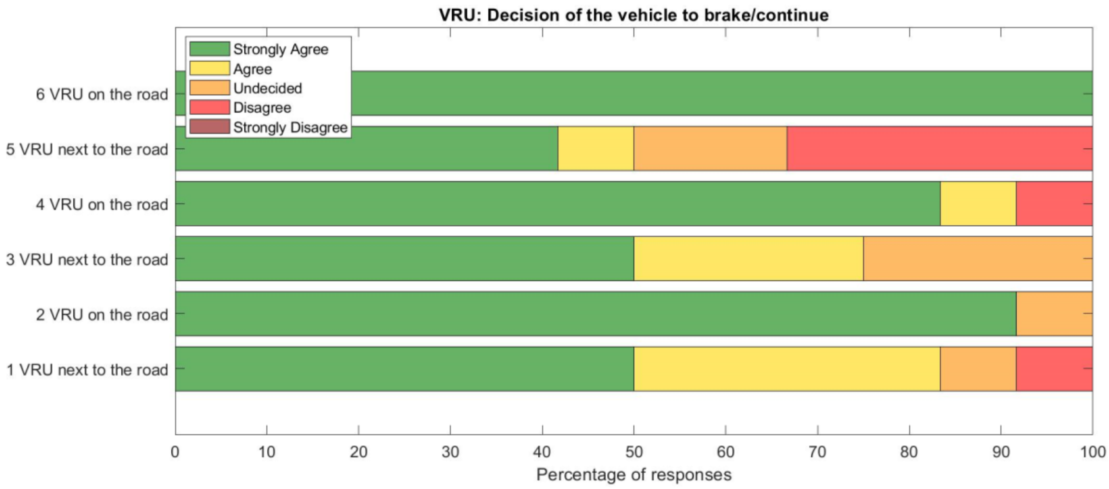


Figure 38: User feedback on the decision of braking for VRU scenarios.

The user feedback on the braking level of the vehicle is summarized in Figure 39. Generally users seem to agree to the way of braking of the vehicle (although a bit too stronger for some, but required to stop for the dummy).

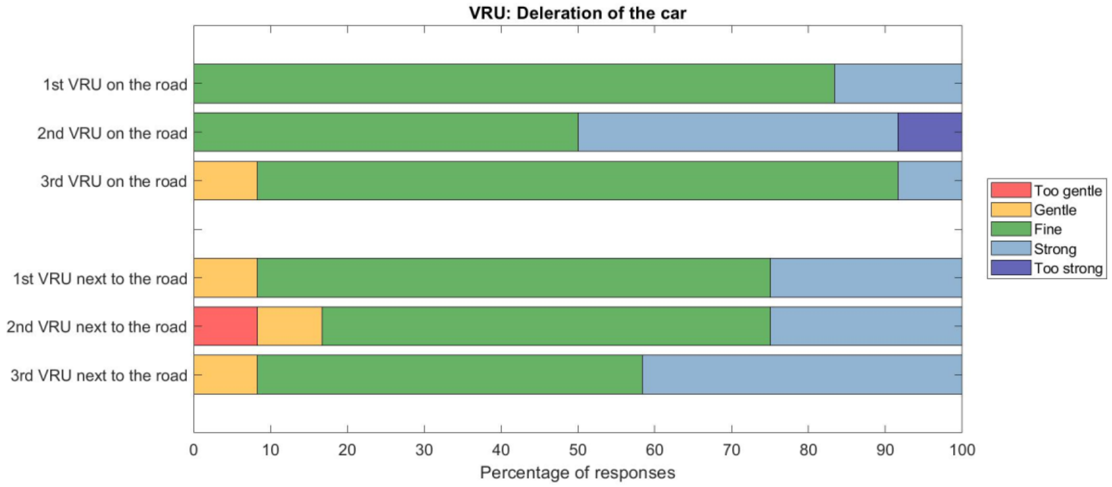


Figure 39: User feedback on the braking level for VRU scenarios

In the debriefing session that followed after the tests the following additional, case-specific questions were posed to the participants.

1. Did you experience the behavior of the car as natural?
2. Did you feel the urge to take over control of the car?
3. How did you experience the car in terms of safety?
4. What is your overall experience of the car?

A summary of key feedback across the above is provided below.

General Behaviour assessment

In general, the functionalities were accepted by the users of the vehicles. User feedback consists of phrases such as: “In general, I experienced the car as natural.” and “Most of the time the behavior looked similar to a human”. In particular a user pointed out that for UC1.1, “braking comes well anticipated. Not stopping for amber halfway the crossing”.

Acceptance regarding safety related aspects

None of the users reported to feel the urge to take over control. Specific users reported among others that they “trust situations could be managed by the car” and “operations always seemed very safe”. Finally a user reported to judge the vehicle to be “Safe because the intentions were in line with mine”.

Some of the users reported, the braking of the vehicle to be a bit too strong in the low velocity regions: “…, sometimes (slightly) too strong braking.” **Although in general the braking of the vehicle (during the majority of the manoeuvre) was accepted to be fine, the last stage of braking (from 10 km/h to standstill) could be further improved.**

Even though the test cases were carried out at a velocity of 50 km/h, which exceeds the general operational speed of e.g. an automated shuttle in urban contexts, some users reported to feel to be safe in all situations “.., also because the speed is not so high”. We can assume this to be influenced by the safety driver positioned behind the steering wheel, which might make the users feel more at ease during the different test cases, compared to when the same test case would be driven completely without driver behind the wheel (e.g. by remote operation). Or, of course, the fact that users were experiencing this in a controlled context without external triggers. In general, we can conclude that the speed setting was appropriate for the driving environment.

Overall experience

Although some users reported that the vehicle takes more precautionary actions in situations where a human driver (e.g. due to experience) would not do so (anymore) "I felt all time the car did a safety job especially at moments I did not see any danger". In general the users seem to accept the vehicle functionalities, and in some cases even especially appreciate the precautionary actions of the vehicle functionalities; "The braking pattern and the moment of braking creates the feeling of safe and naturality".

5.5.3 Research Questions answered for the site

Table 14: Brainport pre-demo response to SHOW research hypotheses and Use Cases.

Research Questions addressed	Relevant Use cases	Overall response
How will road safety, traffic efficiency, mobility, and user acceptance be affected by AV operation (passenger or cargo) in a real city environment when operated in normal speeds, normal/smooth traffic context, without any traffic or other environmental complexity? Also, interfacing to any of the following modes: PT, DRT, MaaS and LaaS.	UC1.1: Automated passengers/cargo mobility in Cities under normal traffic & environmental conditions – **Brainport specific: Intersection crossing at normal operational speed**	In general user feedback on the Brainport functions shows acceptance of the functionalities for automated intersection crossing. Still scenarios and test cases could be extended to generate more safety critical test cases in a safe way.
How will road safety, traffic efficiency, mobility, and user acceptance be affected by AV operation (passenger or cargo) in a real city environment when interacting with not automated (not connected) vehicles and/or VRUs?	UC1.3: Interfacing non automated vehicles and travellers (including VRUs) - **Brainport specific: Safety for VRU at intersections**	In general user feedback on the Brainport functions shows acceptance of the functionalities for automated intersection crossing in close proximity of VRU's. As the current work focused on acceptance of passengers of automated driving vehicles, future work could focus on the external acceptance (e.g. by other road users (including VRU's)) of the AV behaviour in their close proximity.
Can platooning of passenger transport at higher speeds contribute to improved traffic efficiency, energy consumption and environmental impact of transport?	UC1.8: Platooning for higher speed connectors in people transport - **Brainport specific: Vehicle relocation for automated mobility using platooning**	In general, several indicators show further increase of safety and traffic throughput when deploying vehicle platooning. Although, the goal for using platooning in the Brainport area is mainly focusing on vehicle relocation, specific traffic flow improvements might result from stimulation studies in WP10. No users were involved since the objective is to relocate unmanned vehicles.

Nevertheless, it should be noted that all the above are only preliminary findings referring to a controlled environment that should be re-verified in real traffic.

5.6 Lessons learned - recommendations

As mentioned again, the user testing was carried out on the Aldenhoven Test Center. This allowed the functionalities to be tested and assessed in a controlled environment. Regarding related activities, a non-exhaustive itemized list is depicted below;

- Users seem to accept the comfort and safety in the general operation of the vehicle, however the system may need to be optimized for specific scenarios in relation to presence of VRUs and traffic lights.
- Inviting users on a closed test track allows for in-depth assessment of vehicle functionalities by preparing questionnaires tailored to the functionalities. Although this is not the focal point of SHOW evaluation, it has offered benefits, especially when technological solutions are research-wise and of not commercial readiness as it was in the case of Brainport (and TNO).
- The presence of a safety driver (especially behind the steering wheel) is expected to affect the safety perception of passengers.
- Passengers are noticing effects in the performance of the automated driving system that can relate to comfort aspects, or (tactical) decision making of the vehicle for specific scenarios. It is recommended to optimise the driving pattern of the vehicles, both regarding operational control as well as tactical control in relation to critical scenarios of operation.
- Tests with a static dummy VRU may not be representative for user assessment. It is recommended to have a moving VRU (dummy or real person) in this type of tests.

5.7 Conclusion

Table 15: Brainport readiness level towards final pilots.

Readiness level towards final evaluation round of SHOW				
1 - Not ready at all – A lot to do more	**2 – Not ready – Significant corrections/development/integration and optimisation is still required**	**3 – Half ready; good basis but a series of additional development/integration and optimisation is still required**	**4 – Quite ready to go – several optimisations are still required**	**5 – Almost ready to go – only minor optimisation is required**
				x
Ranking justification – what needs to be done in short	Test cases were running smoothly with the setup, unexpected events did not occur. Minor optimisation is required to apply similar procedures to possibly different test-sites. Demonstration in real traffic is planned to be conducted in 2023.			
Estimation of time required for getting 100% ready for the final field trials	4 weeks (totally in time for final pilots)			

TNO considered user acceptance of the vehicle performance one of the critical factors for deployment since their user testing confirmed that passengers are very sensitive to specific vehicle behaviour. TNO will utilize the results and lessons learned from this round in view of the operational phase that will follow in 2023 in real traffic.

6 Gothenburg/ Lindholmen test site (Mega)

6.1 Introduction

This section describes the activities carried out for preparing, implementing, and evaluating the pre-demo phase field trials that were conducted at the Swedish site of Lindholmen in Gothenburg. The key objectives of the specific phase at Lindholmen/Gothenburg, and in view of the final pilots that will be launched towards the end of 2022, have been the following:

- Prove a safe and reliable operation of a fleet of electrical automated vehicles for last/first mile service with a 5G connection.
- Improve user experience for commuters to reach Lindholmen´s different areas.

The total number of passengers transported during pre-demo phase pilots was 1260. The relatively low number of passengers is related to the closedown period due to COVID-19 at that period. The pre-demo was running for 4.5 months between January and May 2021, and during this time data collection was taking place both continuously and at pre-defined occasions. Data is collected through the Navya API. Keolis also collects and analyses data through its Fleet Management System (FMS). Data collected for the KPIs is stored locally at the pre-demo site and then uploaded to the Data Management Portal (DMP) of SHOW and visualised through the SHOW Dashboard.

6.2 General

6.2.1 The ecosystem

Table 16: Gothenburg (Lindholmen) ecosystem.

Participating Entity	Internal to the Consortium	External to the Consortium	Role
Keolis Sverige AB	√		Operator of demo
Ericsson AB	√		5G infrastructure/ Dashboard
RISE AB	√		Mega Site leader and Evaluation of pilots at Lindholmen, Dashboard development
Navya	√		OEM
Västtrafik		√	Public Transport Authority Västra Götaland
Gothenburg Traffic office		√	City Transport Planning Authority

Keolis is the operator of the service, and the shuttles are produced by Navya. RISE is leading overall the Swedish Megasite in SHOW and responsible for evaluation of the pilots at Lindholmen and the dashboard development. Ericsson is one of the leading providers of information and communication technology (ICT) to various actors. Ericsson is leading the effort to connect the service to Control Tower and Ericsson Innovation Cloud. Västtrafik is responsible for all public transport within the Västra Götaland region, including Gothenburg, and is Sweden's second largest public transport company. **The automated shuttle service is integrated to Västtrafik public transport system, running as bus nr 56.**

Gothenburg Traffic Office is involved in the Site Acceptance Test (SAT): written agreement from the local authority to ride on open roads.

The leading partners (Keolis, RISE and Ericsson) of the SHOW pre-demo phase at Lindholmen are also part of the S3 (Shared Shuttle Services) Project, which is a national project that is locally financed by the Swedish Innovation Agency/ Vinnova through the strategic programme Drive Sweden (https://s3project.se/en) and that has financed SHOW trials of pre-demo phase to a 50%. Thus, the partners RISE, Ericsson and Keolis were already engaged in a stable consortium working with Navya shuttles in the area together with partners external to SHOW, namely Västtrafik, Göteborgs Stads Parkering, Chalmers University, Härryda municipality and Johanneberg Science Park. Together the partners followed the mission to actively contribute to the evolution of the city and of people's needs by creating innovative, sustainable mobility solutions accessible to all residents and visitors at Lindholmen.

6.2.2 The setting

The Lindholmen site is an urban area situated in north-western Gothenburg (Figure 40). Around 30000 people commute every day to Lindholmen Science Park with around 350 companies, Chalmers University of Technology, different high schools and approx. 370 other companies of which many are related to mobility and IT.

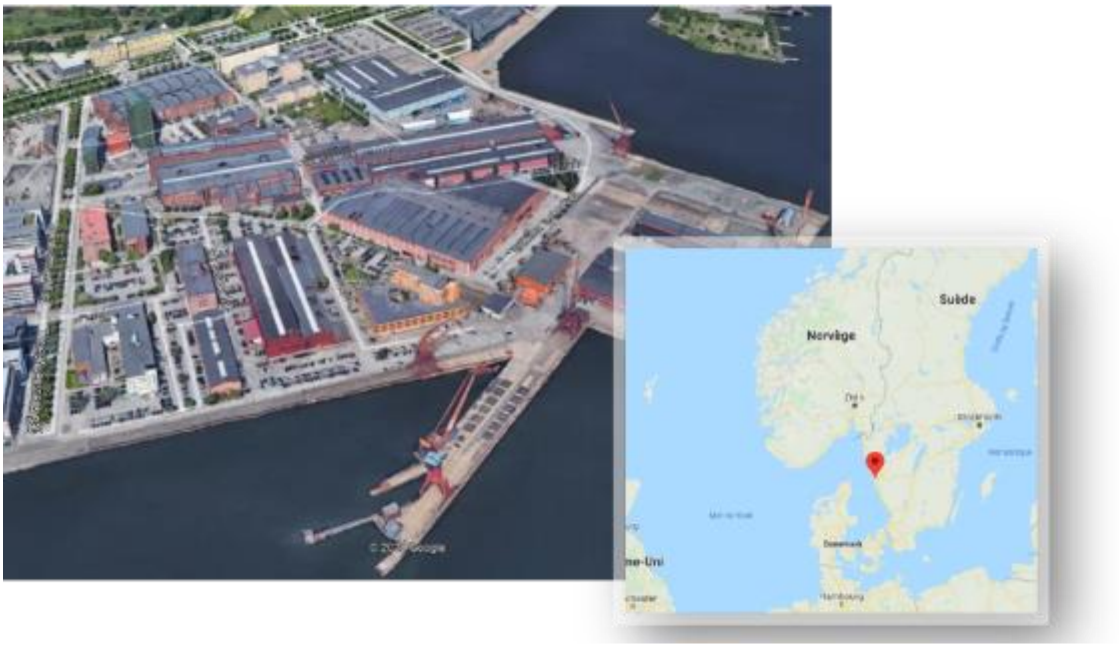


Figure 40: Aerial image and location of the Lindholmen pre-demo area in Gothenburg/Sweden (source: google maps, accessed on 16/06/21).

In the 1990s the city of Gothenburg began to transform the shipyard areas into the dynamic district it is today, with Lindholmen Science Park in the centre (Figure 41). The shipyard crisis had led to almost 20000 people having lost their jobs and the area of Norra Älvstranden was deserted. This transformation is one of the largest urban development projects in Sweden.

Figure 41: View towards Lindholmen Science Park from Lindholmsallén (source: google maps, accessed on 16/06/21).

The area is dominated by office buildings, but recently more residential buildings have been built. A large part of Lindholmen's area today consists of street parking and there is a great shortage of parks and recreational areas. Lindholmen used to be rather empty in the evening and on weekends when the workplaces, university and schools are closed and was then experienced as unsafe and deserted. Yet, with current development towards more residential buildings also evening-open activities begin to establish themselves. Lindholmen is still facing very big changes with the expansion of Frihamnen, Karlavagnsplatsen, Lindholmshamnen, etc. and will be a dense inner city with improved connections to the city center.

Figure 42: More remote area of Lindholmen at Valdemar Noréns Gata, near Hugo Hammars Kaj parking.

The traffic environment is urban with car/bus traffic, pedestrians, cyclists and e-scooters, etc., but in some areas of Lindholmen it can be quite remote (Figure 42). The traffic density varies also across day, with rush hours in the morning, around lunch and in the afternoon/evening.

For the pre-demo, two automated shuttles are driving along the route at Lindholmen in Gothenburg. The route is in total approximately 2.5km long with 3 stops, connecting the public transport network of Västtrafik from the bus station Regnbågsgatan (Figure 43) with a remote parking lot at Hugo Hammars Kaj. The shuttles turn at the parking and head back to the bus station on a slightly different way to enable turning the shuttle and restarting the route.

Figure 43: The route of the shared shuttles (source: google maps & S3 project).

The area between Regnbågsgatan and A Carlssons gata (Figure 43) is a dense urban area with office buildings and restaurants at e.g. Lindholmsallén, which is the main route to the inner city of Gothenburg, furthermore restaurants/shops and few residential buildings around Anders Carlssons Gata. Pedestrians, cycles and e-scooters are frequent and often have a dedicated lane/path.

From the shuttle stop Anders Carlssons Gata towards Hugo Hammars Kaj the area is becoming more remote, with mainly office or garage buildings and a sports hall with fewer pedestrians, cycles/e-scooters, yet without their own path/lane.

Figure 44: Shuttle heading north-west from Hugo Hammars Kaj along Valdemar Noréns Gata (screenshot of real-life operation).

Figure 45: Meeting the other shuttle along Valdemar Noréns Gata, heading north-west towards Anders Carlssons Gata (screenshot of real-life operation).

Figure 46: Coming from Valdemar Noréns Gata, to approach Anders Carlssons Gata turning right after pedestrian crossing (screenshot of real-life operation).

Figure 47: Coming from Anders Carlssons Gata, turning right to head north towards Lindholmsallén, passing a major construction site (screenshot of real-life operation).

Figure 48: Lindholmsallén with shuttles driving in north-east direction, turning right at round-about, passing cycle and pedestrian lane heading towards shuttle stop Regnbågsgatan (screenshot of real-life operation - see also Figure 49).

Table 17: Road, traffic, and weather conditions at Lindholmen.

Variable	Lindholmen
Weather	• Severe winter and wind conditions with rain/snow/sleet/ hail/foggy in January - April 2021, with temperatures below -14° C. • During winter period sun rises at 09 am and sets at 03.30 pm, which means that it is dark at about 40% of operation time. • Heavy rain and extensive, deep puddles can irritate the shuttles, further small fragments such as snowflakes or leaves.
Sight conditions	• Restricted conditions due to rain, snow, fog in January - April 2021. • Restricted conditions also due to glare from the sun, when in lower position in winter.
Road type(s)	• Urban roads with different speed limits on route, varying between 30-50km/h. • Number of intersections on route: in total 14 • No of roundabouts: 1 • No traffic lights on route: 0 • No dedicated lanes for shuttles, mixed traffic roads only • Shuttles are integrated to the to the public transport system of Gothenburg, as bus line nr 56. E-scooters and rental bikes are available for first/last mile transport in the area.
Road works	• Road works (planned/ unplanned) and construction works on buildings ongoing as the whole area is re-shaping. • Time-restricted capacity of passage for shuttles due to delivery trucks and site vehicles.
Incidents	• Time-restricted capacity of passage for shuttles due to delivery trucks and site vehicles. • Major changes at close-by buildings or construction sites, such as scaffolding or equipment lying around can irritate the shuttles.

Variable	Lindholmen
	• Heavy rain and extensive, deep puddles can irritate the shuttles.
Traffic conditions	• Due to COVID-19, the traffic congestion was less for public transport and private cars, whereas construction work and delivery was at high level. • The traffic density varies across the area and across the day, with rush hours in the morning, around lunch and in the afternoon/evening. • The shuttle is running on weekdays only, between 07 am to 06 pm.
Traffic composition	Mixture of cars, delivery vans /trucks, site vehicles, busses, bicycles, mopeds, e-scooters.
Traffic control	-
Area type (In- or outside built-up area)	Outside built-up area

The automated shuttles are integrated to the public transport system, as bus number 56. The shuttles have designated bus stops, where the ETA is shown (Figure 49).

Figure 49: Shuttle stop at Regnbågsgatan.

6.2.3 Field trials operation timing

The shuttles were running between 07am and 6pm on weekdays, from 18th of January 2021 till 28th of May 2021 (4.5 months).

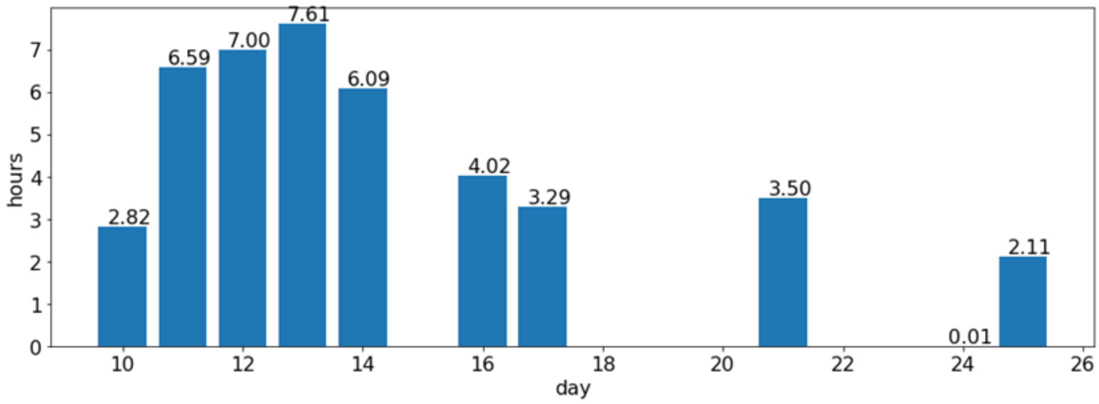


Figure 50: Plot of number of hours one vehicle was in operation during Jan 2022 - Gothenburg.

6.2.4 The Fleet

For the pre-demo, two NAVYA automated shuttles were driving along the route, which is approximately 2.5km long with 3 stops, **connecting the public transport network of Västtrafik with a remote parking lot** to improve first/last mile access in the area. The shuttles turn at the parking lot and head back to the bus station on a slightly different way.

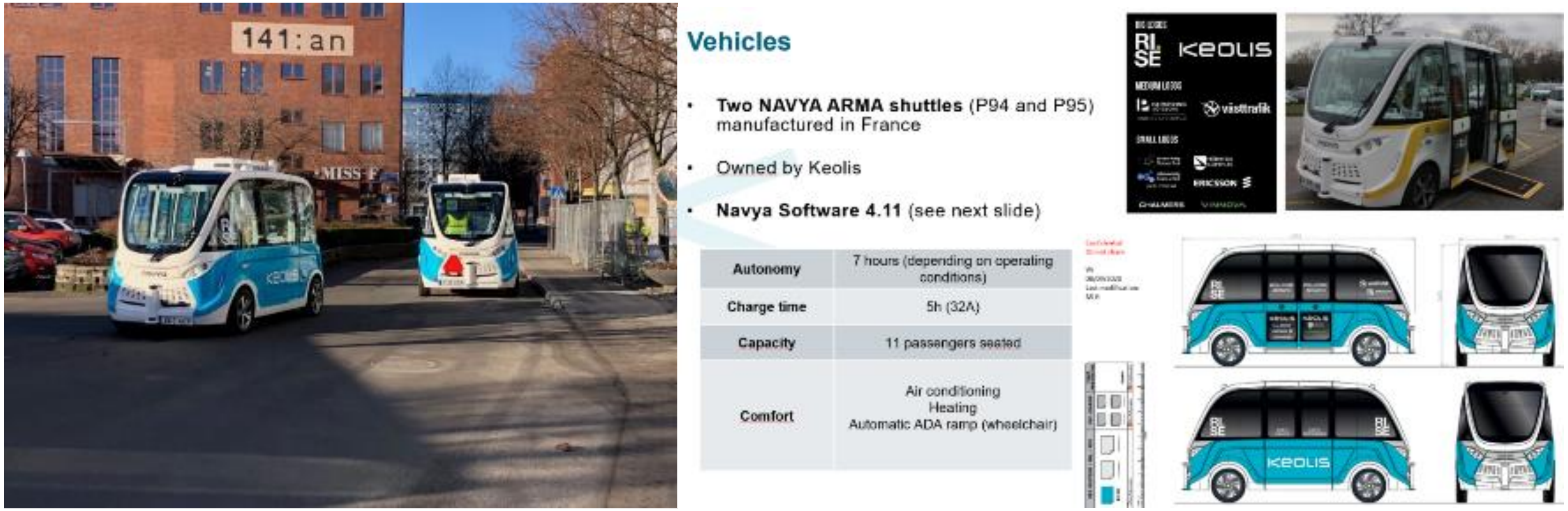


Figure 51: Navya vehicles running at the Lindholmen pre-demo site and their specifications.

Table 18: Lindholmen fleet characteristics.

Test/Use Case [ID as of D1.2]	Deployed fleet characteristics								
	Vehicle brand & model	**Vehicle type**	**SAE Level reached for the field trials [1-5]**	**TRL level reached for the field trials [1-9]**	**Summary of upgrades held during the project (check also D7.1, D7.3 & D7.4)**	**HMI and Hand-over strategies (in consistency with D7.2)**	**Maximum speed reached during the trials (km/h)**	**Average speed during the trials (km/h)**	**Maximum capacity of vehicle**
UC 1.1, 1.2, 1.3, 1.6, 1.7, 3.4	Navya Arma	Shuttle	4	6 Preparing for a 7 during 2022- 2023 pilots	5G box installed in 1 vehicle Connection to the 5G control tower 5G network installed in the area specifically for the project by Ericsson.	Vehicles normally run autonomously. When an event occurs, the vehicle requires handover to the safety driver. At 3 specific points, including 1 specific crossroad, it is mandatory for the safety driver to take over the vehicle, verify the environment and start the vehicle again.	20 km/h	4,9 km/h on average (running without stopped times at stations)	Due to Corona restriction, there were only 5 passengers allowed in each shuttle, plus safety driver.

6.2.5 The Infrastructure

Physical and digital infrastructure: The radio - and mobile network at Lindholmen site in Gothenburg (Figure 52) consists of three 5G mid-band (3760 – 3800 MHz) radio units and a 5G vEPC (virtual Evolved Packet Core). Two of the radio units were temporarily installed on a roof top in the center of the shuttle route (Figure 52), and one radio unit was located at Ericsson's premises at Lindholmen/Gothenburg. The remote radio units were connected to 5G EPC via microwave backhaul (Mini-Link). The 5G vEPC was located in data center in Ericsson premises at Lindholmen. In the shuttles, a 5G modem/router (E-Lins H900 / Quectel RM900Q module) was installed together with a Raspberry Pi 4 equipped with Adafruit GPS HAT. 5G vehicle antennas were mounted on the roof of the Navya shuttle (Figure 53, **Error! Reference source not found.**), and GPS antenna was mounted inside the vehicle at a flat surface by the wind screen.

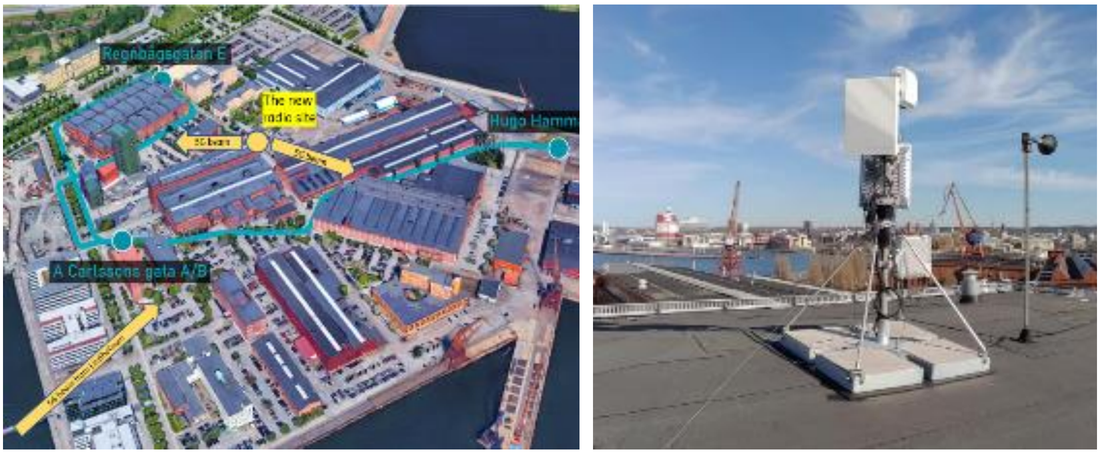


Figure 52: Left: route of the shuttle at Lindholmen/Gothenburg with position of the new radio site – Right: Radio unit installed on roof top at Lindholmen/Gothenburg site.

Figure 53: Left: Navya shuttle at site Lindholmen/Gothenburg with GPS antenna – Right: 5G vehicle antennas on the roof of the Navya shuttles.

Inside the Raspberry Pi, a number of Python3-based modules are running:

- GPS locations extracted from GPS HAT and published on a "location" MQTT topic as well as stored in a local Influxdb database.
- Radio information extracted from modem, using AT commands, and stored in local Influxdb database: MCC, MNC, PCI, RSRP, RSRQ, SINR, CQI and RSSI

- Network latency measurements in form of average round-trip time of 5 x ping tests, packet drops and standard deviation which is stored in local Influxdb database
- Local environmental measurements
    - CPU temperature
    - CPU usage (%)
    - Used memory / free memory

The latest data sets stored in Influxdb database were sent to a MQTT broker in a separate “network” MQTT topic. The backend systems consist of the SHOW Dashboard in Ericsson Innovation Cloud (EIC) and a Network Supervision dashboard. These backend systems subscribed to the MQTT topics and presented the location data and network data in different Graphical User Interfaces (GUIs). Network Supervision dashboard was used at Network Operations Center at Lindholmen to monitor radio characteristics and mobility, and this was a read-only presentation dashboard (Figure 54).

Figure 54: Network Supervision dashboard at Network Operations Center at Lindholmen/ Gothenburg site.

Geofences and VRU detection: SHOW Dashboard, an application within Ericsson Innovation Cloud, besides visualizing location of the vehicle, and network information at the particular location, also contains real-time processing logic to trigger actions based on location / heading of reporting objects. The objects included in the SHOW project were the automated shuttles (marked with vehicle icons) and a Vulnerable Road User (VRU) sensor (marked with vest icon in the middle of Figure 55).

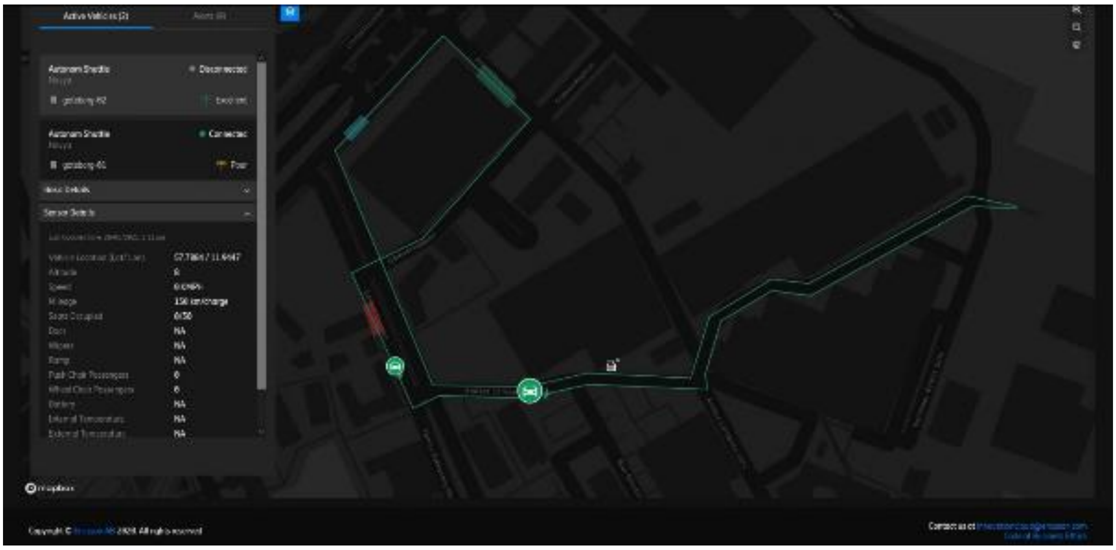


Figure 55: SHOW Dashboard making it possible to visualize location/heading of objects such as shuttles and Vulnerable Road Users (marked with vest icon in middle).

To trigger events, the logic in SHOW Dashboard supports two different kinds of geofences: (i) static geofences, and (ii) dynamic geofences. Static geofences (examples are green, blue and red areas in Figure 55) are defined on the map via geocoordinates. They represent areas where a pre-defined set of realtime rules applies. For example: reduced speed, no-entry, emission-free zone, etc. Static geofence can be applied around e.g. construction work areas, accident area, etc. In the SHOW project, notifications are sent over MQTT protocol to both vehicle and VRU sensor device when events trigged by entering and leaving specific static geofence areas. These notifications are presented as alert messages in both the shuttles and the SHOW Dashboard, while they are represented as audiovisual notifications for the vulnerable road users (LED lights in front and back on safety vest as well as audio in earphones). See Figure 56 and Figure 57.

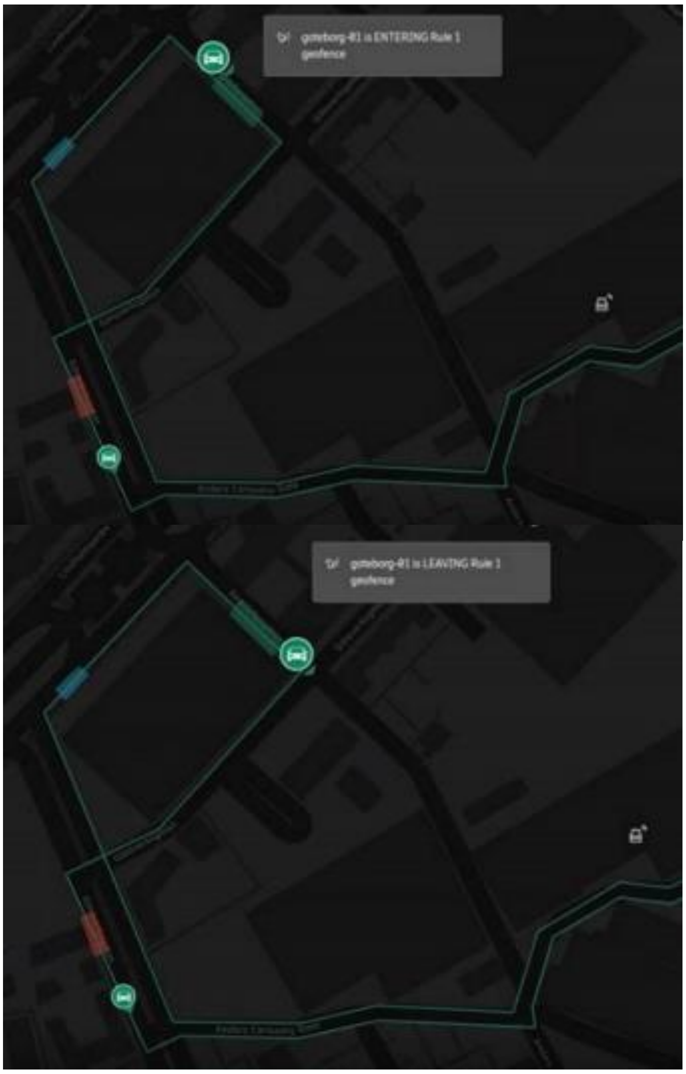


Figure 56: Static geofences for Lindholmen/ Gothenburg site.

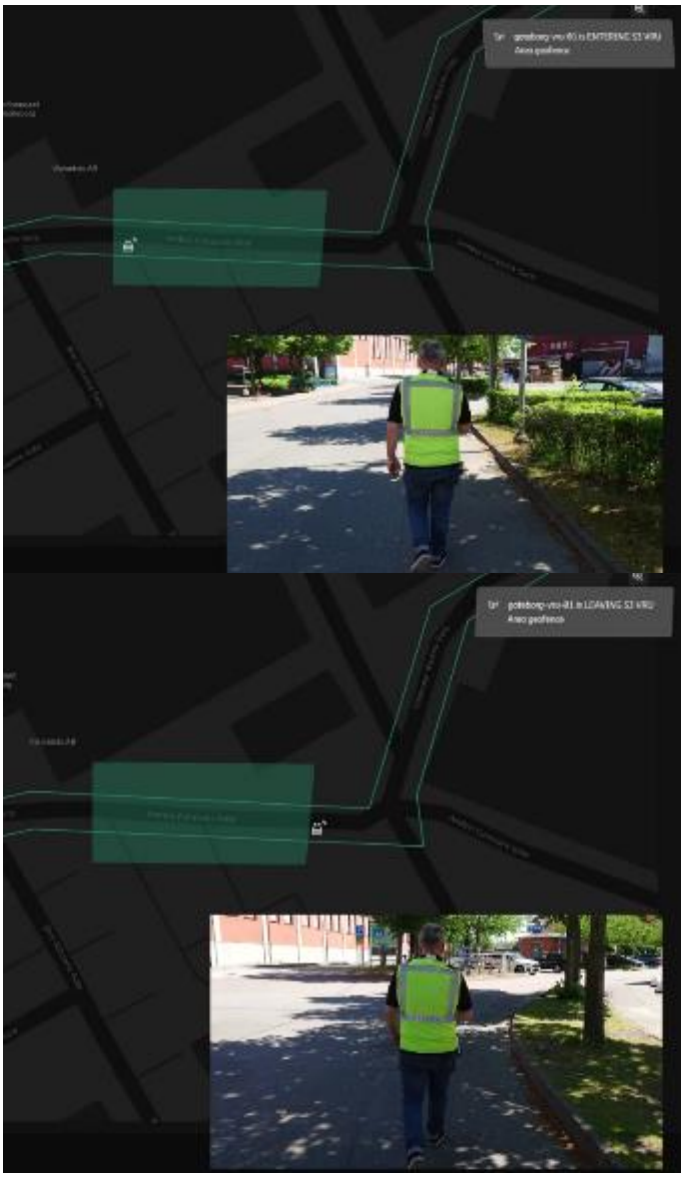


Figure 57: VRU area geofences at Lindholmen/ Gothenburg site.

Dynamic geofences are created around dynamic objects, instead of static coordinates, and follow the object's movements. In SHOW project, dynamic geofences were created as a polygon in the front of the vehicles and a disk centred by Vulnerable Road User sensors (Figure 59).

The area of the dynamic geofences can be defined by the users.

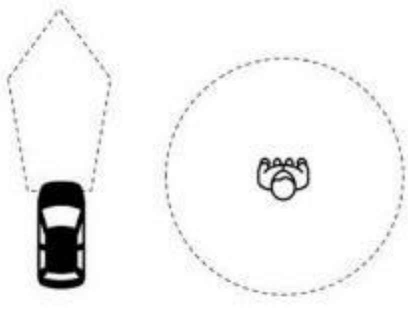


Figure 58: Dynamic geofences.

Once a vehicle- and a VRU dynamic geofences overlap, notifications are sent to respective connected sensor subsystems (notification messages + audio-visual at VRU sensor) as well as in the SHOW Dashboard (Figure 59).

Figure 59: Vehicle-VRU geofence overlap trigger notification messages and audio-visual messages at VRU sensor and in the SHOW Dashboard.

Charging, storage and maintenance: The shuttles were stored and charged in a garage close to the parking lot at Hugo Hammars Kaj (garage building in Figure 43, south-east of the shuttle stop). The garage is a cold storage (Figure 60). Very cold temperatures negatively affect batteries' autonomy and their charging. During winter, the nights were so cold in the garage that heaters were needed to support good battery condition. Parking and charging are included in the safety drivers' shifts. It is part of the work description of the safety drivers. There have been no major software updates during the pre-demonstration period. Maintenance was organized locally. The shuttle was cleaned every day, inside and outside. All lidars and sensors were carefully cleaned every day to prevent deterioration.

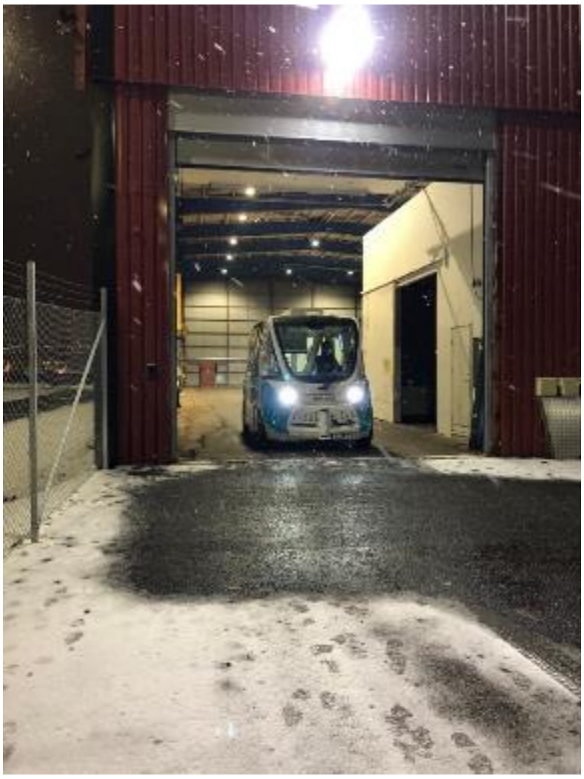


Figure 60: Shuttle is leaving the garage close to Hugo Hammars Kaj.

Dashboard at pre-demo site: Gothenburg site uses 3 dashboards serving different purposes:

- Autofleet solution (https://www.autofleet.io/) for its fleet management system
- Network supervision dashboard at Lindholmen network operation center (NOC)
- D4.2 SHOW Dashboard (https://demo.innovationcloud.ericsson.net/show-project/view/dashboard/Goteborg) site view for visualizing project KPIs.

Realtime vehicle data from Navya's API are collected and aggregated by the Autofleet's platform to produce actionable insights for Keolis (as an operator) to monitor the service performance. The system is also integrated with Västtrafik systems, PTO/Gothenburg, regarding the public transport timetables. KPIs collected on the Autofleet's platform were extracted afterwards and imported into SHOW DMP, and then visualized in the respective KPI screens of SHOW Dashboard.

6.2.6 Users & Stakeholders

6.2.6.1 Passengers and stakeholders in the loop

The number of passengers transported during this pre-demo phase of SHOW was 1260. The relatively low number of passengers is related to the close down period due to COVID-19, as mentioned before. Demographics of the passengers answering the SHOW survey are provided in section 6.5.2. During week 20/2021, user studies (on acceptance and satisfaction) with passengers were conducted. Furthermore, the safety drivers were interviewed, using the template of the user study (results will be shared in the first update of this issue).

About 4-6 observer travellers were involved in the pre-demo (as test users in the vehicles or participating in the test cases), part of which are involved in the SHOW project.

For the VRU use case, personnel from Ericsson and Keolis was involved and recruited to test the equipment (3 test users were involved in the pre-demo phase).

Relevant stakeholders for the SHOW project have been identified in D9.3 within the M3ICA methodology, as follows:

- Vehicle users (end users, drivers, and remote operator). End-users are commuters, residents and tourists/visitors in Gothenburg. In addition, VRUs were involved for the testing of the respective test case.
- Public interest groups and associations
- Decision-making authorities or regulators
- Operators (e.g., public transport operators, private fleet operators)
- Mobility service providers
- Industry (e.g., AV manufacturers)

The interviewed stakeholders tried the service at Lindholmen themselves and were actively involved in the execution and monitoring of the different use/test cases.

Table 19: Stakeholders involved at Lindholmen.

Stakeholders	Target/ Org. Name
Vehicle users (end users, drivers, and remote operator)	Commuters/visitors Safety driver (Keolis) Remote operator (Keolis / Ericsson)
Decision-making authorities or regulators	Swedish Transport Agency (STA) Gothenburg Traffic Office (involved in Site Acceptance Test as described in 6.3.1)
Operators (e.g., public transport operators, private fleet operators)	Public Transport Authority: Västtrafik Götaland
Mobility service providers	Service provider (Keolis) Service provider (Ericsson)
Industry (e.g., AV manufacturers)	OEM (Navya)

6.2.6.2 Local campaign and strategies for awareness, recruitment & engagement

Despite the general approach applied in SHOW, where the pre-demo phase of the test sites is seen more as a rehearsal (in all aspects) and is not foreseen to be open to public, in Lindholment/ Gothenburg, it was the case and the service was fully open to public, following the technical verification/ validation stage.

Due to COVID-19, the public transport provider in Gothenburg and Västra Götaland, Västtrafik recommended under the full time of the pre-demo phase to (Figure 61):

- "Avoid unnecessary travel in public transport. Consider whether you can refrain from traveling by working from home, walking or cycling".
- "Do not travel if you are ill or have cold symptoms".
- "If you must travel: Travel outside rush hour, take the next departure if it starts to get full on board, wear a mouth guard if you are 16 years or older and travel during rush hour at 7-9, 16-18".

Under these conditions it is hard to start a campaign for recruiting passengers. In the same manner, the Public Health Agency of Sweden recommended on national and regional level to a) limit travelling with public transport as much as possible, b) work from home and c) keep distance from others and avoid crowded environments.

Figure 61: Recommendations for passengers using public transport in Gothenburg from Västtrafik (source: https://www.vasttrafik.se/en/info/Corona/, accessed on 21/06/21).

A press release was given out to inform about the pre-demo at Lindholmen and ongoing development, such as on Drive Sweden´s website (Figure 62).

Figure 62: Excerpt of a press release from Drive Sweden´s website to inform about ongoing developments at demo site (source: https://www.drivesweden.net/en/news/5g-autonomous-shuttles-enables-important-developments, accessed on 20/04/21).

Signs were installed at bus stops in Lindholmen, announcing automated shuttles were running in the area, both at AV stops and regular bus stops in the area. Shuttles were also positively exposed on a daily basis when running parallel to the main bus line at Lindholmen LA: passengers in regular buses could see the shuttles running. The AV line was also included in the public transportation app, under the name "line 56". When requesting an itinerary in the area, passengers could have an itinerary with an automated shuttle suggested to them (Figure 63).

Figure 63: Automated shuttles integrated in Västtrafik travel planer as line 56 (source: Västtrafik travel planner, accessed on 24/04/21).

For the user survey, the user opinions were collected on paper as a pre-test and - not via the SHOW on-line tool Netigate - as this was not available at that time due to the early start of the site pre-demo phase. Passengers for the user studies on acceptance and satisfaction were recruited directly at the shuttle stops or in the shuttles while travelling. This was also because the user opinions were collected on paper without the possibility to reach passengers via social media to fill out the questionnaire online. The engaged stakeholders were recruited based on their involvement in SHOW and/or the national project, as described in section 6.2.1 and 6.2.6.

6.2.7 Business Models

A business model has not yet been applied and evaluated for this site. Work is ongoing together with local stakeholders and in SHOW A2.3.

Lindholmen is a university, technology and business area of the city of Gothenburg. As of today, commuters from the outer areas of Gothenburg heavily rely on their car for their commute to work (with >50%), due to a very good connection to the highway and many parking areas at workplaces. To give incentives for commuters to switch to public transportation, a shuttle is established, that rotates within the office area between a remote parking place and a main bus station of the PT network.

The 2022 demonstration business model will most probably be focused on first/last mile automated transport from/to mobility hubs (see WP2 Deliverables for more), such as bus station Regnbågsgatan, to reduce individual traffic, parking spaces and emissions in area. Despite the existence of a well-functioning PT, significant portions of the working population commute by private vehicle, creating congestion issues and using valuable land resources for parking that would otherwise go into recreational areas, denser commercial or residential development. The shuttles are integrated in the PT network of Västtrafik.

6.3 Preparatory Process

6.3.1 Permits

The permits are being requested to the Swedish Transport Agency (STA).

a) The process starts with a Letter of interest:

- General information at: https://www.transportstyrelsen.se/en/road/Vehicles/self-driving-vehicles/
- Application form to fill out:

  - https://www.transportstyrelsen.se/en/Forms/Road/Vehicle/letter-of-interest---permit-for-self-driving-vehicles/
  - https://www.transportstyrelsen.se/globalassets/global/blanketter/vag/english/tsv7100-letter-of-interestt.pdf
- A registration number is then granted to the applicant by the STA. This is the number to refer to in all the dialogue with the STA.

b) **Interactive process of validation**: The STA had a first meeting with Keolis and the manufacturer Navya to explain all the steps of the interactive validation process. Two main tests had to be carried out before getting a permission to run permanently:

- **Factory acceptance test (FAT):** For the Göteborg site, this FAT was carried out by the manufacturer Navya. Since Navya Arma vehicles were already running in Linköping, the process was rather easily executed.
- **Site Acceptance Test (SAT)** is normally carried out directly by the STA on site. But due to COVID-19 we made a work around and shoot a film with four GoPro cameras filming inside and forwards from the AV. Also, a following car was shooting from behind.

c) **Temporary permission:** After reviewing the site acceptance video, and a few modifications and upgrades to the initial plan, the STA granted Keolis a **temporary permission.** This granted Keolis the right to run its vehicle tests on site: hardware and software trials, programming. Keolis trained the safety drivers on site. When local project management was satisfied with the behaviour of the vehicle, traffic safety, training etc., a second SAT video shooting was carried out, with four GoPro cameras like the first time.

d) **Permanent permission:** An intersection requested specific attention, for traffic safety reasons at a road-crossing (Figure 64, red circle). The question was whether switching to manual mode was necessary or not at that intersection. Eventually the permanent permit was granted, provided **a mandatory switch to manual mode at that intersection.** There were 2 other specific points on the route, where it was mandatory for the safety driver to take over the vehicle, verify the environment and start the vehicle again.

Figure 64: Pre-demo route with crossing where to drive manually (red circle).

The permanent permission was given by the STA. It is valid until December 31st 2021 under the following conditions:

- The two vehicles Navya Arma with the following registration numbers are used (not further specified here), operated by Keolis Sverige AB.
- The vehicles are driving along the blue marked route.
- There is a designated person responsible for the test demo (not further specified here).
- Travel must not take place in thick fog, abundant snowfall or heavy rain.
- Vehicles must be fitted with an LGF plate.
- Vehicles must not be driven at speeds higher than 20 km per hour.
- A maximum of 11 seated passengers and one driver may travel in the vehicles (due to COVID-19 restrictions the number of passengers was later reduced to only 5 passengers allowed in each shuttle, plus safety driver)
- The vehicles must be driven in manual position at the intersection, Götaverksgatan, marked with a red ring according in Figure 64, when travelling in a south-westerly direction. The intersection Götaverksgatan can pose a danger as the vehicles cannot sufficiently process information from vehicles coming from the left, as the speed limit here is 50 km/h. Here, the authority sees that the vehicles must be driven manually.
- Before the vehicles are updated with new functionality, a risk analysis must be made, and a dialogue must take place with the Swedish Transport Agency to determine whether the permit needs to be reconsidered.
- The company shall assist authorities with information and assistance in interpreting data collected from the vehicle in connection with any investigations of accidents.
- In the event of an accident, the company must report this via e-mail the authorities (not further specified here) without delay.

6.3.2 Development/ Customisation/ Integration

For the various use /test cases deployed (see section 6.4.1), the vehicles & connected vests (VRU units) were equipped with controller units to connect and exchange data with the local site infrastructure. This controller unit also contained a modem for connectivity, GPS sensor. The local site infrastructure contains two more 5G NSA cells / radios, a baseband and microwave (mini-link) backhaul between the “M1” site and Ericsson Lindholmen. Software tools such as InfluxDB and Grafana deployed on CentOS virtual machine in the IT cluster for supporting the operations at the local site.

The local site team have developed multiple scripts that run on the controller units for performing various operations such as:

- Initiating latency(ping) tests from probe
- Fetching location data from onboard GPS sensors
- Reporting location data
- Reporting network measurements

Each script was deployed as a service and was executed as a background process in the controller units. In addition to the operations mentioned above, the units were equipped with scripts for connecting to the SHOW MQTT Broker for reporting the data directly to the SHOW infrastructure.

The scripts for reporting the location data and network measurements were developed specifically for the SHOW use-cases and multiple strategies such as fault management, persistent storage for backup etc., were employed to measure the network data and to reduce the latency in reporting the data to the SHOW infrastructure. In addition to reporting the data to the SHOW Digital Infrastructure, the relevant data was also stored in the site’s local persistent storage.

The connection strings and user-credentials for connecting to the SHOW MQTT Broker were generated by utilizing the self-serviced onboarding workflow of SHOW Dashboard. The connection strings and user-credentials were used to establish a connection with the SHOW MQTT Broker and subscribe to relevant MQTT Topics for reporting the data related to location and network measurements.

6.3.3 Training

Training consisted of some major steps, namely:

- Recruitment process of safety drivers with focus of English and technology skills.
- Eventually 8 safety drivers were chosen.
- 2 Trainers from Navya spent 5 days each at site and trained the safety drivers theoretically about the vehicle and practically in driving and behaviour of vehicle. Also, virtual meeting was held with control centre in Paris (supervision).
- The safety drivers were also trained in using the FMS Fleet Management system.
- After the first week there was a test of the skills of the safety drivers. Everyone passed.
- Week 2 after the trainers leaving the site the safety drivers were running and testing themselves (2 in each vehicle).
- There was an interesting learning curve and improvements in the vehicle behaviour and service to public was continuously improved.

6.3.4 Ethics & GDPR

In D3.4 it is stated, that for 6 of the demo sites (Graz, Kista, Brainport, Copenhagen, Tampere, Turin) there is no ethics controlling body or controlling committee necessary to be contacted and get approval (on national/regional/local/institutional level) for the experimental procedures prior to the tests. The pre-demo has been moved from Kista to Lindholmen/Gothenburg, yet with no effect on the need for an ethics committee.

The questionnaire on ethical and legal issues was filled in by the LER (Local Ethics Representative), responsible for conducting trials involving human participants. It is a checklist reminding the researcher to consider all relevant ethical aspects before planning and then conducting any data collection activities within SHOW. The LER is also the one responsible for keeping track of the procedure of ethical considerations from planning to realisation of a demonstration activity or an evaluation process through a dedicated checklist. Before the pre-demo launch, the questionnaire on ethical and legal issues has been completed by the LER for the Lindholmen site. This is included and reported in D3.5.

In SHOW it is mandatory for all demonstration sites to consider if a Data Protection Impact Assessment (DPIA) is needed, and if yes perform such. Following the process and template within SHOW, it was not required to conduct a DPIA for the pre-demo at Lindholmen site.

Data Protection Officer for the Kista site is now DPO for the Lindholmen/Gothenburg site. The DPO has several tasks where the major task is to monitor the projects compliance with GDPR and other Data Protection laws. Another task for the DPO is to advise and support the Controller/Processor when conducting a DPIA.

Traveller groups and involved stakeholders have been recruited and invited at a very small scale during the conduction of the pre-demonstration phase tests. All participants had the competence to understand the informed consent information. For test cases involving vulnerable road users, participants of the SHOW consortium/partner employees were participating.

All data collected that will be shared across partners, needs to comply with the Ethics and Data Protection Policy defined in D3.4: SHOW updated Ethics manual & Data Protection Policy and Data Privacy Impact Assessment. No GDPR-related data was collected by Keolis or Ericsson during the pre-demonstration. Only anonymised or pseudonymised data will be processed and used in the evaluations and, therefore, no personal data will be processed in relation to specific user, as further described in D3.4.

6.3.5 Other

- Maximum capacity of vehicle: due to COVID-19 restrictions, currently there are only 5 passengers allowed in each shuttle, plus safety driver.
- Face masks were used by passengers and safety driver in the shuttles.

6.4 Pre-demonstration study design

6.4.1 Test Scenarios

6.4.1.1 Use Cases – Test Cases

The key objectives of the demo site at Lindholmen/Gothenburg are the following:

- Prove a safe and reliable operation of a fleet of electrical automated vehicles for last/first mile service with a 5G connection.
- Improve user experience for commuters to reach Lindholmen´s different areas.

The following test cases were deployed and evaluated:

First/last mile PT at Lindholmen/Gothenburg (responding to UC1.1)

Close to the bus station Regnbågsgatan, the AV starts its drive along a designated route in the urban area of Lindholmen. To get closer to their offices several passengers take the shuttle connection from the bus station at Regnbågsgatan. The shuttle is driving along its route through Lindholmen, stopping at Anders Carlssons Gata and proceeding to the more remote area of Lindholmen, finally arriving at the parking place at Hugo Hammars Kaj. Passengers that left their car at the remote parking place catch the shuttle to get to the office areas of Lindholmen.

First/last mile PT at Lindholmen/Gothenburg under complex environmental conditions (responding to UC1.2)

The service operated with “extreme weather conditions” as listed in UC 1.1: snow and -14°C at night. It is lightly snowing in Gothenburg. Thanks to the AV service, passengers easily and comfortable can commute to/from their job with PT catching the shuttle for first/last mile transport.

Shuttle connecting to other passengers/VRUs at Lindholmen/ Gothenburg (responding to UC1.3)

The shuttles can connect to other road users in the surrounding area of the vehicles. When the shuttle is approaching, 15 to 20m, in this test case, a yellow vest connected via the Ericsson control tower, carried by selected VRUs (Ericsson employees), starts flashing.

First/last mile PT at Lindholmen in mixed traffic (responding to UC1.6)

The AV is operating on real roads together with other cars, trucks, buses, bicycles, and e-scooters, crossing streets, bicycle lanes and pedestrian crossings on its way, either with prioritization for the shuttle or not.

Connection to 5G infrastructure for remote supervision (responding to UC1.7)

The AVs are connected to the 5G infrastructure in the Lindholmen area for remote communication and supervision. There is a deviation in this test case, from the planned test case in Kista as remote control could not be realised as this was not included in the permission of the STA. The backend systems consist of Ericsson Innovation Cloud and a Network Supervision dashboard. These backend systems present the location data and network data. Network Supervision dashboard is used at Ericsson´s Network Operations Center at Lindholmen to monitor radio characteristics and mobility (see section 6.4.1.1).

Automated driving functions at bus stop (responding to UC3.4)

Assistance systems will help the vehicle at the bus stops. Navya vehicles/API have a functionality that assists to get back on the road.

There was a seamless/parallel assessment of test cases along the route for UC1.1, UC1.2, UC1.6 and UC3.4 at the bus stops. The trials were conducted in the context of current operational lines. The frequency of operation for each test case was from 7am to 6pm on weekdays, for 4.5 months between Jan-May 2021.

UC1.3 with regards to VRUs was tested at specific sections of the route, in extraordinary lines and at least 10 times for each test case. UC1.7 for 5G connection and remote supervision of the vehicles was enabled as of April 2021.

The relevant research hypotheses addressed for Gothenburg are discussed in section 6.5.4.

6.4.1.2 Mobility services & apps

The system is integrated with Västtrafik systems, PTO/Gothenburg, regarding the public transport timetables. The AV line was included in the public transportation app, under the name “line 56”. When requesting an itinerary in the area, passengers get an itinerary with the automated shuttles suggested to them (Figure 63).

6.4.2 Evaluation methods & data collection tools

The pre-demo phase of the site was running for 4.5 months between January and May 2021, and during this time data collection was taking place both continuously and at pre-defined occasions. The study design has its starting point in the use cases, the related research questions and the KPIs. All is reported in D9.2.

Keolis has its own internal data flows with Navya for the Lindholmen site. Data is collected through the Navya API. Keolis also collects and analyses data through its Fleet Management System (FMS). Data is then shared with the SHOW Data Management Portal (DMP) to be visualised via the SHOW Dashboard. Full access to NAVYA API was also granted later to CERTH for all the sites it deploys, though it is not necessary for Gothenburg in specific.

As mentioned, Gothenburg pre-demo phase was conducted prior/ very close to the finalization of the evaluation protocols in D9.2. Still, the protocolled survey tools of the project were used. Before the pre-demo site of Lindholmen started, technical verification and validation of the systems and functions was successfully passed as described in chapter 6.3.1 (reported in D11.2 series of Deliverables).

6.4.3 Experimental process

For the test cases **UC1.1, 1.2, 1.6 and 3.4** a typical day of field trials was organised in the following format and successfully run for the full period between 18/01/21 - 28/05/21 between 07am and 6pm on weekdays:

> **Maintenance & charging:** The shuttles are parked and charged in a garage at night. The garage is a cold storage (Figure 60). During winter, the nights are

so cold that heaters were needed to support good battery condition. The shuttles are cleaned every day, inside and outside. All lidars and sensors are carefully cleaned every day to prevent deterioration. Parking and charging are *included in the safety drivers' shifts. It is part of the work description of the* safety drivers.

Operation: The two safety drivers drive the two shuttles manually out of the garage to begin operation on the route between Regnbågsgatan and Hugo Hammars Kaj. During winter period sun rises at 09 am and sets at 03.30 pm, which means that it is dark at about 40% of operation time then. The shuttles are operating in autonomous mode on the route with max speed of 20km/h. Speed limit in the area is 30km/h, which is a city environment with a normal/smooth traffic context between Hugo Hammars Kaj and Anders K Gatan, i.e. without any traffic or other environmental complexity **(UC 1.1).** Between Anders K Gatan and Regnbågsgatan the shuttles operate within a more complex traffic context (e.g. curvatures in roundabouts), interfacing to the PT hub at Regnbågsgatan. Complex environmental conditions such as extreme winter and wind conditions with rain/snow/sleet/ hail/foggy occur between in January - April 2021, with temperatures below -14° C (see further **Error! Reference source not found.**). Due to delivery trucks and site vehicles time-restricted capacity of passage for shuttles can occur **(UC1.2).**

On this part of the route, the vehicles must be driven in manual position at the intersection Götaverksgatan/Lindholmsallén (Figure 64) when travelling in a south-westerly direction. The intersection can pose a danger as the vehicles cannot sufficiently process information from vehicles coming from the left, as the speed limit here is 50 km/h. Here, the authority sees that the vehicles must be driven manually. Further, at 2 other points on the route, it is mandatory for the safety driver to take over the vehicle, verify the environment and start the vehicle again **(UC1.2)**.

The shuttles are operating in mixed traffic on real roads together with other cars, trucks, busses, cycles and e-scooters, crossing streets, bicycle lanes and (pedestrian) crossings on its way, either with prioritization for the shuttle or not. The traffic density varies across day, with rush hours in the morning, around lunch and in the afternoon/ evening **(UC1.6).**

Under operation in mixed traffic, the shuttles honk to warn other road users, stop at pedestrian crossings/crossings, overtake and/or wait for free passage. It can happen on the way that the shuttles brake abruptly **(UC1.6)**.

At the three bus stops, passengers enter or leave the vehicles, and operation is integrated into the PT system/app. ETA is announced at the bus stops. Assistance systems help the vehicle at the bus stops, for example the vehicles/API have a functionality that assists to get back on the road **(UC3.4).**

After the final route of the day, the two safety drivers drive the shuttles manually to the garage for charging and maintenance.

The test case **UC1.3** with regards to VRUs is tested at specific sections of the route and has been performed successfully at least 10 times. A typical day of field trials for this case was organised with personnel from Keolis and Ericsson as follows:

The objects included in this UC are the autonomous shuttles operated by Keolis and a Vulnerable Road User (VRU) sensor integrated in a reflective vest worn by Ericsson personnel (see Figure 55). By means of the digital infrastructure, as described in section 6.2.5, and SHOW Dashboard real-time processing to trigger actions/events is enabled based on location/heading of reporting objects, such as the VRU and the vehicles.

For the field trials, static geofences were set-up at the Lindholmen site. They represent areas where a pre-defined set of realtime rules applies, e.g. reduced speed, no-entry, emission-free zone etc. Static geofence can be applied around construction work areas, accident area, etc.

When an event is triggered, notifications are sent to both vehicle and VRU sensor device. When the objects are entering and/or leaving the static geofence areas on the route, these notifications are presented as alert messages in both the shuttles and the SHOW Dashboard. For the VRU they are represented as audio-visual notifications with flashing LED lights in front and back on safety vest as well as audio in earphones. See Figure 56 and Figure 57.

For the field trials, also dynamic geofences are created around dynamic *objects, and follow the object's movements. In this case, dynamic geofences* are created as a polygon in the front of the vehicles and a disk centred around VRUs (Figure 59).

Once a vehicle and a VRU dynamic geofences overlap on the route, notifications are sent to respective connected sensors. Presented as notification message for the safety driver and audio-visual notification at VRU´s vest as well as in the SHOW Dashboard.

The test case **UC 1.7** with regards to 5G connection is tested/available along the whole route. The 5G connection and remote supervision tests have been performed since April 2021 at least 10 times. A typical day of field trials for this case was organised with personnel from Keolis and Ericsson as follows:

The radio- and mobile network at Lindholmen site in Gothenburg (Figure 52) is *installed to give good coverage along the shuttles' route. The shuttles are* equipped for the project with 5G modem/router, 5G vehicle antennas and other equipment needed (Figure 53).

The backend systems consist of the SHOW Dashboard in Ericsson Innovation Cloud (EIC) and a Network Supervision dashboard. These backend systems present during the field trials the location data of the vehicles and network data in different Graphical User Interfaces (GUIs). Ericsson personnel is able to monitor radio characteristics and mobility remotely from the Network Operations Center at Lindholmen (Figure 54).

During week 20, user studies (on acceptance and satisfaction) with passengers were conducted. Again, due to COVID-19, a low number of passengers was present in the area. An overview of the demographics in the user acceptance survey is presented in the following section. Furthermore, quantitative data has been collected and analysed regarding SHOW KPIs (see section 11).

6.5 Pre-demo phase field trials results

6.5.1 Overall performance results

The test cases at Gothenburg performed good overall, although several challenges have been noticed in each of them (see more in section 6.5.4). One of the key challenges, it was revealed to be the winter conditions. In order to study the impact of severe winter conditions, the number of hard-brakings per kilometre has been calculated each month by analysing the data that were reported in the manufacturer (NAVYA) API. It can be noted that the hard-brakings have decreased throughout the field trials duration thanks to the increase in temperature (see the chart below).

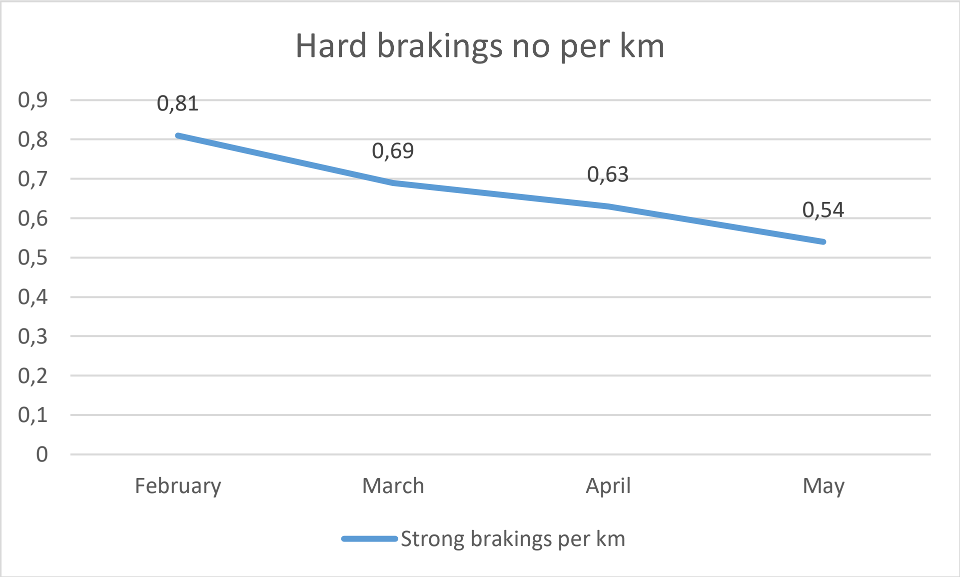


Figure 65: Hard-brakings per km.

To monitor safety on board:

- Safety drivers were always in contact with the control tower thanks to the 5G communication system.
- The shuttles monitored all events. These events were analysed to prepare for any emergency event.
- In case of any security-altering event, an alert popped up on the safety driver's screen to switch to manual mode.
- Passengers on board were reported by the safety driver. Processes were developed to answer to any passenger incident on board.
- Temperature inside and outside was measured (depending on the weather, this might indicate a necessary service interruption).

To monitor traffic efficiency, the following indices were measured:

- Distance travelled with / without travellers
- Total fleet distance
- Average speed / Average commercial speed
- Max speed for each shuttle everyday
- Number of rotations (laps)
- Distance travelled in autonomous mode vs manual mode
- Number of manual mode initiated
- Battery level for each shuttle
- Passing frequency measured at each station (regularity)
- Number of passengers boardings & drop-offs at each station
- Time spent at each station

The key consolidated KPIs for the pre-demo phase of Gothenburg are provided in section 11.

6.5.2 End-user acceptance

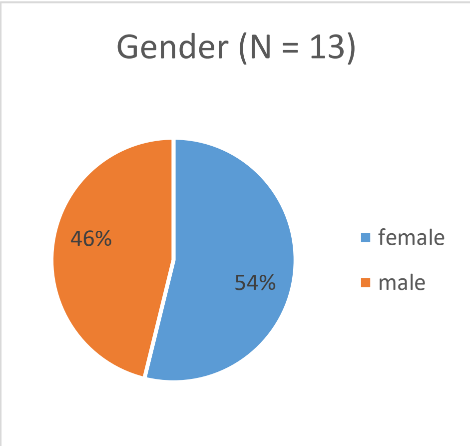
6.5.2.1 Demographics

13 full responses were collected in the Gothenberg pilot site as a pre-test and later transferred into Netigate format. The respondents had an average age of 47 years old. The oldest respondent was **86 years old**, while the youngest was 19 years old.

Table 20: Age distribution in Gothenberg.

Age	
Mean response	47.00
Standard deviation	17.34
Median	42.00
Minimum	19
Maximum	86
Number of responses	13

The gender distribution was almost equal (6 men and 7 women), while education level is relatively high (≈60% of the sample) having at least completed a university degree. All but one participant reported their household type, and most are predominantly members of households with children (60%).



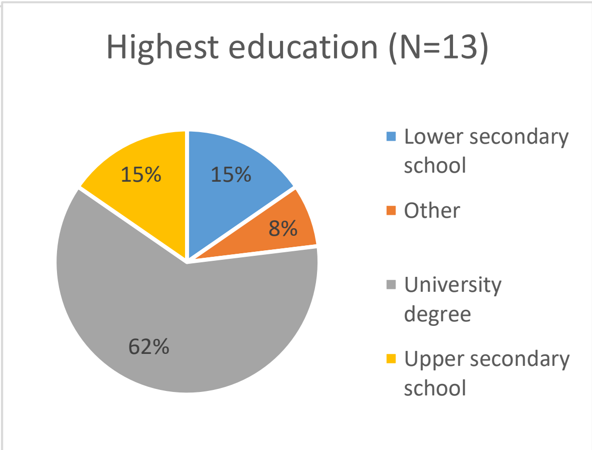


Figure 66: Distribution of the gender and level of education of respondents in Gothenberg.

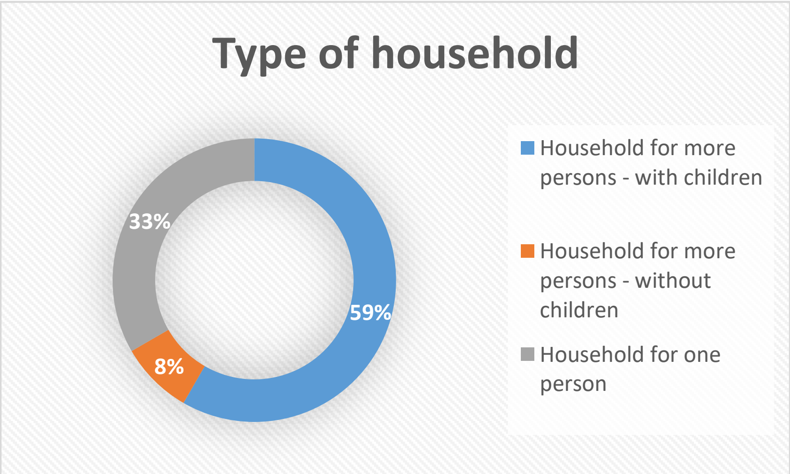


Figure 67: Type of household – Gothenburg respondents.

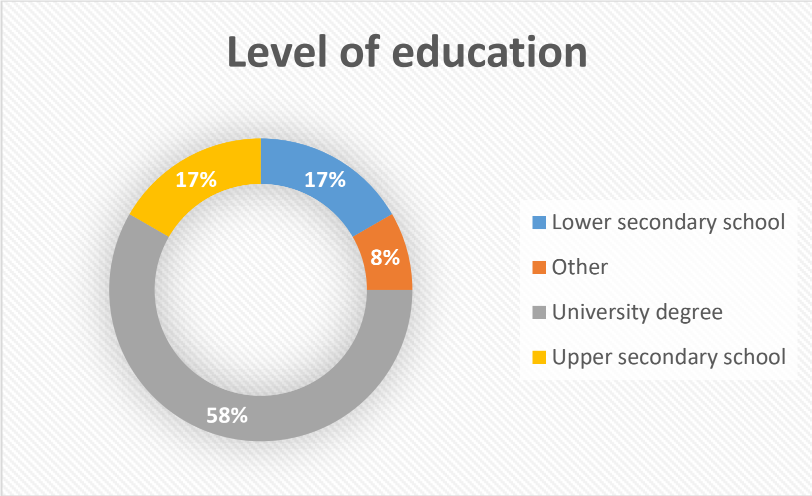


Figure 68: Level of education – Gothenburg respondents.

Most of the respondents are employees (67%).

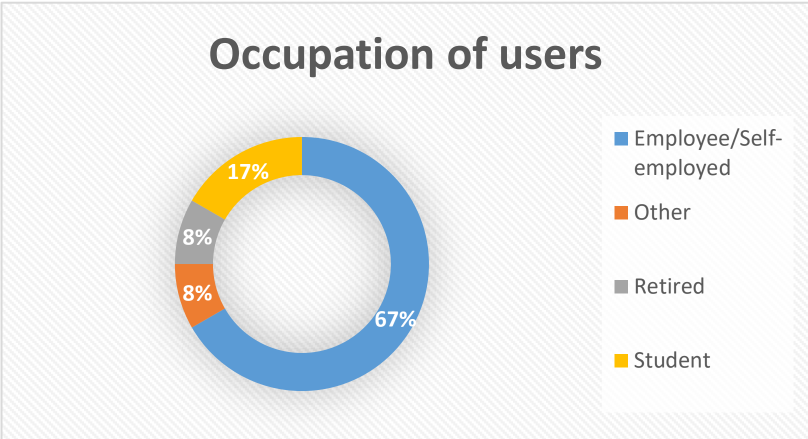


Figure 69: Occupation – Gothenburg respondents.

Most of the respondents are residents (50%) or commuters (34%).

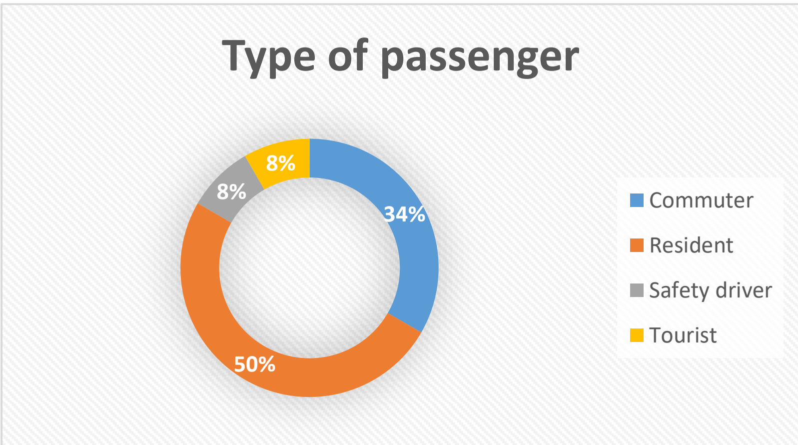


Figure 70: Type of passengers – Gothenburg respondents.

6.5.2.2 User Acceptance Results

The general acceptance score is relatively high, with a mean of 7.61 and a median of 8 with around 13.8 responses. This was because one respondent did not complete 3 out of 10 acceptance survey questions.

Overall, the satisfaction metrics are high across the sample, with the lowest rated factors being usefulness (average score of 6.57) and adequacy (average score of 6.62). Ease of use was rated the highest by respondents, with an average score of 8.38 (median=8). Standard deviations are low, indicating relatively tight distributions around the mean scores, highlighting not so large discrepancies in the scores from the mean. The exceptions to this are usefulness, safety, and adequacy, with standard deviations greater than 2. This is largely due to the occurrence of minimum scores of 1.

As far as safety is concerned, only one person assigned a “1”, the lowest possible score. On deeper inspection, this respondent reported that they had fallen during a hard braking event. This indicated that the occurrence of such events (hard braking, conflicts, accidents…) during a trip have naturally a significant influence on how people perceive the safety of these vehicles.

Taking a deeper look at usefulness and adequacy, we observe that the same 2 respondents gave a score of “1” to both factors. One of the participants did not provide their demographic information. The other participant is the oldest in the sample by far, at 86 years old (the average age is 47), is retired and mostly used the shuttle for traveling rather than commuting purposes. Based on these characteristics, the purpose and value of an automated shuttle does not match the needs of this participant, though they are satisfied with the experience itself of riding an AV. However, considering it is only one respondent, we cannot extract any significant conclusions from this observation, but the link between age, employment status and trip purpose and the evaluation of usefulness and adequacy of AVs can be further examined with a larger sample in future in SHOW.

Table 21: Descriptive data of acceptance in Gothenberg.

Descriptive data	Mean response	Standard deviation	Median	Minimum	Maximum	Number of responses
Satisfaction	8.14	1.17	8.50	5	9	14
Usefulness	6.57	2.82	7.00	1	7	14
Ease of use	8.21	1.12	8.50	5	9	14
Ease of learning	8.38	0.65	8.00	7	9	13
Reliability	7.50	1.79	8.00	2	9	14
Safety	7.14	2.35	8.00	1	9	14
Adequacy	6.62	2.69	7.00	1	9	13
Comfort	7.93	1.14	8.00	6	9	14
Intention to re-use	7.50	1.40	7.00	5	9	14
Recommendation Intention	8.07	0.92	8.00	7	9	14

6.5.3 Stakeholder acceptance

4 stakeholders were interviewed during the pre-demo phase of Gothenburg/ Lindholmen through Teams call and using as a basis the structured SHOW interview form. 2 of them were from KEOLIS and Ericsson, 1 of them coming from NAVYA and 1 of them from Västtrafik.

All of them were males, with an average age of 54 (the eldest contributor was 62 years old, whereas the youngest one was 40 years old). Their educational qualifications are prevalently advanced: 75% of respondents have at least one higher education degree (a master's degree, and a PhD). Among the interviewees, the stakeholder subgroups consist of service providers and operators (75%), as well as authorities' representatives (25%) (see Figure 71). Their primary fields of expertise are telecommunications and IT, new mobility solutions, and project management. The respondents have an average work experience of more than 10 years (in their fields), with a mean of 2-3 years of working experience in automated services and vehicles.

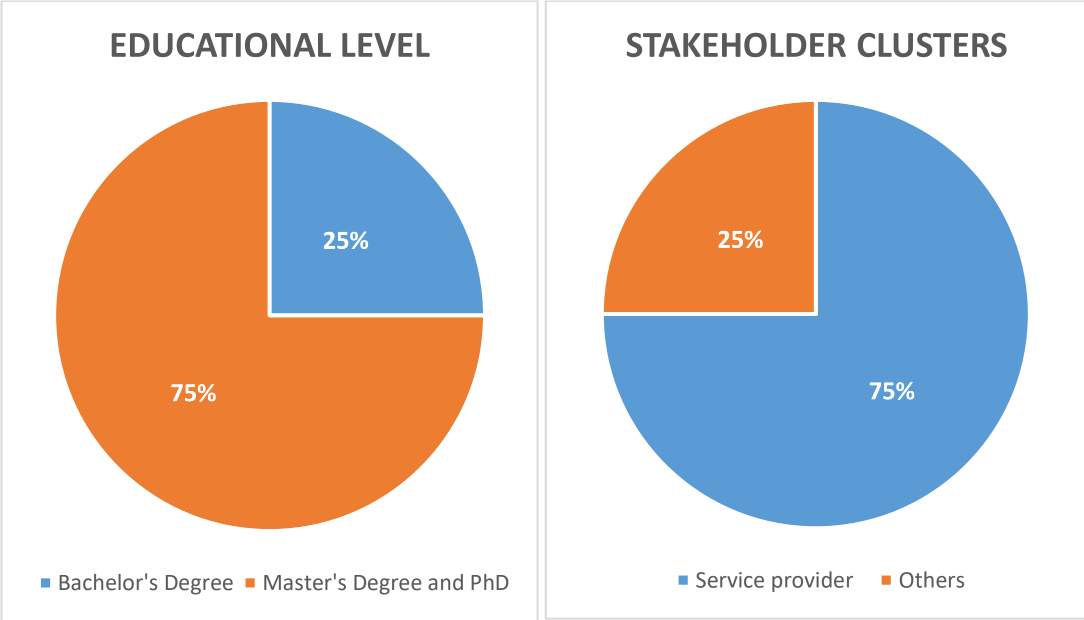


Figure 71: Distribution of education level and stakeholders' clusters in Gothenburg/ Lindholmen.

The key consolidated findings as of the interviews with all 4 respondents are as follows:

- Overall, stakeholders favored the automated services deployed.
- Most of them agreed unanimously that the automated vehicles are useful and pleasant, still not all of them agreed on their effectiveness and robustness.
- Add-ons that were proposed by the stakeholders for the service optimisation (and that could be offered by some of them) were mentioned to be the 5G network deployment, the control tower technology, the dashboard solution, the governance between different actors and the provision of information technology services to the end customers. The add-ons proposed would assist the user groups of automated vehicles with respect to first/last mile connectivity, accessibility, provision of mobility where public transport is lacking and a more reliable service through available service information. Service providers interviewed focused mainly on the first/last mile connectivity and availability of efficient service, while authorities and public bodies concentrated on the need for a more reliable service and accessibility.
- Stakeholders also stressed that past experience in automated mobility initiatives but also business models and testing/ regulatory issues, can radically assist with a successful deployment.
- The **key barriers** mentioned were, on behalf of service providers, operational and implementation aspects, whereas from the authorities' point of view, technology maturity and cost-efficiency of service as well as experimentation aspects.
- Regarding the **expectations** from the project, the interviewees referred to the importance of the **whole value chain stakeholders' involvement**, the **consideration of cultural differences affecting mobility** and the **collaboration between stakeholders relying on trust**.

- Service providers stated that there is **room for improvement** in terms of **knowledge exchange**, **engagement strategies**, **understanding of automated services**, **interoperability of operation across member states** as well as **creating a functional bridge between the automated services primary deployers and the rest of stakeholders**. From a public authorities' perspective, the deployment and acceptance of automated services is associated with **service reliability**, **technical simplicity** and **communication between all stakeholders in order to achieve greater social inclusion and involvement**. With respect to reliability, the integration of the shuttles into the PT system was very useful although ETA was not at all times correct during the field trials, e.g. when technical issues occurred (UC1.2). They also stated that the overall performance could possibly be improved when combining the shuttles with static and dynamic geofences, as tested in this test case, in dynamic or sensitive areas (UC1.3). Also, overall performance could be improved by 5G infrastructure and remote functionalities, particularly in dynamic or sensitive areas. Such/more specific questions should be added in the stakeholder interviews for the real-life demo depending on test case (UC1.6).
- From both stakeholder groups' perspectives, **the SHOW project** enables the stakeholders to enhance organisational aspects, to transfer/ exchange knowledge in different application contexts and for different types of services, to proceed with systemic demonstration and to acquire further expertise for future deployments. Stakeholders highlighted also the importance of combining trials with simulations and digital infrastructure/telecommunication with knowledge about user behaviour/acceptance.
- Service providers' main **concerns** were associated with the **safety issues** as well as the fact that a **consensus regarding decision making seems to lack**. **Insufficient funding** that would allow further in-depth research on vehicle technologies and impact of automated services field trials was also raised as a concern.
- Stakeholders named the importance of a business model, especially for integrating such a service as first/last mile solution into a PT system. One stakeholder pointed out that the tests are important, but that it needs a combination of different factors to successfully integrate AV shuttles in the future PT system: a technical development boost regarding the shuttles, including the digital infrastructure, business model development and reliability of the service for the end users. Currently, also the permission process can be time-consuming and a prompt coordination with local traffic authorities can help to enable good service. The stakeholders participating n the pre-demo rated the importance of the business model "First/Last mile automated transportation to mobility HUBs" as likely to be the most suitable for implementing CCAVs in the short/mid-term. Whereas shuttle solutions might be rather efficient for short routes.
- All participants stated their commitment to continue and get more heavily involved in automated and, in general, green and smart mobility while they all gave credit to the potential of CCAVs for **end-users with disabilities that will have increased chances to equal mobility.**

6.5.4 Research Questions answered for the site

Table 22: Gothenburg/ Lindholmen pre-demo response to SHOW research hypotheses and Use Cases.

Research Questions	Relevant Use cases	Overall response
How will road safety, traffic efficiency, mobility, and user acceptance be affected by AV operation (passenger or cargo) in a real city environment when operated in normal speeds, normal/smooth traffic context, without any traffic or other environmental complexity? Also, interfacing to any of the following modes: PT, DRT, MaaS and LaaS.	UC1.1: Automated passengers/cargo mobility in Cities under normal traffic & environmental conditions – **Gothenburg specific: First/last mile PT at Lindholmen/Gothenburg**	For this test case in specific, about 42% of users strongly agreed that the AV was useful and about 17% of them (strongly) disagreed. About 50% of users strongly agreed that they were satisfied (Likert scale: 9). About 41% of users strongly agreed that the AV was comfortable. None rated lower than 6. There was successful performance detected in this test case when the shuttles were under normal traffic and environmental conditions. Preparation of the route, such as cutting overhanging trees and further clearance of the shuttles track beforehand enabled a smooth operation. **Yet, changes at close-by buildings or construction sites, such as scaffolding or equipment lying around can irritate the shuttles.**
How will road safety, traffic efficiency, mobility, and user acceptance be affected by AV operation (passenger or cargo) in a real city environment when operated in normal speeds but within a complex traffic or environmental context (e.g., curvatures in roundabouts, etc.)? Also, in cases of additional restrictions applied (e.g., heavy traffic, extreme weather conditions, etc.).	UC1.2: Automated passengers/cargo mobility in Cities under complex traffic & environmental conditions - **Gothenburg specific: First/last mile PT at Lindholmen/Gothenburg under complex environmental conditions**	About 25% of the users strongly agreed that the shuttles are safe (Likert scale: 9), most passengers (59%) mostly agreed that the shuttles are safe (scale 7-8), 16% rather disagreed or strongly disagreed. Very positively rated was also the reliability perceived with 92% of passengers that strongly agree – agree that the AV are reliable (Likert scale 7-9). In the same way, users agreed - strongly agreed that the AVs correspond to their needs. 92% of the users indicated that they agree - strongly agree (scale 7-9) to use the

Research Questions	Relevant Use cases	Overall response
		service again and would also recommend it to a friend or colleague. In combination with the long user needs and acceptance studies, more conclusions could be drawn. As it was noticed in this case, severe winter and wind conditions with rain/snow/sleet/hail/foggy in January - April 2021, with temperatures below -14° C can affect the performance. Very cold temperatures negatively affect batteries' autonomy and their charging. During winter, the nights were so cold in the garage, which was a cold storage, that heaters were needed to support good battery condition. Heavy rain and extensive, deep puddles can also irritate the shuttles during operation, further small fragments such as snowflakes or leaves. The shuttle was cleaned every day, inside and outside. All lidars and sensors were carefully cleaned every day to prevent deterioration.
How will road safety, traffic efficiency, mobility, and user acceptance be affected by AV operation (passenger or cargo) in a real city environment when interacting with not automated (not connected) vehicles and/or VRUs?	UC1.3: Interfacing non automated vehicles and travellers (including VRUs) - **Gothenburg specific: Shuttle connecting to other passengers/VRUs at Lindholmen/Gothenburg**	This test case, which was conducted with selected passengers in the area (Ericsson employees), also performed successfully. It was possible to test static and dynamic geofences with the equipment. Yet, the alert/information sent to the shuttle/safety driver was more useful than the information/alert sent to the VRUs due to the test equipment and set-up. This part will get improved for the final demo.
How will road safety, traffic efficiency,	UC1.6: Mixed traffic flows- **Gothenburg specific:**	Although the acceptance results are seen to be

Research Questions	Relevant Use cases	Overall response
mobility, and user acceptance be affected by AV operation in a real city environment when operated in mixed flows with AV and non-AV vehicles?	**First/last mile PT at Lindholmen in mixed traffic**	positive, the conductors are avoiding drawing any conclusions, as especially this test case should be verified in long-term acceptance studies during the final phase. Still, none of the users during the trials made remarks regarding the speed of the shuttles, which might be encouraging. As it was revealed in this test case, operating in mixed traffic flows can affect the performance. As it has been mentioned, the shuttles were operating in mixed traffic on real roads together with other cars, trucks, busses, cycles and e-scooters, crossing streets, bicycle lanes and (pedestrian) crossings on its way, either with prioritization for the shuttle or not. Violations of the traffic rules by other road users happened on a regular basis; this could be related to the reduced speed of the operation in comparison to e.g. other motor vehicles and/or related to human error/ misbehaviour. Due to delivery trucks and site vehicles, time-restricted capacity of passage for shuttles can occur as well as during rush hours. At three points on the route of the site, it has been mandatory for the safety driver to take over the vehicle and verify the environment, as has been considered during the authority audit that there is a risk that shuttles cannot sufficiently process information from vehicles approaching with around 50 km/h.

Research Questions	Relevant Use cases	Overall response
		Under operation in mixed traffic, the shuttles honk to warn other road users, stop at pedestrian crossings/crossings, overtake and/or wait for free passage. It can happen on the way that the shuttles brake abruptly. The safety driver needed to make passengers aware of this beforehand.
How will road safety, traffic efficiency and user acceptance be affected by AV operation connected to a control centre for teleoperation and remote supervision in a real city environment?	UC1.7: Connection to Operation Centre for tele-operation and remote supervision **Gothenburg specific:** Connection to 5G infrastructure for remote supervision	As revealed throughout the operation, this test case performed as expected throughouth the full duration of the trials. The AVs were successfully connected to the 5G infrastructure in the Lindholmen area for remote communication and supervision. There was a deviation in this test case, from the planned test case in Kista, as remote control could not be realised as this was not included in the permission of the STA.
How will traffic efficiency and road safety be affected by automated services at bus stops?	UC3.4: Automated services at bus stops - **Gothenburg specific: Autonomous driving functions at bus stop**	This Use Case also performed successfully. The vehicles/API have a functionality that assists to get back on the road.

6.6 Lessons learned - recommendations

Lessons learned for future final demo phase are as follows:

- In Sweden, the homologation process was to be run in parallel with 2 different entities, the local traffic office and the Swedish Transport Agency, unless you want to prolong the process.
- A first insight was acquired on how to operate in harsh winter conditions, on 5G connection implementation and on interfacing with vulnerable road users, which is expected to prove precious for the coming final demo phase.
- Working in close cooperation with all partners is essential for a smooth operation and permission.
- Business models and further technology development is needed.
- COVID-19 restrictions/recommendations reduced the number of passengers significantly.
- Integration into PT system/app was realized for the first time in Sweden, providing valuable insight on operational processes in near future.

- With regard to UC3.4 (Automated services at bus stops), the potential of automated functions at bus stops would rather be valuable for specific user groups, which were not included at this stage. This needs to be considered for the final pilot phases.
- With regard to the interfacing to VRUs, the information/ alert sent to the VRUs will be reevaluated for the final demo phase.

6.7 Conclusion

Table 23: Readiness level of Gothenburg/ Lindholmen towards final pilots.

Readiness level towards final evaluation round of SHOW				
1 - Not ready at all – A lot to do more	**2 – Not ready – Significant corrections/development/integration and optimisation is still required**	**3 – Half ready; good basis but a series of additional development/integration and optimisation is still required**	**4 – Quite ready to go – several optimisations are still required**	**5 – Almost ready to go – only minor optimisation is required**
		x		
Ranking justification – what needs to be done in short	All use cases were implemented successfully during the pre-demonstration and can be reconducted during the actual demonstration in 2022-2023. But due to the early start of the pre-demo, and despite of the corrective actions done (completion of SHOW surveys by the same respondents), not all SHOW tools could be tested, and studies applied. These processes need to and will be fully applied for the demo in 2022 to allow a fully consistent. Preparation of an alternative route in Gothenburg for the demonstration in 2022 has started. An experimentation was previously conducted by Keolis on this alternative route. The authorization process will consequently be shorter than for the pre-demo.			
Estimation of time required for getting 100% ready for the final field trials	6 to 8 months			

7 Link° ping test site (Mega)

7.1 Introduction

This section describes the activities carried out for preparing, implementing, and evaluating the pre-demo phase field trials that were conducted at the Swedish site of Linköping. **401 passengers were transported with 2 automated shuttles (one NAVYA and one EM) during the pre-demo phase pilots that were conducted in November and December 2021**. In Linköping, there was an approach followed in conducting an as short as possible pre-demo pilot phase so that the site would proceed fast to the open to the public pilot phase (which it did).

7.2 General

7.2.1 The ecosystem

The Linköping site has a local demo board consisting of eight members.

Figure 72: Linköping's local ecosystem partnership.

The local board meets once each week (starting from the pre-demo phase and for the full duration of the final phase). In addition, Combitech, Veridict and Edeva is involved to solve specific solutions relevant for only SHOW. They are connected to one of the working groups focusing on Digital infrastructure, that is led by RISE Linköping. The Linköping Ecosystem is presented in the following table and in 7.2.6.1 on more operational level.

Table 24: Linköping ecosystem.

Participating Entity	Internal to the Consortium	External to the Consortium	Role
VTI	√		Site leader and responsible for the evaluation. Financial support of the shuttles, acting as depot, providing the workshop for service and installations. Owner or 1 shuttle.
Transdev Sweden	√		PT operator. Responsible for the daily operation with 8 shuttle safety operators. Financial support of the shuttles. Management and support for the daily operation. Owner of 2 shuttles.
Östgöta trafiken AB		√	PT provider. Responsible for the connection to PT. Financial support of the shuttles.
RISE	√		Responsible for the digital infrastructure and solution including Dashboards, stream of data to DMP, visualisation of maps, rider information, etc.
LiU		√	Hosting students, one of the key traveller groups also involved in

Participating Entity	Internal to the Consortium	External to the Consortium	Role
			land use issues. Financial support of the shuttles.
Linköping municipality		√	Owner of the ground in Vallastaden, responsible for communication issues, and infrastructure solutions like bus stops etc. Responsible for the maintenance and service at Vallastaden, Owner of the school and the retirement home with one of the key travelling groups. Financial support of shuttles.
Akademiska hus		√	Owner of the ground, responsible for maintenance and service at Campus.
Combitech	√		Responsible for the dashboard and the preparations toward a remote solution.
Linköpings Science park		√	Responsible for connection to the companies at the technology village.
Veridict AB	√		Subcontractor to VTI, developing the connection to user applications for booking and visualisation.
EDEVA	√		Provider of system for accelerations in three dimensions with high sampling frequency.
Webropol AB	√		Provider of the customer rating of satisfaction and its dashboard.

7.2.2 The setting

In Linköping test site, the geographical context is considered as important to evaluate how the mobility service and its technology fits into a real-life context. Partly the University area (in the middle of the map (Figure 73)) are used to evaluate conflicts and interaction and collaboration with pedestrians and bicycles.

Nearby the university there is a newly built residential area, Vallastaden, built with smart city in mind with relatively few parking spaces and optimized for walking and cycling. In Vallastaden there is also a school and a retirement home for elderly people. The closest PT bus stop is almost 300 meters away and the shuttles are aimed to provide a first and last mile solution to the nearby trunk line. To the west an industrial and business area lies, called Linköping Sience park “Linköpings Silicon Valley” where tech companies with 1000 employers who are commuting on a daily basis. However, this area is not connected to the current driving path at the moment. People work here, people study here, people live here and need to be transported in between.

The route is approximately 4 km long with 13 bus stops which are both shared with PT and explicitly only for AVs. The AV’s depot is located at VTI’ backyard approximately 200 meters from the main autonomous line.

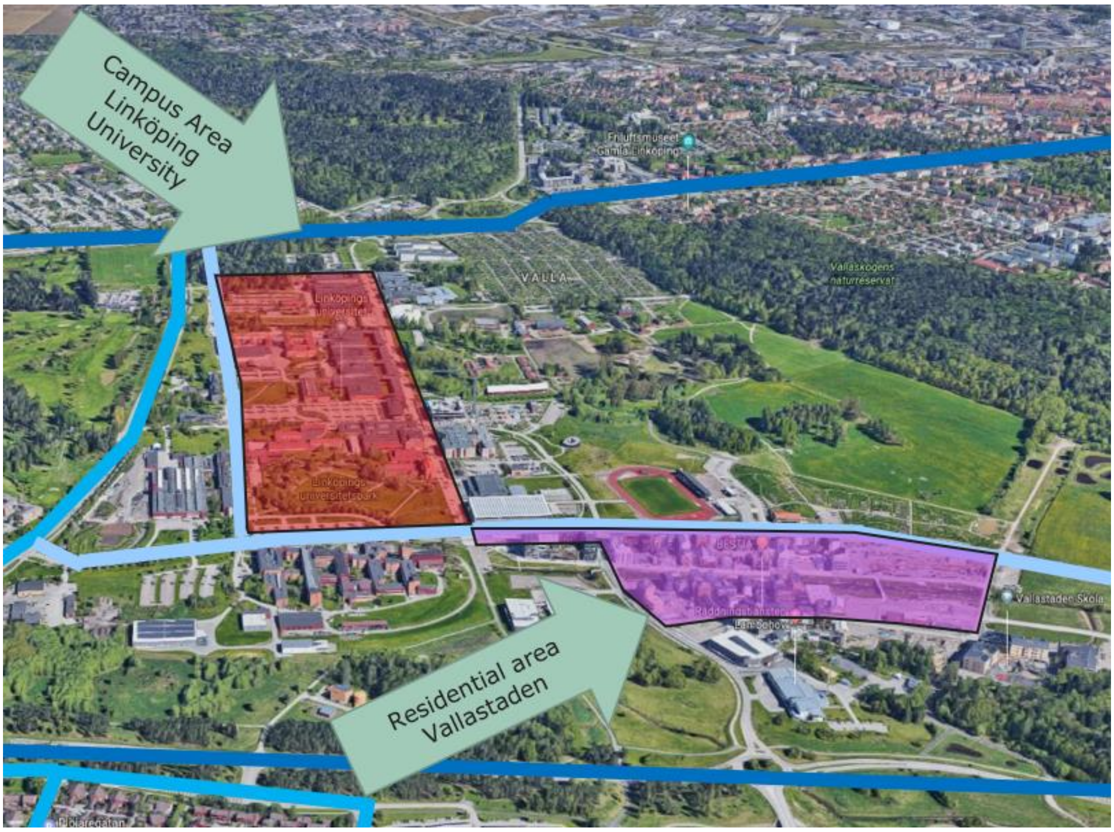


Figure 73: The geographical context in Linköping's Pilot site. The red area states the Campus and the purple area represents the Vallastaden residential area. The blue lines are illustrated as normal PT trunk lines.

Figure 74: The autonomous driving path in detail, specifying length and bus stations as well as the representation of a merged AV and PTA bus stop and an explicit AV bus stop.

Eight safety drivers working for Transdev Sweden AB were responsible for the daily autonomous operation service. Weather conditions were typical of autumn season in southern Sweden with a combination of sun, rain, dry and snow conditions. No fog was detected. The shuttles are equipped with winter tires.

Thanks to the varying weather conditions, the site has learned the importance of maintenance and had to focus on problems related to hard braking due to external issues like leaves, snowbanks, etc. On the other hand, the mix of road type provided the site with a greater understanding about the potential of AV operation, but also revealed the barriers. The most demanding situation was when the campus was crowded with pedestrians and cyclist, as well as in Vallastaden during mornings with lot of parents leaving their children at school.

For more details about the pre-demo phase conditions, see the following table.

Table 25: Road, traffic, and weather conditions at Linköping.

Variable	Linköping
Weather	Temperatures varied between 10° C to -5° C
Sight conditions	Good. This is a requirement to have the right to drive.

Variable	Linköping
Road type	Urban road with paths for pedestrians, shared space at Campus, dedicated PT designed road.
Road works	The part Vallastaden is an area under construction. Thanks to a good collaboration with the municipality the respect between the shuttles and the construction builders were good.
Incidents	One safety operator fell due to unforeseen hard braking.
Traffic conditions	High density at mornings and evenings in general. At the Campus there are a lot of VRUs before start 8 CET, at lunch 12-13 CET and at end 16 CET) otherwise the area has more moderate volumes.
Traffic composition	Depening on where on the route the shuttles are, it differs. The site is a combination of ordinary urban road surrounding a Campus with mainly passenger cars to interact with (but also some zebra crossings), a dedicated area through Campus with only high interactions with pedestrians and cyclists, and then a residential area with a lot of ordinary PT coming across a lot of interactions with busses and different type of cargo vehicles.
Traffic control	There is no physical traffic control that is digitalized.
Area type (In- or outside built-up area)	Most part around Campus and at Campus is in a typical peri-urban environment, the residential area is under construction and more city center like.

7.2.3 Field trials operation timing

The pre-demo phase for Linköping was run **between November - December 2021**, after the realisation of then verification and validation procedure. However, preparations and operation has been done stepwise on part of the route since mid 2021.

7.2.4 The Fleet

The Linköping pilot site consists of a total of 3 AV shuttles (2 EasyMile EZ10 Gen-2 and 1 Navya DL4 Arma). During the pre-demo phase two shuttles (1 EM and 1 Navya) were used, while the planning and integration of a third shuttle took place to however get deployed only in the final demo phase of the site.

Figure 75: The three AV shuttles in Linköping. The middle shuttle is a Navya DL4 Arma, the two on the sides are EasyMile EZ10 Gen2. Photo My Weidel, VTI.

Table 26: Linköping fleet characteristics.

Test/Use Case [ID as of D1.2]	Deployed fleet characteristics								
	Vehicle brand & model	**Vehicle type**	**SAE Level reached for the field trials [1-5]**	**TRL level reached for the field trials [1-9]**	**Summary of upgrades held during the project (check also D7.1, D7.3 & D7.4)**	**HMI and Hand-over strategies (in consistency with D7.2)**	**Maximum speed reached during the trials (km/h)**	**Average speed during the trials (km/h)**	**Maximum capacity of vehicle**
Same for all UCs: UC1.3; UC1.6; UC1.7; UC3.1; UC3.2; UC3.4:	EasyMile EZ10 Gen2-036	Shuttle	4	6	SW version Voyager 7 updated to SW Voyager 11	SW version Voyager 7 updated to SW Voyager 11	17	4,9	11 PAX excluding operator (5 during Nov-Dec due to COVID-19)
	Navya DL4 Arma	Shuttle	4	6	SW version 4.11.3 updated to SW 6.1.4	SW version 4.11.3 updated to SW 6.1.4	19	3,7	13 PAX excluding operator operator (6 during Nov-Dec 2021 due to COVID-19)

7.2.5 The Infrastructure

The infrastructure consists of two parts: Campus and Vallastaden. The first part of the Campus part is on public road with interactions with PT and other passenger cars, the second part is through the heart of the Linköping's University using the shared space with the path for cyclists as the road. The Vallastaden part is only on public road, passing through a construction area ending up at the school by Linköping's municipality and retirement home for people with cognitive disabilities. The route was extended during the final demonstration and included a turn back loop through Paradisgatan making the route as two circles, see red markings in the map.

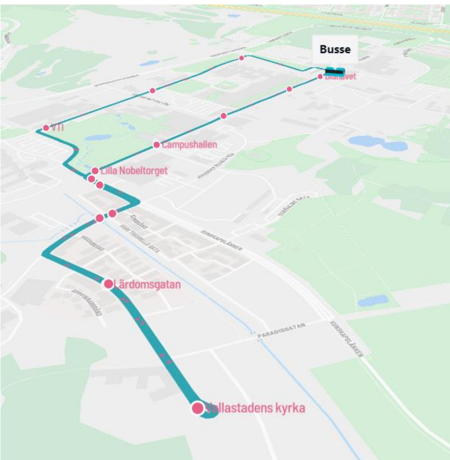


Figure 76: Digital map of the Linköping pilot test site.

7.2.6 Users & Stakeholders

7.2.6.1 Passengers and stakeholders in the loop

The preparation of the test site was heavily dependent on the collaboration within the local demo board. The group had weekly meetings solving raised day to day questions. There was also a steering group that had an overall responsibility and took decisions. The work was divided into six working groups with one representative (underlined below) at the core group meetings, see Figure 77.

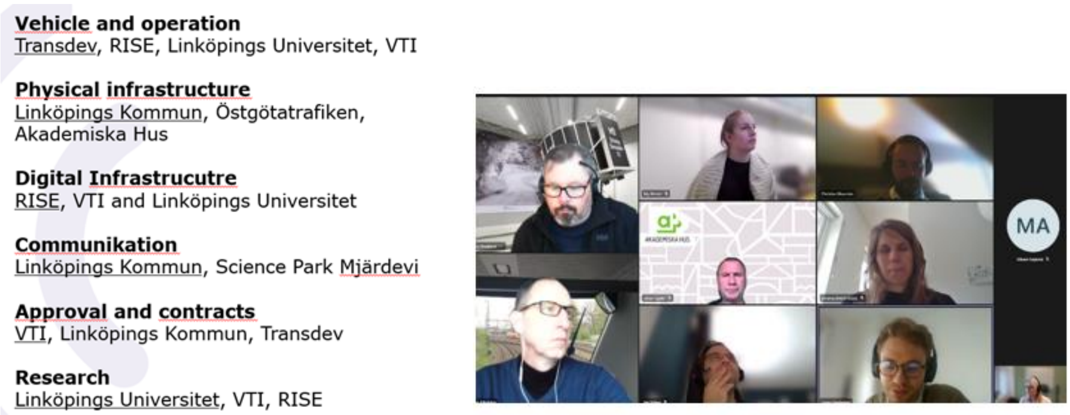


Figure 77: Local Linköping demo board meetings with the test site partners.

Several activities have been conducted during the preparation and the pre-demo pilot phase to understand the user group in focus (children and elderly) needs and wishes. On-board studies took place with children during normal conditions and more demanding situations (i.e. adverse weather conditions) - see Figure 78.

Figure 78: User engagement in Linköping with children - screenshots of paintings, elderly and blind persons with guide dogs.

Numerous dry runs have been performed during day-to-day operation by mapping and gathering preliminary user and technical input to develop and streamline the Linköping pilot site further before real-life demonstration begins.

During November and December 2021, **401 passengers** have been transported, as seen in Figure 79. The passengers were mainly students at Campus, employees at Campus and visitors to the area. No specific invitations were sent out. However, the safety operators at Transdev were very active inviting people to come on board and join the ride. There was a barrier to get people on again after the restrictions from Covid and when the shuttles have been running for technical test, but without passengers.

In parallel to the pre-demo phase external passengers and travellers have attended and experienced the mobility service of the automated shuttles.

The number of passengers and the driven km are presented in the following figures. It can be observed that during winter season and Christmas holidays in December 2021, the number of passengers is heavily reduced.

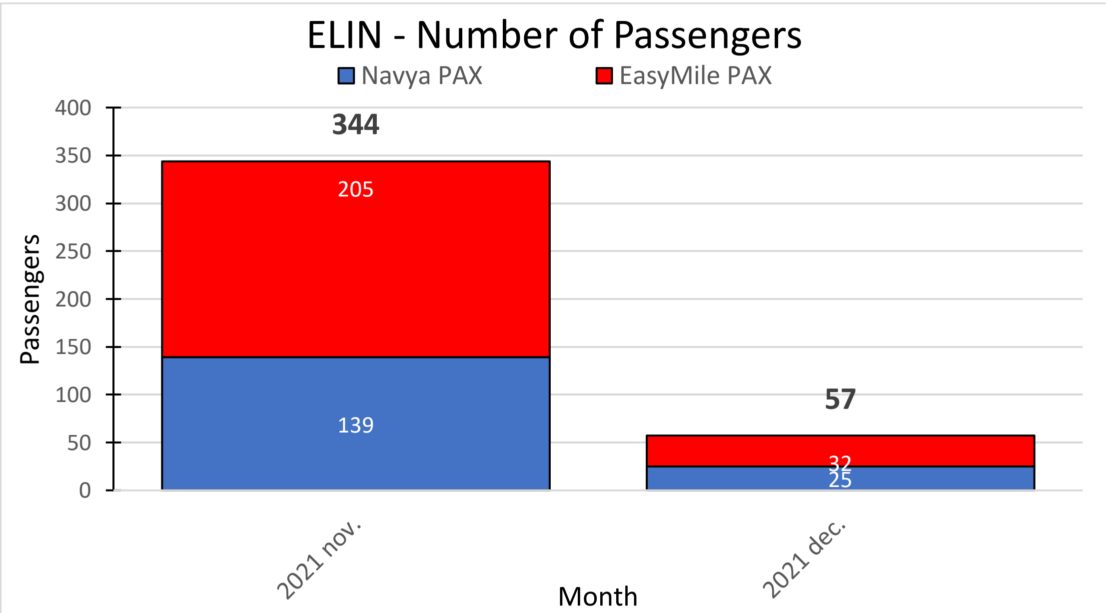


Figure 79: Monthly number of passengers riding with to each shuttle brand - Linköping.

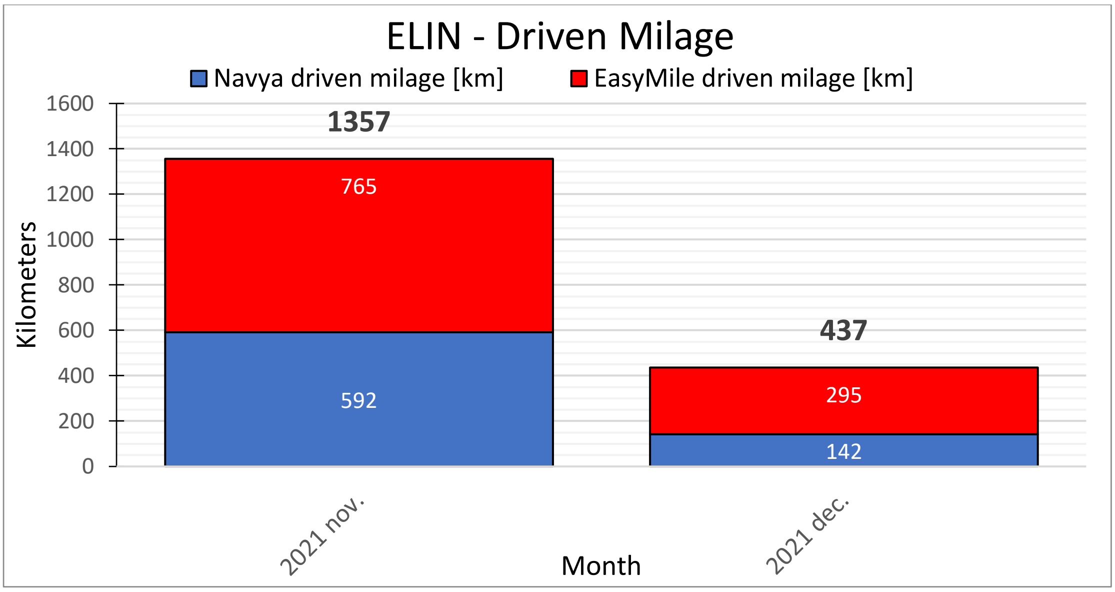


Figure 80: Monthly driven kilometres related to each shuttle brand - Linköping.

7.2.6.2 Local campaign and strategies for awareness, recruitment & engagement

One of the workings groups has been dealing with external communication and has arranged several events such as kick-off when new AVs are up and running or when a new part of the route is opened, etc. In total four videos have been created to show and inform VRUs and other road users on what to expect in relation to the automated vehicle's behaviour.

7.2.7 Business Models

A workshop has been done between Transdev, VTI and Vedecom identifying the most relevant BM for Linköping. The most relevant Business model (BM) selected was BM 7: Sustainable living areas with autonomous public transportation (see D2.2 for more details on that).

The objective of this BM is to provide improved mobility solutions in a newly built residential area (former exhibition area) in order to challenge the usage of the privately owned car and its utility model. A special attention is given in this business model to the impact on inequality and the access of people with special needs to the transport and providing first and last mile transportation to the nearby PT trunk lines.

7.3 Preparatory Process

7.3.1 Permits

As in Gothenburg site, the permission for running the operation with AV shuttles followed strictly the requirements and process anticipated by the Transport Administration (Figure 81).

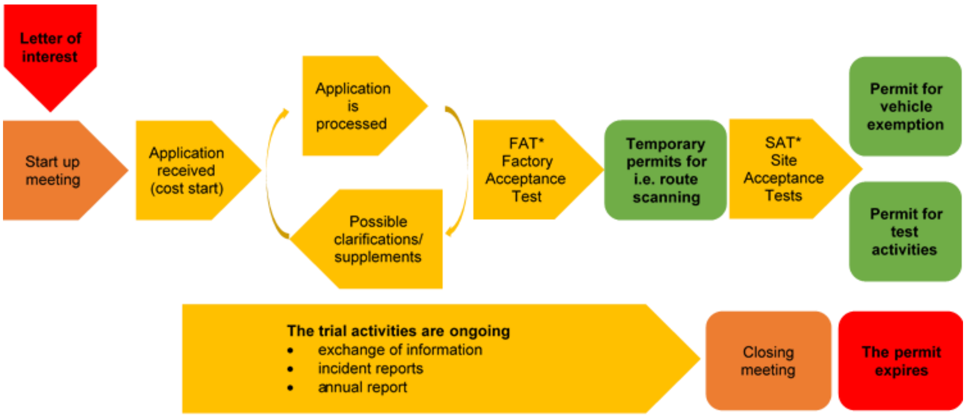


Figure 81: Illustration of the Swedish application process for trials with self-driving vehicles.

7.3.2 Development/Customisation/Integration

During the preparation phase the shuttles were equipped with safety belts and a safety arm as a support for the safety driver in case of hard braking. In addition, cameras to be used as mirrors were installed in the cabins.

Figure 82: Safety belt for incidents' avoidance - Linköping.

Also the infrastructure had to be adapted. Lidar signs were made at VTIs workshop and mounted in the area in line with the OEMs requirements. In addition a GNSS mast was installed for local mapping.

7.3.3 Training

During the pre-demo phase, some safety drivers lacked the specific training to manoeuvre both brands of shuttles. Still, for the final demo phase, they have been all educated in order to have the right competence and knowledge to operate both brands. This is crucial to make the operation less dependent on specific individual drivers and to secure the long term personal management. It is required that the drivers have the D-driving, a valid professional driver competence (YKB in Swedish) and the relevant education required by each AV provider, which takes 3-4 days to complete.

7.3.4 Ethics & GDPR

No sensitive personal information is collected, hence no ethical application was needed. For data collection involving children the parents signed an informed consent. This was a procedure handled by the school teachers. The ethics checklist has been printed, checked, signed and a pdf version is uploaded at SharePoint of the project.

VTI also performed a DPIA included in D3.5. For the processing of data the Controller/Processor have a valid lawful basis to Process Personal Data. In Linköping this is a public task. This is decided by the Controller/Processor and documented.

7.4 Pre-demonstration study design

7.4.1 Test Scenarios

7.4.1.1 Use Cases – Test Cases

In Linköping 7 use cases are anticipated to be covered, with the following site specific test case descriptions:

First & last mile public transportation in normal conditions (responding to UC1.1)
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 meters and hence too long to walk. The work is connected to the PT service. Thanks to the AV shuttle the children and elderly will be able to access the PT.

First & last mile public transportation at shared space with VRU (responding to UC1.3)
The area at the Campus Core consists 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 outer boundaries of the area. The work is connected to the PT service.

First & last mile public transportation in mixed traffic (responding to UC1.6)
In the area of Vallastaden the operation is done on normal traffic road and integrated with passenger cars, buses and trucks using the same lanes. In addition, pedestrian/cycle crossing exists, sometimes with prioritisation for shuttles and sometimes not. The work is connected to the PT service.

Linköping operational Dashboard (responding to UC1.7)
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). To make this happen we use the Combitech SAFE platform, that has been further developed.

On-demand stop signal at bus stops (responding to UC3.4)
The shuttles intend to stop only when there is an actual demand. Using the shuttles control APIs, the shuttles will stop only when travellers want to get on or off board. A simple but integrated and connected “stop button” is placed along the route. The stop button placed at each bus signed bus stop are installed and connected through a Nifi network to the app showing positions of the buses to passengers (developed by Veridict), but also show the bus operator if passengers are waiting at a specific stop. The work is hence connected to a DRT service.

Route optimisation based on passenger counting (responding to UC3.1)
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. The work is connected to a DRT service.

Personalised route (on & off) suggestions (responding to UC3.2)

This is not a use case that was tried during the pre-demo. The purpose is that combining Linköping MaaS, real time data city wide public transport information, historical travel data and passenger information, it will be possible to suggest the most optimal way of transport for all individual users of this service in terms of where and when to embark and disembark. The system considers the users' personal preferences and/or limitations e.g special needs.

- 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).

7.4.1.2 Mobility services & apps

In Linköping a solution has been developed to support travellers to know where the shuttles are in real time and to send information to the safety operator that they want to ride (Figure 83). This map also shows the normal PT buses. This solution has been developed by Veridcit AB (VTI subcontractor) and first version were tested during the pre-demo.

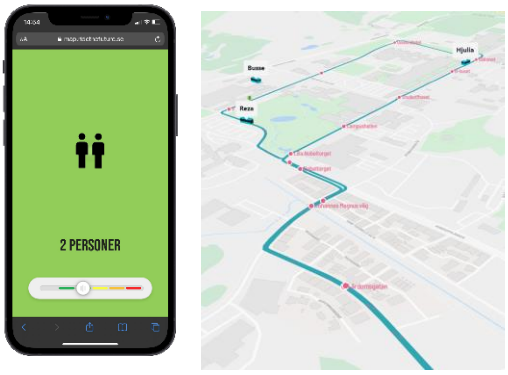


Figure 83: Where is the bus - I want to go (see: www.ridethefuture.se) - Linköping.

7.4.2 Evaluation methods & data collection tools

7.4.2.1 User surveys

The site followed the formal evaluation protocols of SHOW for the subjective views collection (as presented in D9.2). The pre-demo acceptance survey was distributed through Facebook, in total 20 responses were achieved at this phase (no analysis takes place in the current Deliverable as this is an objective of D1.3: Stakeholder & travellers needs evolution through Pilots). For the acceptance survey, the respondents were asked to use a QR pointing at the survey implemented in the survey tool Netigate. The one question about satisfaction was implemented on a touch screen using five smiles from happy to not happy. One screen is implemented in each AV.

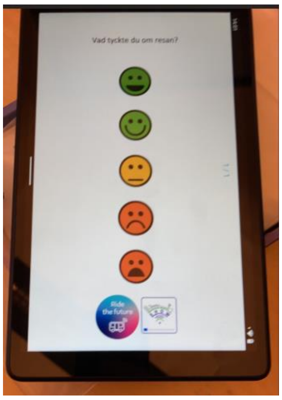


Figure 84: Touch screen for satisfaction reporting - Linköping.

Interviews with stakeholders took place in December 2021. Three different stakeholders were interviewed using the prepared interview guide presented in D9.2. The received information was summarised and uploaded using the Netigate tool provided by AVL (see section 7.5.3 for the results).

7.4.2.2 Vehicle data

To collect daily events for further analysis and to count passengers per day a solution for the bus drivers was developed by Transdev Sweden. This is a part of the Ride the future initiative and all information collected is included in the data uploaded to the DMP (see section 11).

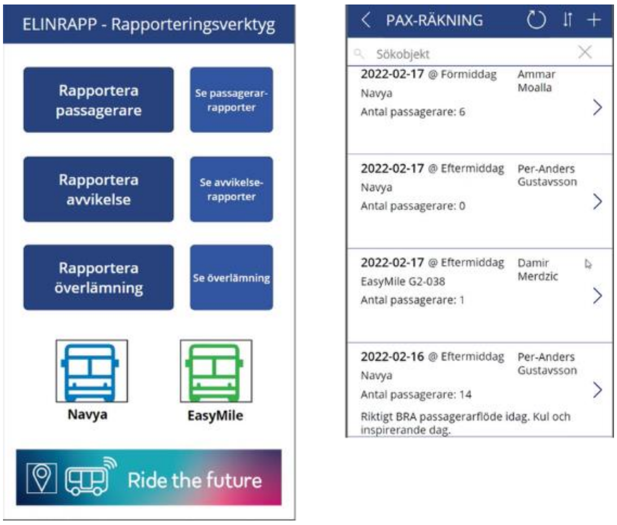


Figure 85: The daily event logging app developed by Transdev Sweden capturing traffic deviations and passing operational relevant information to the next driver - Linköping.

Observations needed to calculate the relevant KPIs took place during November and December 2021. The data was logged and uploaded in real time to the local data management platform (see Figure 86). The real time data was simultaneously streamed to the local dashboard (innovation cloud – see also Gothenburg site), and later also to the central to SHOW DMP were relevant KPIs were calculated and then visualized in the project Dashboard. Based on the data provided from the available API coming from the shuttles it was clear that the resolution, especially for the acceleration, was too low. An extra system with accelerometers were installed in all three shuttles with a possibility to have data about x,y and z accelerations with a frequency of >50 Hz.

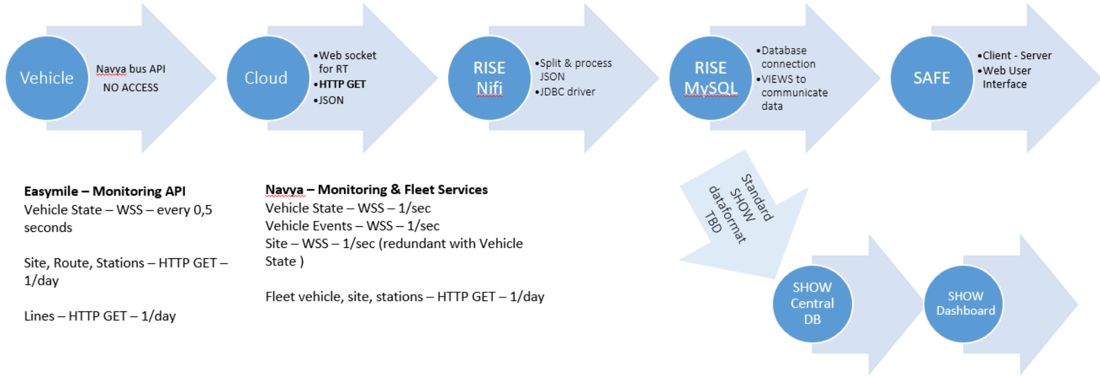


Figure 86: Overview of data collection architecture - Linköping.

The data from the vehicles and other related data is collected via a data collection tool called Nifi[1]. It is a graphical tool that can be used to design data collection system (Figure 87).

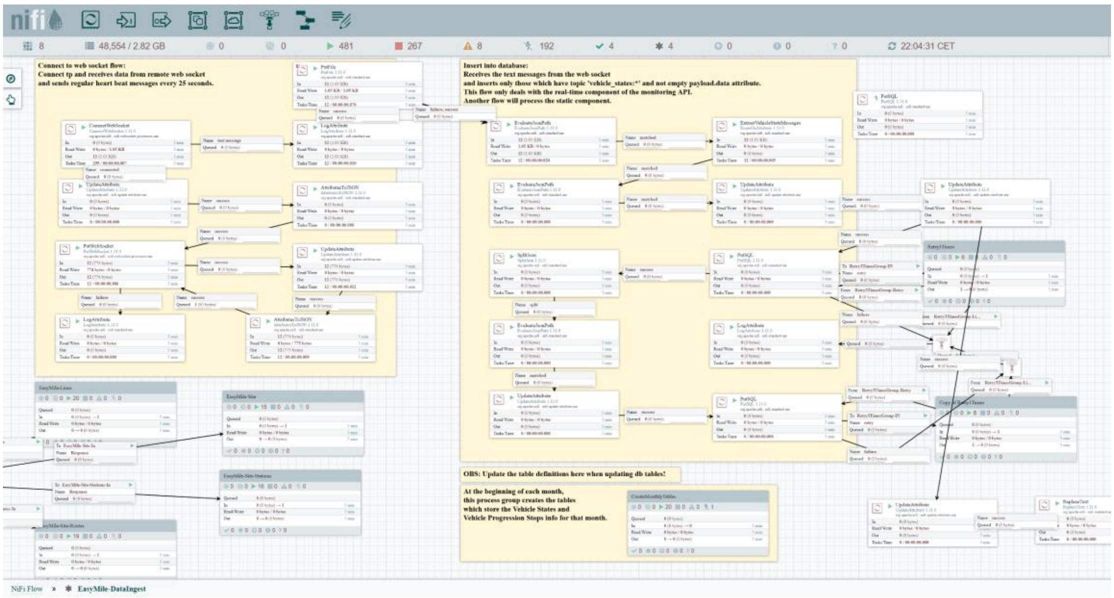


Figure 87: Screen shoot of the Nifi data collection flow for the Linköping site.

As mentioned, the collected data is then distributed to other system such as the SHOW DMP and more local tools as site dashboard maps and analysis tools.

[1] https://nifi.apache.org/

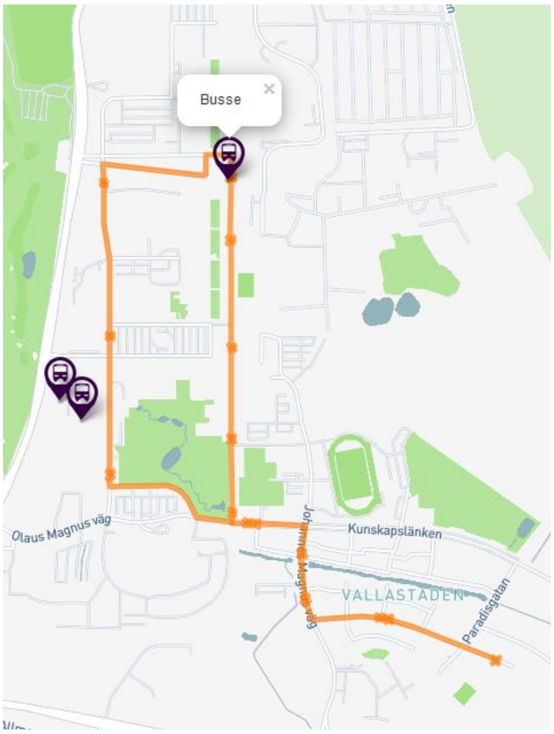


Figure 88: Local Map solution to show the automated vehicle's position in real time - Linköping.

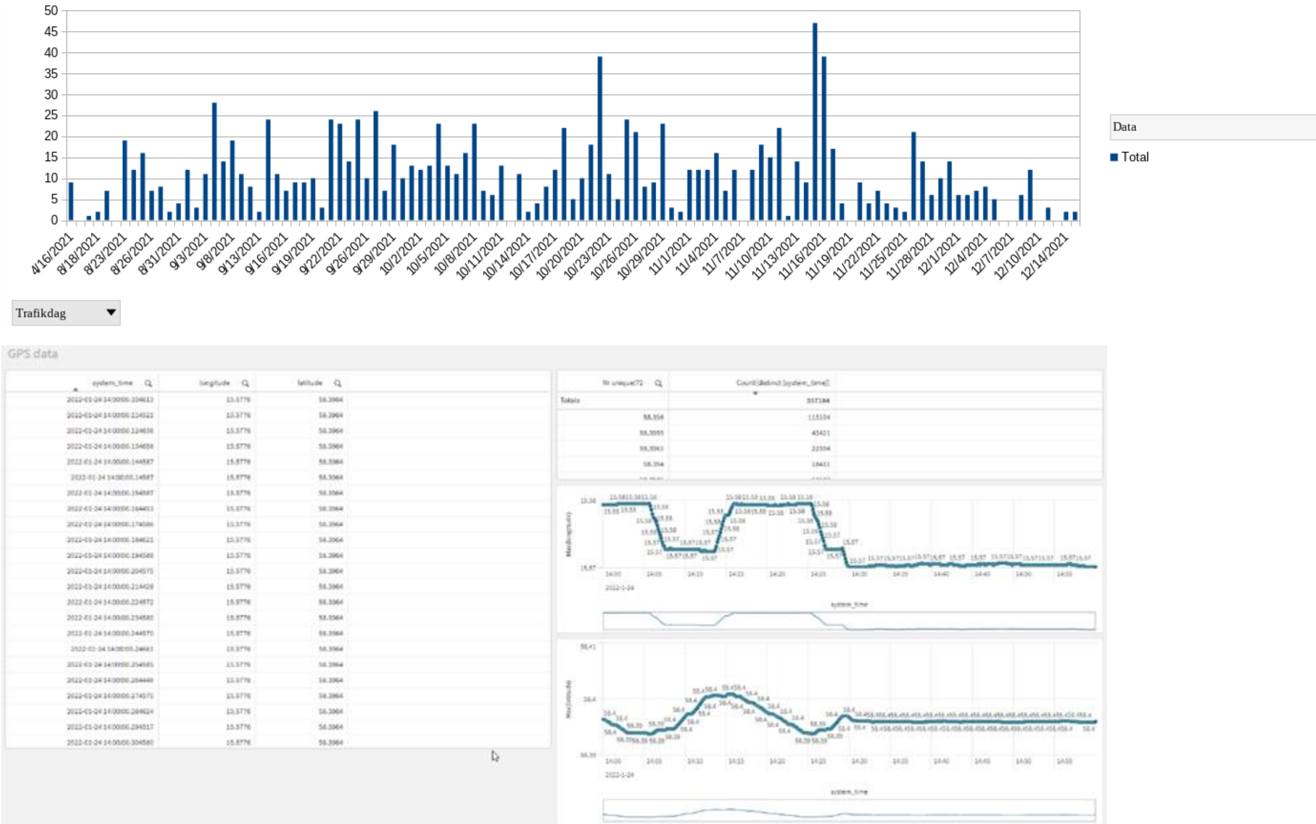


Figure 89: Examples from two of the local data analyses toolbox. Top: Passenger counts per day. Below: High resolution GPS coordinates vs gyro and accelerometer data - Linköping.

The key list of KPIs related to the real time vehicle data was reviewed in collaboration with CERTH in WP5 and was logged in DMP to be then be visualized in the Dashboard.

In addition, a system with higher resolution for accelerations has been installed, measuring on 50 Hz, to be able to calculate jerk (Figure 90).

Figure 90: EDEVA system for 50 Hz measures of accelerations - Linköping.

7.4.3 Experimental process

A typical day of field trials looked as follows for the site.

> During a normal test day the operation with the shuttles started at 8.00 in the morning, leaving the depot at VTI. The 2 shuttles were up running in parallel. During the day the safety drivers had a shift change with 2 new drivers taking over after lunch and operating until 18 CET. The shuttles were charged a lunchtime, however most often one was out driving, and one was charged. In the end of the shift the shuttles were taken back to the depot, cleaned, and charged.
>
> Throughout a day the driver invited persons along the route to get on-board.
>
> The pre-demonstration was also about testing the evaluation tools from WP9 to be able to adapt and improve the tools. Linköping was one of the first site testing them out. During the end of the pre-demo they also asked if they were willing to answer the acceptance survey and also if they could rate their satisfaction from the ride.
>
> After the pre-demo period interview with key stakeholder took place and the results were reported into Netigate. Needs for revisions were identified and input were provided to the WP9.

7.5 Pre-demo phase field trials results

7.5.1 Overall performance results

As already presented, the site has applied all relevant tools in order to collect and stream real time to SHOW all key data/KPIs (i.e. vehicle position, speed, number of passengers, etc.). Those have been reviewed in WP5, logged in the project DMP and then visualised in the project Dashboard. The site had also additional data sources (i.e. event diaries of safety drivers on accidents, etc.) that have been used for complementing some KPIs, while environmental data like CO_2, dust particles, and weather data have been collected in another project and is under exploration on how to be merged in SHOW data streams. The key consolidated KPIs for the pre-demo phase of the site are provided in section 11.

7.5.2 End-user acceptance

7.5.2.1 Demographics

During the pre-demo phase fully completed responses in Netigate **totalled 9**, with 7 reporting their socio-demographic characteristics. This sample has a mean age of 49.43 years old, a median of 57 years old and a standard deviation of 16.7. The sample has an over-representation of women (86%) and PhD holders (71%). Furthermore, a high percentage of travellers overall came from a rural area (86%), followed by urban areas (14%).

Table 27: Distribution of Age in Linköping.

Descriptive data	
Mean response	49.43
Standard deviation	16.7
Median	57.00
Minimum	22
Maximum	65
Number of responses	7

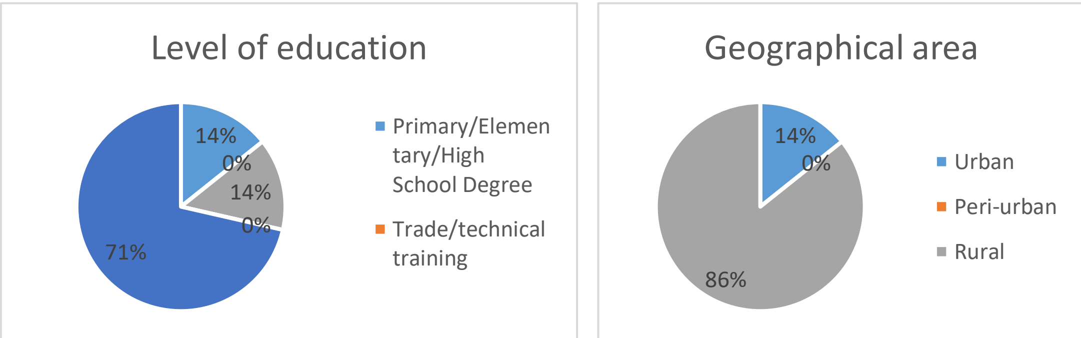


Figure 91: **Distribution of the level of education and geographical area of respondents in Linköping.**

7.5.2.2 End-user acceptance results

Of the responses collected in Netigate, 9 are completed and are considered for analysis here. The acceptance score of respondents (who provided full answers) is relatively low with a mean response of 4.28, a median of 5.00, a standard deviation of 3.19. Looking deeper at the individual acceptance elements, we see that most are scored **below 5 on average**, though **high standard deviations indicate some high peaks**. **Adequacy is considered the worst performing element of acceptance**, as not only the mean is the lowest (3.56), but the median is as well (1, indicating that 50% of the responses are equal to or lower than 1).

Table 28: Descriptive data of acceptance in Linköping.

Descriptive data	Mean response	Standard deviation	Median	Minimum	Maximum	Number of responses
Satisfaction	4.22	3.27	4.00	1	8	9
Usefulness	4.33	3.39	4.00	1	8	9

Descriptive data	Mean response	Standard deviation	Median	Minimum	Maximum	Number of responses
Ease of use	4.67	3.67	5.00	1	9	9
Ease of learning	4.33	3.28	5.00	1	8	9
Reliability	3.78	3.03	3.00	1	8	9
Safety	4.22	3.19	5.00	1	9	9
Adequacy	3.56	3.13	1.00	1	8	9
Comfort	4.22	3.15	5.00	1	8	9
Intention to re-use	4.80	3.76	7.00	1	9	9
Recommendation Intention	4.56	3.47	6.00	1	9	9

The influence of geographical area and gender could not be evaluated due to the lack of representation of all areas, as 6 out of the 7 respondents that reported their demographic characteristics (86%) are women and report to coming from rural areas. Other areas and genders are thus not represented enough to make reasoned inferences.

Travellers with lower education levels generally found the service to be useful, easy to use, and adequate for their needs. **Whereas respondents with the highest education level** (Phd) **scored most elements of satisfaction very low** (average scores are between 3.6 and 5.2). While it seems that the pattern is that highly educated respondents report lower scores on average, that is likely due to the presence of only two respondents that have completed a lower degree. As a result, we cannot claim – for now - that there is a correlation between education levels and acceptance levels. Still, this remains a finding to be revalidated in the final phase complete analysis.

We observe that around 4 respondents report very low scores ("1" for most metrics). At deeper inspection we see that one of the respondents report that **hard braking was an issue raised for them**, and this was reported by other participants as well. Therefore, we see that the occurrence of events like conflicts and hard braking events can have a significant negative effect on the evaluation of the service. The correlation of subjective and performance data, provided in section 11 validates this conclusion.

Aside from the quantitative evaluations of the service, some comments that some participants provided to open questions are quite interesting. The first one was related to the purpose of the AV trip, and the main motivations were **curiosity** and interest to experience an automated shuttle. Overall, the interest in the service stems mostly from its novelty.

Still, the most common issue reported and stressed also in the qualitiative comments was regarding **hard-braking** and its consequences on the operations of the shuttle. One participant commented that rapid braking was a problem, and that "The entire system was even shut down at one point". Another one mentioned as well that "Buses stopped without warning."

7.5.3 Stakeholder acceptance

According to the interview responses, there are 3 interviewees with a mean age of 41.33 years, a median of 39 and a standard deviation of 14.64. 2 of them were male and one female. 66.67% had a bachelor's degree and 33.33% a Primary/Elementary/High school degree background. One of them came from the public administration and 2 of them were representing transport providers/ operators.

Their areas of expertise are essentially public transport, business development, innovation, and traffic operations. The respondents had an average of about more than 10 years working experience in their fields, with an average of about 5 years of working experience in automation in specific. Still and despite this later experience, they stated that they have never participated in the past actively in real-life operations or demonstrations and highlighted how much insightful this has been.

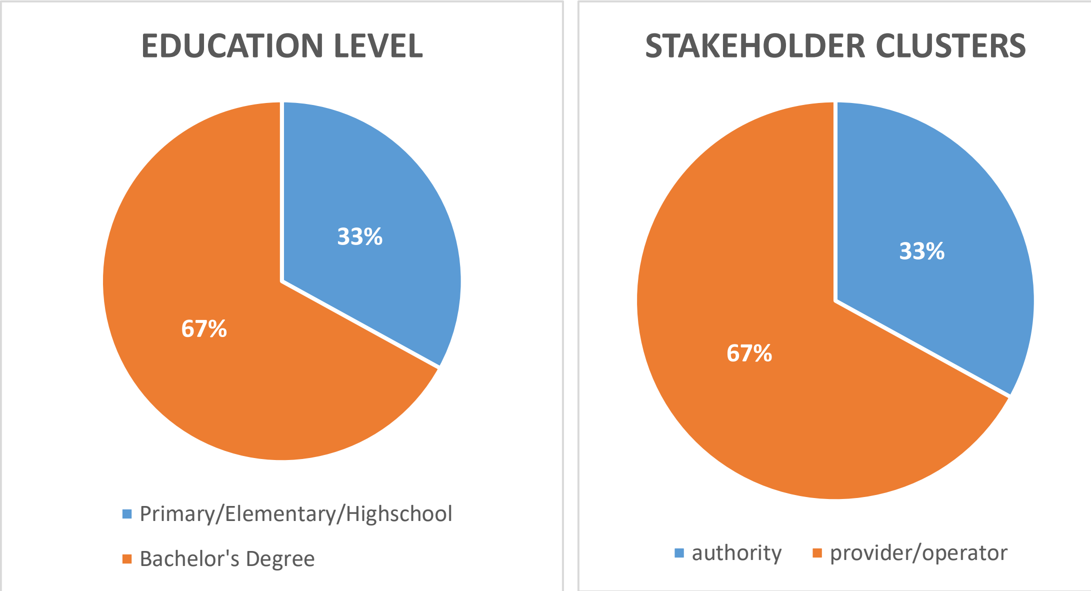


Figure 92: Distribution of education level and stakeholders' clusters in Linköping.

The key consolidated findings as of the interviews with all 3 respondents are as follows:

- The stakeholders claimed that there are certain critical aspects that ought to be addressed for the success of the integration, exploitation and implementation phases of the automated service, sich as service responsiveness, safety, cost efficiency and social inclusion. Specificall stakeholders with experience in public transport operations, stressed that it is **vital to focus on the intuitive behaviour of the shuttle, on mature technical solutions, cost-efficient business models in the long-run, validated operations and cleal communication to the public but also all stakeholders how it works. The later is especially important for people with disabilities or any other special mobility requirements.**
- The need for a **higher speed was also stressed**, such as the necessity to eliminate unpredicted stops and unecesary hard-brakings.
- New funding opportunities, even within SHOW course, were favoured by all, while they stated that effort should be concentrated on **exchange of know-how** (across different mobility contexts and cultures), **engagement of citizens** and **deeper understanding of technologies deployed**.
- The interviewees with expertise in public administration further emphasised the requirement to ensure a **good cooperation among the various partners and stakeholders** and an interaction between municipalities, other public agencies, citizens, and particular user groups.
- They criticized that automated mobility services will come to **address first to last mile solutions from mobility hubs** and will **basically favour those who are unable to walk or cycle.**
- Despite the overall positive feeling, the stakeholders shared their concern that the ambition of SHOW is greater than the achieved technology maturity. Which, in turn, **pushes to infrastructure adaptation (rather than vehicles upgrade),**

challenges in the operator role where the shuttles are built to be driverless but still need on-board operators to ensure a complete service provision. Engagement of citizens, and especially of senior and younger ones is also challenging.

7.5.4 Research Questions answered for the site

Table 29: Linköping pre-demo response to SHOW research hypotheses and Use Cases.

Research Questions	Relevant Use cases	Overall response
How will road safety, traffic efficiency, mobility, and user acceptance be affected by AV operation (passenger or cargo) in a real city environment when operated in normal speeds, normal/smooth traffic context, without any traffic or other environmental complexity? Also, interfacing to any of the following modes: PT, DRT, MaaS and LaaS.	UC1.1: Automated passengers/cargo mobility in Cities under normal traffic & environmental conditions - **Linköping specific: First & last mile public transportation in normal conditions**	Up to now the concept seems to work. It is however important to have a high quality solution that is trustable in order to change the behaviour of travellers.
How will road safety, traffic efficiency, mobility, and user acceptance be affected by AV operation (passenger or cargo) in a real city environment when interacting with not automated (not connected) vehicles and/or VRUs?	UC1.3: Interfacing non automated vehicles and travellers (including VRUs) - **Linköping specific: First & last mile public transportation at shared space with VRU**	There is no reason to believe it will be negative. However, still unforeseen hard brakings needs to be fewer.
How will road safety, traffic efficiency, mobility, and user acceptance be affected by AV operation in a real city environment when operated in mixed flows with AV and non-AV vehicles?	UC1.6: Mixed traffic flows - **Linköping specific: First & last mile public transportation in mixed traffic**	There is no reason to believe it will be negative. However, still unforeseen hard brakings needs to be fewer.
How will road safety, traffic efficiency and user acceptance be affected by AV operation connected to a control centre for teleoperation and remote supervision in a real city environment?	UC1.7: Connection to Operation Centre for tele-operation and remote supervision **Linköping specific: Linköping operational Dashboard**	This is too early to say. Still a lot of legal barriers exist.
How will transportation services (mobility) be affected by using services based upon self-learning DRT?	UC3.1: Self-learning Demand Response Passengers/Cargo mobility - **Linköping specific: On-demand stop signal at bus stops**	This is promising. A lot of dissemination in combination with trustable operation is however needed.
How will traffic efficiency and road safety be affected by automated services at bus stops?	UC3.4: Automated services at bus stops **- Linköping specific: On-demand stop signal at bus stops**	This is promising. A lot of dissemination in combination with trustable operation is however needed.

7.6 Lessons learned - recommendations

Thanks to the pre-demo we were able to identify and solve a lot of weak technical problems with an impact on mainly hard braking and mal function shuttles. This was related to sensors, updates of software, interaction between systems etc. The key lesson learned is to not underestimate the time needed for such work.

The focus for Linköping is however on the users and we learned the importance of:

- Avoid hard braking: extra problematic for fragile elderly and persons with a need to be able to predict what is going to happen next on board.
- Make sure there is a standard of the use of sound: Persons with hearing problems do not know if the AVs is close behind or signal that it is about to stop, and blind persons do not understand what the sound is aimed to solve.
- The driver role will be different: they have to support to get on / off, they need to inform when to get off/on, they are considered as the link to a safe/secure ride.
- The mounting of wheel chairs is not safe since no backrest exist and hence backward facing is not possible.

7.7 Conclusion

Table 30: Readiness level of Linköping towards final pilots.

Readiness level towards final evaluation round of SHOW				
1 - Not ready at all – A lot to do more	**2 – Not ready – Significant corrections/development/integration and optimisation is still required**	**3 – Half ready; good basis but a series of additional development/integration and optimisation is still required**	**4 – Quite ready to go – several optimisations are still required**	**5 – Almost ready to go – only minor optimisation is required**
				x
Ranking justification – what needs to be done in short	Solve the final "want to go" solution in the app by Veridict. Mount and integrate the buttons at bus stops.			
Estimation of time required for getting 100% ready for the final field trials	2 weeks			

8 Tampere test site (satellite)

8.1 Introduction

The pre-demo was carried out in December 2021 and early January 2022. The vehicles started test runs in mid-December 2021. **12 test users were involved** along with 6 stakeholders that were interviewed and transported in the pre-demo phase of **Tampere pilot phase 1**[2] with two Proace vehicles. As in Linköping, the same approach was followed in this test site as well, and the goal was to conduct an as short as possible pre-demo pilot phase so that the site would proceed fast to the open to the public pilot phase (which it did).

8.2 General

8.2.1 The ecosystem

City of Tampere is the administrative "backbone" of the SHOW activities in Finland and acts as the "owner", facilitator & enabler of the Tampere site. Sitowise is responsible for the co-ordination of the Finnish activities and acts also as the SHOW Satellite Pilot Leader. VTT provision both the ITS-G5 roadside unit and one pilot vehicle (Auvetech)) – Phase 2 of the site. VTT is also responsible for the safety validation and expertise on automated driving technologies. VTT is also the Data collection and Data Protection Officer in Finland.

Sensible 4 provided the pilot phase 1 automated vehicles with intelligence for autonomous vehicles for all-year round use, even for winter conditions and extreme environments. Nysse, Tampere City Transport acted as an enabler and Business Tampere has been the provider of the Hervanta Level 4 automated driving test environment. Remoted will join the consortium officially in 2023 and acts as service operator, remote controller bringing also the needed vehicles for the project in pilot phases 3 and 4 (already in 2022).

Table 31: Tampere ecosystem.

Participating Entity	Internal to the Consortium	External to the Consortium	Role
City of Tampere	√		"Owner", facilitator & enabler of the Tampere site.
Sitowise Oy	√		Management and co-ordination of the Finnish activities. SHOW Satellite Pilot Leader.
VTT	√		Provision of a roadside station (and a pilot vehicle later). Safety validation and expertise on automated driving technologies. Data collection and Data Protection Officer in Finland.
Sensible 4	√		Provision of pilot automated vehicles with

[2] Tampere site has 4 phases; with the first one of them being the one being referred here and corresponds to the deployment of 2 Toyota Proace vehicles, retrofitted by Sensible4. Phase 2 and Phase 3 pre-demo will be addressed in the first update of the current issue.

Participating Entity	Internal to the Consortium	External to the Consortium	Role
			intelligence for autonomous vehicles for all-year round use, even for winter conditions and extreme environments
Nysse, Tampere City Transport		√	Enabler, PT operator.
Business Tampere		√	Planner of the Hervanta Level 4 automated driving test environment.
Remoted	√		Operator and vehicle provider.
Nysse Lab test-users		√	Test-users (mainly private car users)
Accessibility Working Group		√	Test users.

8.2.2 The setting

Prior to the pre-demo phase, there have been validation & verification tests that were carried out in two routes in urban environments in Espoo and Tampere. The Espoo test track is a closed route for initial testing. Approximately 0.6km long where bus stops, turns and traffic circles can be added as required (Figure 93).

Figure 93: Espoo validation & verification test track in Tampere test site.

The pre-demo phase (as well as the upcoming final demo phase) was conducted in open roads at Tampere trial/pilot site; approximately 3.3 km long route with bus stops, four right turns and one roundabout. The distance between each bus stop is 200 m for most of the route, and the vehicles stop on every bus stop (Figure 94).

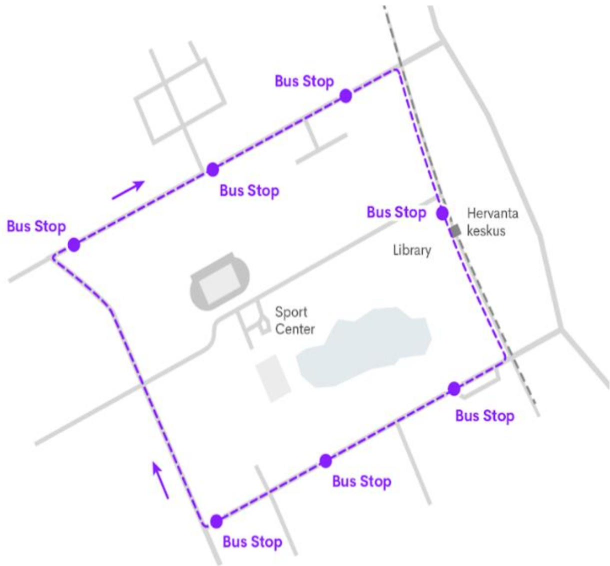


Figure 94: Tampere Phase 1 - test & pilot route in Hervanta.

The vehicles have passed the tests as set to them and were found to be ready for validation and demo operations. Each test performed was performed in an iterative manner, and much of the data has already been proven to be functional in previous Sensible 4 pilots in Finland and Norway, where the vehicles have been operational for several months. The final verification actions took place at the Tampere demo site on route. There were no issues observed. As Sensible 4 client projects have been taking place in other places, as mentioned, the vehicles had been tried before in varying conditions. Vehicles were tested in operational environment in normal traffic, rush hour traffic and varying weather conditions from fair weather to heavy rain and snow.

Table 32: Road, traffic, and weather conditions at Tampere.

Variable	Tampere
Weather	Tampere is situated in Finland and has all the possible weather conditions, sometimes harsh.
Sight conditions	Tampere is situated in Finland and has all the possible sight conditions.
Road type	Suburban streets. One section (700 m) to be shared with tram. Two lanes, speed limit of 30 km/h.
Roadworks	Roadworks occasionally, restricting capacity.
Incidents	No planned events, occasional calamities, not very much.
Traffic conditions	Rather fluent traffic all the time, no major congestion.
Traffic composition	All types allowed and occurring.
Traffic control	Two traffic light sections.
Area type (in- or outside built-up area)	Suburban, inside built-up area.

8.2.3 Field trials operation timing

The preparations for the Tampere pilot/demo started in the early phases of the project and continued until the commencement of the pilot in the beginning of 2022.The pre-demo in specific was carried out in December 2021 and early January 2022. The vehicles started test runs in mid-December 2021. Test rides, interviews and discussions with test-user groups (NysseLab - local test group set up by Tampere City Transport - and from Accessibility Working Group of the City of Tampere) took place in December 2021. Because of Covid 19 the Accessibility Working group made test-rides in January 2022, when the pilot was already running.

8.2.4 The Fleet

Two Toyota Proaces were fitted with front, rear and side LiDARs, radars and cameras as a sensor suite, and Sensible 4 Autonomous Driving kit. The kit is a LiDAR-based positioning system that enables self-driving vehicles to operate in any kind of weather or environment. The software filters out outliers from the air, such as snow, rain and fog – and allows automated vehicles to drive on roads without lane markers and landmarks. The full stack solution consists of 4 modules: positioning stack, obstacle detection, control stack, and fleet operation.

In addition to the safety driver utilized in the Tampere site, the vehicles can carry 4 passengers due to current COVID regulations. One of them is normally a 6-seater. The vehicles have been approved for road operations by Traficom, the Finnish authority for traffic and communications. The vehicles are capable of operating at a maximum speed of 30 km/h on the pilot route (see S4 vehicle in Figure 105).

Table 33: Tampere fleet characteristics – Phase 1.

Test/Use Case [ID as of D1.2]	Deployed fleet characteristics								
	Vehicle brand & model	**Vehicle type**	**SAE Level reached for the field trials [1-5]**	**TRL level reached for the field trials [1-9]**	**Summary of upgrades held during the project (check also D7.1, D7.3 & D7.4)**	**HMI and Hand-over strategies (in consistency with D7.2)**	**Maximum speed reached during the trials (km/h)**	**Average speed during the trials (km/h)**	**Maximum capacity of vehicle**
UC 1.1; 1.2; 1.4; 1.7; 3.1	2 Toyota Proace vehicles retrofitted by Sensible4	Van	4	9	Development of sensor data filtering to improve bad weather driving capabilities, development of dynamic trajectory planning, development of vehicle – remote operator communication	Touch screen human machine interface is used to move between manual and autonomous operating modes. Another touch screen operated monitor is used for the startup of the system, and for selection of routes to be driven as well as for visualizing the sensor data.	30	11.3	4 + safety driver (in SHOW)

8.2.5 The Infrastructure

The test area of Tampere Satellite Site is depicted in the map in the figure below. It is roughly the same as the area of “L1” communications network that has been built by Nokia to enable future smart city services. This private network supports pilot operations in the area and consists of Nokia Flexi Zone Micro Outdoor, LTE-A base stations. One of the key objectives in the area is to guarantee a sufficient band for automated vehicles even if commercial networks are too crowded.

Figure 95: L1 test area for smart city innovations – Tampere – Phase 1.

The next figure tabulates the specifications of the communication components in use.

Product	Flexi Zone Micro Outdoor
LTE Band Support	Band-38 (2600 MHz) Frequency[1]: UL/DL 2575 – 2615
RF Output Power	250mW to 5W per Tx branch
Carrier	2
Bandwidth Support	10, 15, 20 MHz
Connected User Support[2]	600
Size	Dimensions[3]: 247(H) x 327(W) x 120(D) mm Mass: 5.2 Kg Volume[4]: 7.2 L
Synchronization	RF GPS IEEE 1588v2 (Freq/Time/phase)

Figure 96: Nokia Flexi Zone Micro Outdoor specifications - Tampere.

The next figure shows where the eight eMBB base stations in L1 area installed to the light poles.

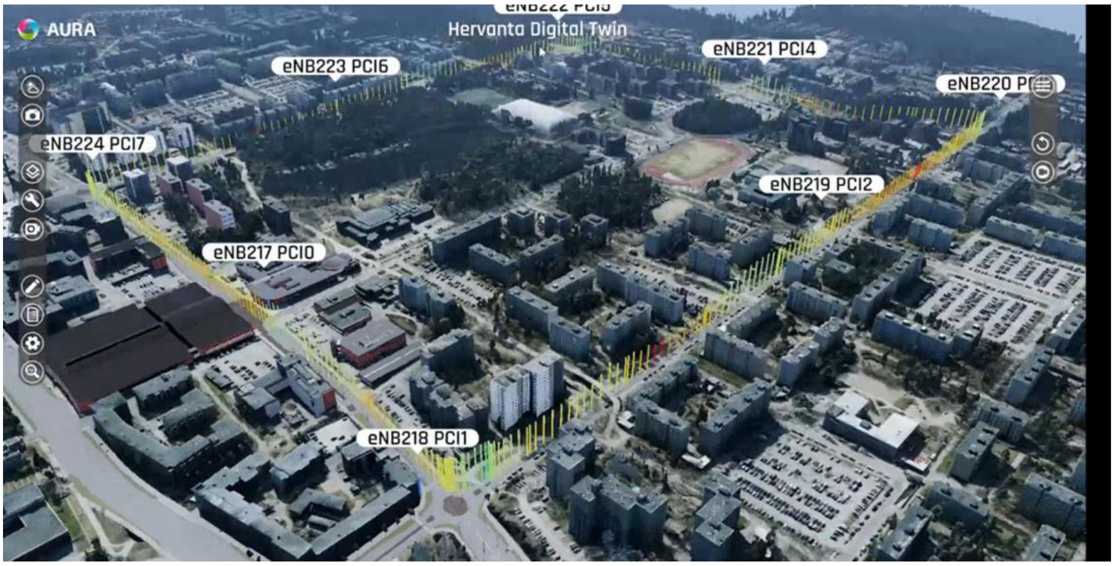


Figure 97: Nokia Flexi Zone Micro Outdoor, LTE-A base station locations – Tampere.

There are three hybrid V2X road side units in the area to support ITS G5 operations. The devices used are PEEK/Dynniq RSU Wifi-11p Mk2 G5 routers. Figure 98 presents locations of the devices in the area, whilst Table 34 lists their main specifications.

Figure 98: PEEK - Dynniq Wifi-11p Mk2 V2X RSU locations in the test site – Tampere.

Table 34: PEEK - Dynniq RSU Wifi-11p Mk2 specifications - Tampere.

Communication (internal antenna)
G5 modem interface
- Transmit power: +23 dBm max.
- Receive sensitivity: -97 dBm
GNSS receiver (internal antenna)
3G modem interface (internal antenna)
100 Mb Ethernet
IEEE 802.11p
ETSI ES 202 663

RSU n3 is capable of sending lane specific GLOSA messages over the air from the traffic light controller of intersection TRE906. Traffic light controller TRE906 is accessible also from the infrastructure side. Mattersoft Oy provides MQTT protocol topic streams for the intersection TRE906 as well as for several other locations. The available topics and different traffic lights are: TRE906/A, TRE906/B, TRE906/C,

TRE906/, TRE906/D, TRE906/E, TRE906/F, TRE906/G, TRE906/_H, TRE906/_J and TRE906/_K. The intersection figure below presents the lane configuration.

Figure 99: Intersection TRE906 lane configuration - Tampere.

The test area includes two intersections with a newly installed tram traffic light. These tram traffic lights (see Figure 100) are right before the roundabouts and they are there to provide priority for trams as well as safety for other road users.

Figure 100: Tram traffic lights at Tampere.

Work was ongoing to access the status of the tram traffic lights over internet. The alternative of detecting traffic light status using vehicle systems would not be straightforward, as the traffic light type is new to most popular neural networks for the purpose.

The following relative correction services for satellite positioning are available in the Tampere area:

- Tampereen Infra Oy provides free of charge RTK correction service for the Tampere downtown area.
- National Land Survey of Finland, RTK is available for research purposes only
- Hexagon HxGN SmartNet.

The test vehicles in SHOW use map matching based positioning supported with RTK GPS. In addition, a landmark-based positioning setup has been considered for supporting automated driving scenarios. The commercial mobile network coverage in the area is depicted in the following figure. It presents the main cell tower locations, eNB IDs and approximate signal strength.

Figure 101: Commercial Elisa 4G-LTE mobile network coverage in Tampere Satellite Site area (©Cellmapper).

VTT has developed a small, camera and lidar-based roadside monitoring system to detect the presence of vehicles and pedestrians in a specified area. The area can be an intersection with visual obstructions, where a pedestrian or vehicle could appear suddenly. The goal is to support vehicle detection systems and further improve safety. Alternatively, the same system can be used to count passengers waiting at bus stops. Still, the solution was not deployed in the pre-demo phase. The figure below shows an example of the used sensor data fusion, where a neural network-based detection of objects is combined with (here lidar) distance measurements.

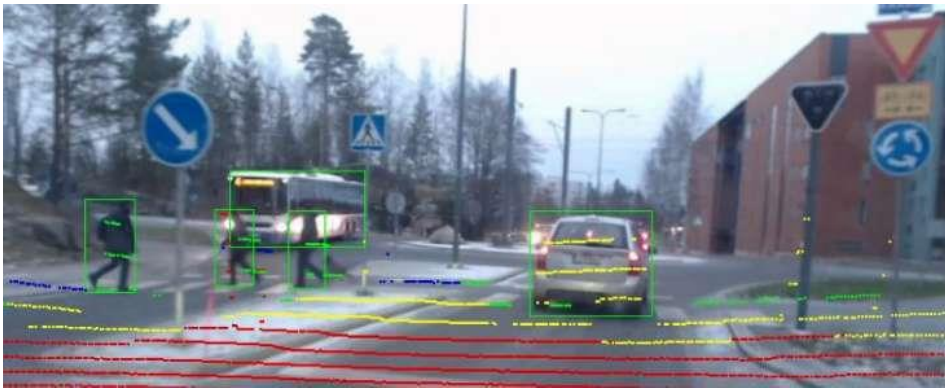


Figure 102: VTT's sensor data fusion for detection of road users

4G/LTE connectivity was ensured by commercial networks. The private 5G test network was also available, but it was not needed in pilot phases 1 and 2, because the 4G/LTE latency was good enough for the SHOW project. No new infrastructure was needed nor added.

To support the development of automated transport a digital twin was developed in Tampere, Hervanta suburb. The digital twin is not directly part of digital infrastructure, but uses data received from it. The goal of the Hervanta Digital Twin project is to create high quality replica of the Tampere autonomous vehicle test site in Hervanta and facilitate third party stakeholders with access to data. In collaboration with VTT, Business Tampere and the city of Tampere, Sitowise created a Digital Twin of the area. The broader goal was to pilot the uses of the Digital Twins in autonomous driving testing and studies, with the focus on innovation, efficiency and quick iterations in conducting studies. The real-world geometry and infrastructure were modelled featuring dynamic weather and time simulation from local data and real time 5G mmWawe propagation simulation tool.

In Tampere, there will be 27 spots/sites with 79 monitoring cameras along the new tramline that have been launched and fully opened for public in August 2021. These cameras are used to monitor traffic, especially tram. They are also used to monitor movement and behavior of people. Two of these spots/sites with 7 cameras are situated close/alongside the SHOW automated feeder transport pilot route. These settings are described in Figure 103. The two spots/sites are presented in red circles with dotted lines in the big figure. The rectangular sub-figures surrounded with red lines show, what kinds of cameras are being used, how they are positioned and mounted, etc. The cameras have been available already during the pre-demo phase.

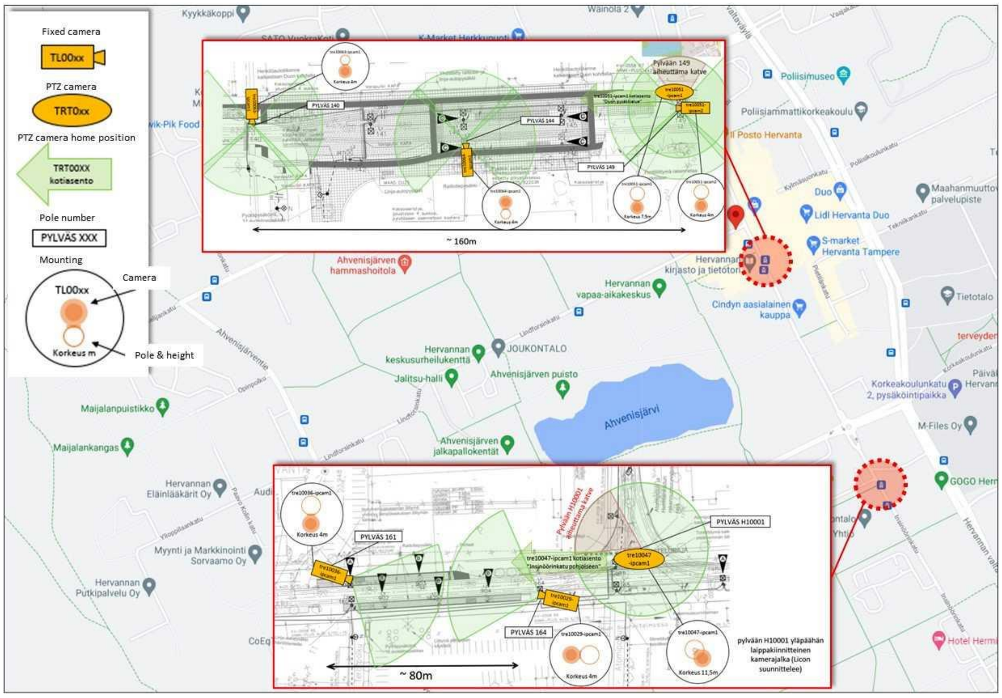


Figure 103: Tram monitoring cameras in Hervanta suburb.

The cameras are coming from several main manufacturers and thus there are several models and types being used. However, because of data protection issues, there is a suggestion from the authority side, that the names of vendors and cameras are not publicly announced. They are all full HD cameras with 4K resolution. They are either fixed or PTZ (pan tilt zoom) cameras. The height of the camera poles varies from 4 meters to 11,5 meters. The cameras will be used to monitor the tram and its environment. Thus also the automated vehicles, when moving in the tram corridor in Tampere/Hervanta, will be monitored by these fixed and PTZ cameras.

8.2.6 Users & Stakeholders

8.2.6.1 Passengers and stakeholders in the loop

When it comes to test-rides for targeted users during the pre-demo phase, there were **12 selected test-ride users**. Additionally the related stakeholders (authorities, researchers, technical experts, etc.) were involved in the pre-demo activities and related tests. The test-ride users were given notebooks, reflectors, pens and other material, when participating the pre-demo activities.

8.2.6.2 Local campaign and strategies for awareness, recruitment & engagement

There have been direct recruiting activities related to targeted users during pre-demo. Interviews and discussions with selected test-user groups (NysseLab - local test group set up by Tampere City Transport - and from Accessibility Working Group of the City of Tampere) have taken place. The local and national experts, authorities and stakeholders have been approached and discussed with about their wishes, opinions and expectations. A lot of marketing during and after the pre-demo phase in local and national media has taken place (articles, videos, interviews in radio and TV). Tampere University has also been involved in recruiting activities.

8.2.7 Business Models

The business model that has been applied in Tampere - and is being evaluated - is mainly the Business Model 8 - First/Last mile autonomous transportation to mobility HUBs. The BM8 in Tampere focuses on the first/last mile automated feeder transport from/to mobility hubs, which in Tampere is the main tram and bus stop HUB in Hervanta suburb, in front of the DUO shopping centre. The main objective in this business model is to help citizens to use tram by providing them with feeder transport service that is integrated with the Tampere public transport system. The business model also aims to reduce the need for parking places in the HUB area and to attract car users to use public transport services and thus to reduce the number of cars in city streets. This in the future is expected also to reduce congestion and emissions. The Tampere business model has some elements also from BM 5 - Peri-urban automated transportation and C-ITS connectivity and BM 10 - Interoperable IoT platforms for automated mobility. Still, the focal BM as mentioned is BM8.

8.3 Preparatory Process

8.3.1 Permits

In Finland the permission process is rather easy and lightweight. The current road traffic legislation enables and allows automatic vehicle experiments in Finland, also in mixed traffic. To test/pilot automated vehicles in traffic, a test number certificate must be obtained from Traficom - the Finnish Transport and Communication Agency. The certificate allows to test automated vehicles in traffic. There are some pre-conditions, as follows:

- the applicant needs to be an organisation that is involved in R&D of automated vehicles;
- the certificate allows to use the vehicle(s) temporarily in suitable places;
- the certificate is valid for one year and is being renewed annually without any separate application;
- the testing plan is required, and after the test period a report to Traficom is required.

A safety driver is always needed in the pilots, but it is important to notice that the driver does not have to be physically inside the vehicle. Thus, remote monitoring and control is (also/ alternatively) allowed.

8.3.2 Development/Customisation/Integration

The experiments were conducted with two Toyota Proaces fitted with front, rear and side LiDARs, radars and cameras as a sensor suite, and Sensible 4 Autonomous Driving kit. The kit is a LiDAR-based positioning system that enables self-driving vehicles to operate in any kind of weather or environment. The software filters out outliers from the air, such as snow, rain and fog – and allows automated vehicles to drive on roads without lane markers and landmarks. The full stack solution consists of 4 modules: positioning stack, obstacle detection, control stack, and fleet operation. The vehicles have been approved for road operations by Traficom, the Finnish authority for traffic and communications.

8.3.3 Training

Sensible 4 has provided the training for all actors needed to provide the pilot services, including especially the safety drivers. During the pre-demo phase of pilot 1 Sensible 4 provided the training for all actors needed to provide the pilot services, including especially the safety drivers. The end users have had no training, but they have had printed instructions at stops, how to use the service. For the pilot phase 1 all were marked (including routes, timetables, instructions, etc.) as shown in the figure below (pilot phase 1 stop marking).

Figure 104: Signs on the bus stops – Tampere – Phase 1.

8.3.4 Ethics & GDPR

In Tampere no special permit from an ethics committee was required. The ethics checklist has been signed. A DPIA has been performed (see D3.5).

To ensure safe operation of the experimental Pilot Vehicle in the public traffic, prevent collision due to any vehicle malfunctions, any damage to health and personal safety of the Traffic Participants, public and private property on the road and nearby, the activities have been carried out in public interest, Art. 6(1)(c) GDPR (general public and property safety).

To comply with general traffic safety rules applicable to passenger vehicles by operating a new technology prototype vehicle in piloting/testing mode the controller's obligation resides under law, Art. 6(1)(d) GDPR (comply with the applicable law on traffic safety).

The pilot operator and supporting technical team are watching all images in the video-stream in real time transmitted through the mounted cameras and vehicle computer during the Pilot Vehicle driving on the public road in the open traffic.

Video-stream from the mounted cameras is also transmitted to the Pilot Vehicle's computer (PC) and driver manually saves recording on encrypted storage media. Limited number of the authorised technical experts format the recorded video into special files ("ROS bags"), which can be read only by an experienced IT expert. The formatted video-files are saved to the secured physical or cloud servers located in Finland. Transfer of files takes place in accordance with internal process of strict monitoring, ensuring safety of the data.

Video images are monitored and recorded in the dynamic mode (on-the-move) in the open public traffic during Pilot driving testing and operation by video cameras mounted on the Pilot Vehicle. Saved video files are modified and applied in the software development activities by a limited number of authorised experts for creation of a tool teaching our autonomous-driving software system to recognize and detect obstacles, including people, animals, bicycles, other vehicles, buildings, traffic lights etc, where individual personalities are irrelevant (machine-learning).

Sometimes Video footage is sampled into fractions of short-interval recording and transmitted for testing functioning of connection and correctness of integration with the monitoring centre located away from the Pilot Vehicle, sometimes in another EEA country; in such case a limited number of authorised customer employees, local transport authorities, fleet operator has access to the samples of the video footage for the described purpose.

8.4 Pre-demonstration study design

8.4.1 Test Scenarios

8.4.1.1 Use Cases – Test Cases

The SHOW project use cases studied at Tampere have been and will be during all pilot phases (details can be found in D9.2 and D9.3):

- 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.
- UC1.4 Energy sustainable automated passengers/cargo mobility in Cities.
- UC1.7 Connection to Operation Centre for tele-operation and remote supervision.

When it comes to UC3.1 the discussions and planning with Nysse - the Tampere City transport related to DRT are still going on. If DRT services will be implemented and deployed, they will cover fleet management and monitoring, order management, first/last mile service optimisation (heuristic & algorithms), pre-booked and ad-hoc transports, use of smart phones and the data they offer, passenger profiles, vehicle profiles and service parameters, etc.

8.4.1.2 Mobility services & apps

No mobility services/apps were integrated to the Tampere fleet. The vehicles run circularly on a new fixed route without a schedule. They were not present in the local mobility services and are free for public to use as they arrive to the fixed bus stops during operational hours. The frequency of a shuttle was/is approximately 10 minutes. The final demo phase 1 of the Tampere pilot service operated in spring 2022 on a circular route of some 3.5 km on public streets. One section of the route operated on a busy stretch of a street with the main tram and bus stops in front of a large Duo shopping mall. The phase 1 feeder services to tram operated at some 10 minute intervals between 8:30 – 15:30 on weekdays.

8.4.1.3 Evaluation methods & data collection tools

The SHOW survey tools in Netigate have been used to collect opinions and feedback. For responding to the surveys (and also for the final demo phase that followed right after), co-operation with the Tampere University has taken place. Interviews and discussions were conducted with test-user groups (NysseLab - local test group set up by Tampere City Transport - and from Accessibility Working Group of the City of Tampere). Also decision takers and authorities have been interviewed (the City authorities, Traficom – the Finnish Transport and Communication Agency, etc.). Vehicle sensor data, such as location, speed, operation time, etc. has been and will be logged and collected by Sensible 4 (through their local data platform) and then conveyed to the DMP for getting visualised in the SHOW Dashboard. In addition, observation data has been collected (especially related to driving in winter conditions).

8.4.2 Experimental process

The tests were conducted in the final stages in the Tampere demo route in mixed traffic. Prior to the pre-demo commencement, the vehicles had passed the tests as set to them and were deemed ready for validation and demo operations. As mentioned, the vehicles and their AD systems have been in operation for over a year in demos outside SHOW project and had therefore been tested extensively already outside of SHOW. The final verification actions for SHOW specific setup took place at the Tampere demo site on route (in 2021, just before the launch of the pre-demo phase). There were no issues observed.

The experiments initially were tested in a closed area near Sensible 4 offices. Each test was performed in an iterative manner; under several iterations; 10 as a minimum over one day. These test days were repeated several times over December 2021 by Sensible 4 safety drivers and testing team.

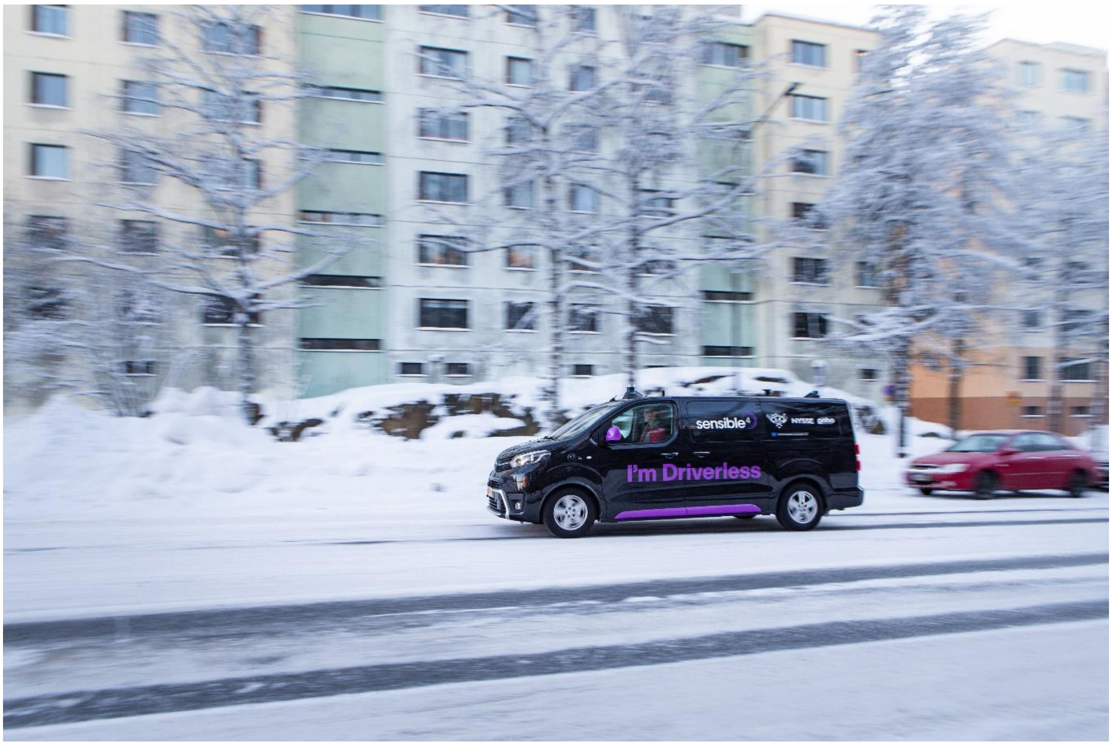


Figure 105: Sensible 4 safety driver conducting testing in Tampere.

The pre-demo field trials were conducted with the two Toyota Proaces.

For UC1.7 and in that phase, the operation centre for monitoring and remote operations, while did exist, did not have the functionality to do the actions described. Data from vehicles did flow to a remote monitoring centre and will be utilised in the future. The remote supervision will be a feature in the Tampere site later in the project and will be tested before utilisation.

8.5 Pre-demo phase field trials results

8.5.1 Overall performance results

The vehicles communicate with Sensible 4 remote dashboard and SHOW DMP through APIs. The field trials performed well overall – please check more details in section 8.5.4. The key consolidated KPIs for the pre-demo phase of Tampere are provided in section 11.

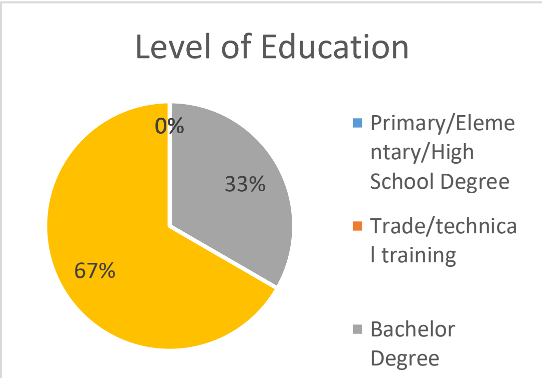
8.5.2 End-user acceptance

8.5.2.1 Demographics

During the pre-demo phase of Tampere, the total number of complete responses recorded in Netigate with demographic characteristics is **5**. Their mean age is 49.40, a median of 45.00 and a standard deviation of 15.21. The majority of respondents are living in urban areas (80%), and the sample contains no participants form rural areas. Concerning gender and education, only 3 participants reported these characteristics (1 man, 1 female and 1 preferring not to report their gender). The level of education is high, with 2 of them having obtained a Master's degree, and one of them a Bachelor degree.

Table 35: Distribution of age in Tampere.

Descriptive data	
Mean response	49.40
Standard deviation	15.21
Median	45.00
Minimum	35
Maximum	66
Number of responses	5



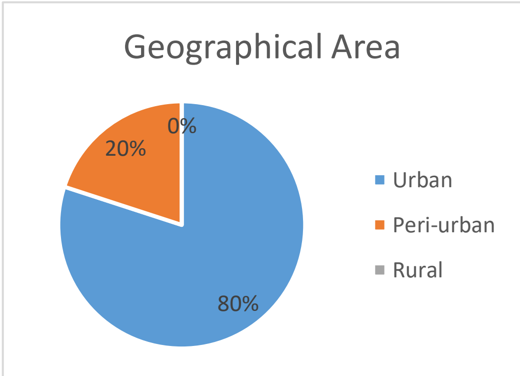


Figure 106: Distribution of the level of education and geographical area of respondents in Tampere.

8.5.2.2 End-user acceptance results

Out of the complete responses in Netigate, the overall acceptance score is medium with a mean of 6.80, a median of 7, a standard deviation of 1.77 with 5.4 responses. Mean scores across all questions range from 6 to 8.00. Usefulness is evaluated the best out of all the acceptance elements, with a mean score of 8, indicating that participants see that the service can have some value in their daily travels. On the contrary satisfaction, comfort, and intention to re-use were rated the lowest (mean score of 6). This indicates that comfort is a significant element that influences whether or not people would want to use the service again, thus improvements in that area may be needed.

Table 36: Descriptive data of acceptance components in Tampere.

Descriptive data	Mean response	Standard deviation	Median	Minimum	Maximum	Number of responses
Satisfaction	6.00	1.26	5.50	5	8	6
Usefulness	8.00	1.26	8.50	6	9	6
Ease of use	6.83	1.50	8.00	4	9	6
Ease of learning	6.83	2.23	7.00	3	9	6
Reliability	7.20	0.45	7.00	7	8	5
Safety	7.20	1.30	8.00	5	8	5
Adequacy	6.20	2.17	5.00	4	9	5
Comfort	6.00	1.87	5.00	4	8	5
Intention to re-use	6.00	2.74	4.00	4	9	5
Recommendation Intention	7.60	1.34	7.00	6	9	5

We notice that residents of urban areas tend to score the service lower on all acceptance elements, they are largely over-represented in the sample (80% of the sample). Similarly, the influence of gender and education could not be evaluated due to the small sample size, as only 3 participants reported their gender and highest degree obtained.

In addition to the above, some participants provided additional comments to open questions. The first open question related to the purpose of the trip, and most participants report that they have used the vehicle out of curiosity and interest in testing the AV service. One participant reported that they would use the AV service for occasional trips, "If necessary, e.g. Pharmacy, doctor, visiting the theatre occasionally".

Several participants reported some of the problems they had encountered during their trial of the AV service. An area of concern is accessibility. Indeed, two participants reported that "The accessibility of the car is not at the level I need", and that "there are challenges regarding accessibility." – see more detailed comments below. Another challenge reported is comfort when sitting opposite the direction of travel "Staying at the right stop is challenging, especially when traveling backwards."

In addition to the above, direct feedback regarding the first test runs from a NysseLab (local test group set up by Tampere City Transport) and from Accessibility Working Group (AWG) was received in early January 2022. The test-users had a ride and after the ride, they were asked for a satisfaction grade between 0 to 100. The feedback was mainly very positive. The 7 NysseLab from test users (mostly private car users) gave the grade of 84,3/100 for the service. The grade from the 5 Accessibility Working Group test users were lower - users liked the service itself very much, but the vehicles were not (yet) accessible enough to them.

The main messages received from AWG are as follows:

- Easy access, low floors and ramps are needed.
- Proper lighting and interior with light colors are essential for the visually impaired users.
- Vocal information for the visually impaired users is important.
- For hearing impaired people good signs are needed inside the vehicles.
- Enough space for wheelchair and walking aids, etc. is important.
- It is also important that wheelchair users could see out from the bus windows and therefore big windows are also needed.
- Smoothness of driving is essential (no fast movements or sudden braking) for people with impaired mobility.
- Vehicles don't have to be fancy & luxurious, but practical & easy to use.
- Service as such is very welcome and should be deployed all over Tampere.

8.5.3 Stakeholders acceptance

The overall number of responses is 6, with a mean of 55.33, a median of 56 and a standard deviation of 14.76 (with a minimum of 35 and a maximum of 73). The response rates are consistently higher among men (83.33%), and with women accounting for 16.67%. The prevailing level of education is PhD (16.67%), followed by Master's degree (83.33%) as it is shown in the following figure. Subsequently, the stakeholder groups are categorised as transport service provider (16.67%), public bodies (16.67%) and other groups (66.67%) as administrative matters, consultants or transport operators/suppliers in which is shown in Figure 107.

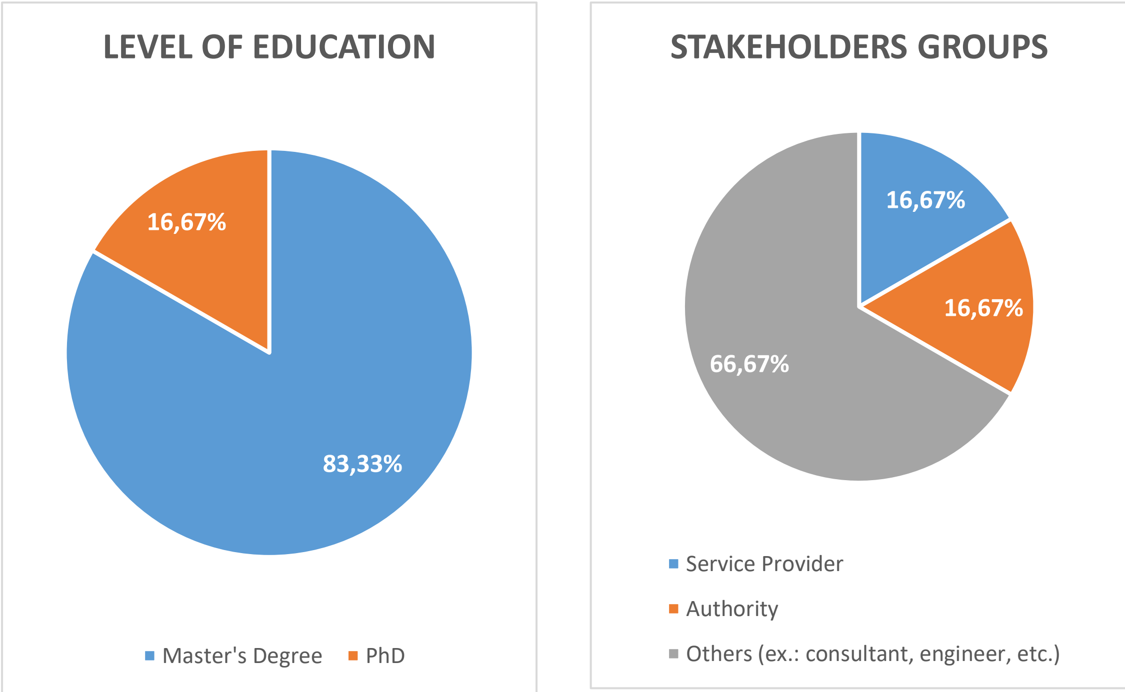


Figure 107: Distribution of the level of education and clusters of stakeholders interviewed in Tampere.

Beyond that, most of the stakeholders have expertise in the fields of ITS, transport, logistics, automated transport, smart city solutions, and vehicle technology and transport digitalization.

The key consolidated findings as of the interviews with all 6 respondents are as follows:

- On the basis of the descriptive data analysis (Table 37), the outcomes indicated that the interviewees had the highest level of agreement on the usefulness of automated vehicles; on the opposite, they averaged very low on the automated vehicles being undesirable (which supports the overall positiveness of responses).

Table 37: Descriptive data of acceptance components of the automated city mobility service in Tampere [Likert scale: 1-5].

Descriptive data	Mean response	Standard deviation	Median	Minimum	Maximum	Number of responses
Usefulness	4,50	0,55	4,50	4,00	5,00	6
Pleasant	4,17	0,75	4,00	3,00	5,00	6
Poor	1,00	0,00	1,00	1,00	1,00	6
Good	4,17	0,75	4,00	3,00	5,00	6
Effectiveness	3,83	1,17	4,00	2,00	5,00	6
Irritating	1,00	0,00	1,00	1,00	1,00	6
Supportiveness	3,83	1,33	4,00	2,00	5,00	6
Undesirable	1,00	0,00	1,00	1,00	1,00	6
Vigilance	3,33	1,63	3,50	1,00	5,00	6

- Based on the overall outcomes of the interviews, it has been seen that the mean scores of the level of agreement across different aspects is different depending on the cluster of stakekolders (Figure 108). In specific, it is noticeable that the mean values of the utility levels differ between the stakeholder clusters. Still, respondents stated that the usefulness of automated vehicles is significantly better than traditional approaches with similar mean scores (4.0; 5.0; 4.5). The pleasanteness, however, differentiates more across groups, with mean scores of 3.0; 5.0 and 4.25 respectively; likewise for effectiveness, with mean scores 3; 5.0 and 3.25. Respondents have differing attitudes towards the supportiveness of AV for mobility, with varying mean scores (2.0; 5.0; 4.0) and on the vigilance of AV with varied mean scores (2.0; 1.0 and 4.25).

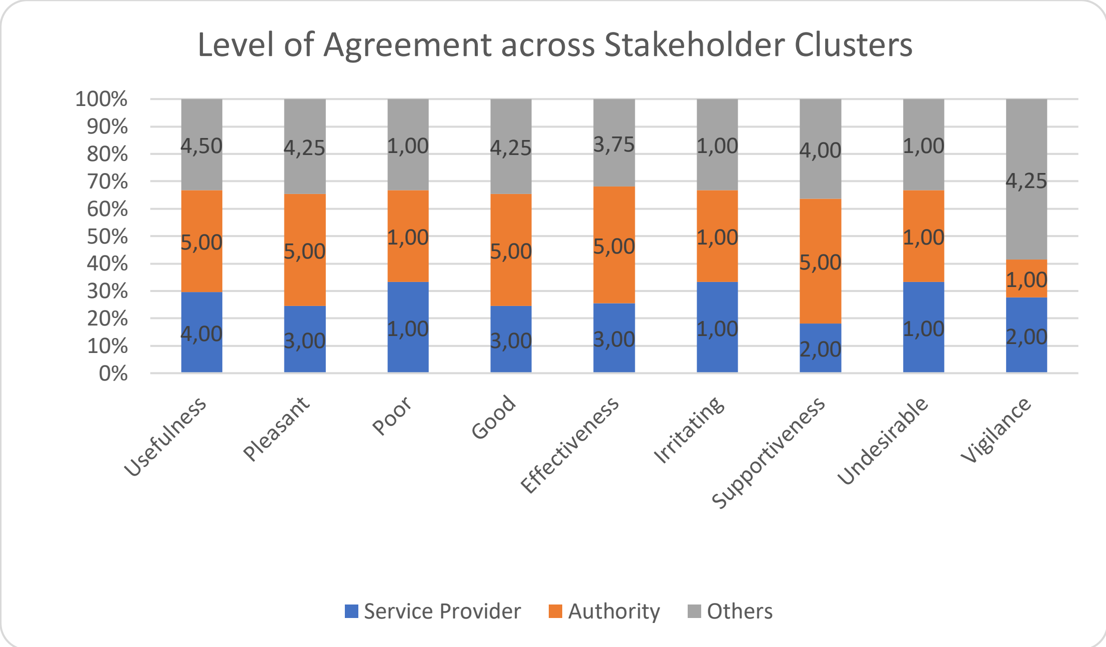


Figure 108: Level of Agreement across Stakeholder Clusters.

- In the view of the stakeholders who have been actively engaged in the project, the project demonstrations are bringing diverse possibilities or novel opportunities for cooperation with numerous partners having different competencies and technical know-how. Besides, the stakeholders positively rated certain significant aspects, as some of the stakeholders mentioned that they had a pleasant journey. Still, some of the interviewees had **less pleasant experiences at project demonstrations due to occasional sudden vehicle reactions (braking/ accelearation) which reduced notably the comfort level, and not being very accessible.**
- In cases in which the stakeholders have not actively been participating but only invited to the demonstrations, the interviewees indicated that the main advantage of SHOW demonstration is **their conduct in real world environment** as well as the **good performance in winter conditions as well.**
- On the contrary, some interview respondents have rather **negative feeling about the diesel and not electric based vehicles** and the cumbersome process of integrating a variety of vehicle features, which made them feel the vehicles were not ready enough.
- Based on the participants' responses, the major concerns lie in readiness of society, operational feasibility, degree of acceptance, employment, delay in implementation into service, maintenance, and lack of development and driver experience. They also shared **concerns about safety, when no safety driver will be present.** Still, they saw SHOW as a step forward in turning automated mobility solutions owning a significant merit in safer, more efficient, and pollution-free transport systems, serving also as a trigger for urban mobility developments towards more inclusive and sustainable mobility. To some of them, such a project

can change the perception of some stakeholders on the contribution of AVs to safety, decreasing the number of accidents.
- Stakeholders anticipate themselves getting more involved in near future in automated (and electrified) mobility.
- Stakeholders stressed the accessibility aspects of the AVs, as they see them as a key means for inclusive mobility in near future transport.

8.5.4 Research Questions answered for the site

Table 38: Tampere pre-demo response to SHOW research hypotheses and Use Cases.

Research Questions	Relevant Use cases	Overall response
How will road safety, traffic efficiency, mobility, and user acceptance be affected by AV operation (passenger or cargo) in a real city environment when operated in normal speeds, normal/smooth traffic context, without any traffic or other environmental complexity? Also, interfacing to any of the following modes: PT, DRT, MaaS and LaaS.	UC1.1: Automated passengers/cargo mobility in Cities under normal traffic & environmental conditions	Safety: The AVs had good visibility of other traffic in every intersection, bus stop and pedestrian crossings. Situational speed was found to be good in all parts of the route for the weather conditions. Performance: The vehicles seemed to be capable of operating at a maximum speed of 30 km/h on the pilot route. Distance between each bus stop is 200 m for most of the route, and the vehicles will stop on every bus stop, so the AVs will not significantly disturb other traffic. Quality of Service: The demo route works well for the transporting passengers to the Hervanta tram stop. After pre-demo of phase1, when the two AVs were operating continuously, the maximum waiting time for the passengers at any bus stop was around 8 minutes.
How will road safety, traffic efficiency, mobility, and user acceptance be affected by AV operation (passenger or cargo) in a real city environment when operated in normal speeds but within a complex traffic or environmental context (e.g., curvatures in roundabouts, etc.)? Also, in cases of additional restrictions applied (e.g., heavy traffic, extreme weather conditions, etc.).	UC1.2: Automated passengers/cargo mobility in Cities under complex traffic & environmental conditions	Safety: Validation of the deployment was also done during rush hour and no additional safety concerns were found. Performance: The AVs had difficulties in entering the roundabout on the route when the amount of traffic was significanly higher than normal. In some of the cases the safety operator had to take manual control and drive through the roundabout. Quality of Service: Vehicles were driving on one predefined route. The amount of traffic on the route did not affect the quality of service.
Will AV operation (passenger or cargo) using an energy sustainable operation be able to cover the same services as the conventional vehicles?	UC1.4: Energy sustainable automated passengers/cargo mobility in Cities	During the pre-demo and actual phase 1 pilot, the vehicles have diesel engines. During other pre-demos and pilot phases the vehicles have been electrified and, thus, energy sustainable.
How will transportation services (mobility) be affected by using services	UC3.1: Self-learning Demand Response	When it comes to UC3.1 the discussions and planning with Nysse - the Tampere City transport related to DRT are still going on. Most likely the

Research Questions	Relevant Use cases	Overall response
based upon self-learning DRT?	Passengers/Cargo mobility	DRT services will be implemented and deployed, after the SHOW project. They will cover fleet management and monitoring, order management, first/last mile service optimisation (heuristic & algorithms), pre-booked and ad-hoc transports, use of smart phones and the data they offer, passenger profiles, vehicle profiles and service parameters, etc.

8.6 Lessons learned & Recommendations

Lessons learned for this phase came basically from from the Sensible 4 safety drivers during testing and are as follows:

- In heavy snow conditions the plowing of routes is important. Roads should be of equal width in both snowy and non-snowy conditions.
- Wet snow or freezing rain can obstruct the vehicle LiDAR, so a good way to clean the exterior of the LiDAR needs to be studied for these situations.
- There are different parking rules on every other day on the route, which means that the route needs two trajectories: One for even and one for odd days due to changes in roadside parking.

8.7 Conclusion

Table 39: Readiness level of Tampere towards final pilots.

Readiness level towards final evaluation round of SHOW				
1 - Not ready at all – A lot to do more	**2 – Not ready – Significant corrections/development/integration and optimisation is still required**	**3 – Half ready; good basis but a series of additional development/integration and optimisation is still required**	**4 – Quite ready to go – several optimisations are still required**	**5 – Almost ready to go – only minor optimisation is required**
				x (Phase 1)
Ranking justification – what needs to be done in short	Only final data flow needs to be completed.			
Estimation of time required for getting 100% ready for the final field trials	1 week			

9 Madrid test site (Mega)

9.1 Introduction

The pre-demo of Madrid has started, initially, in Carabanchel - in May 2022 and was finished in October 2022. The current report addresses the period up to end of May 2022 and will be complemented in the next issue of the Deliverable. Overall, the field trials occurring in Carabanchel, are seen as the first step before moving to open traffic in Villaverde (in 2023). Until end of May 2022, there were **10 passengers** transported (still; until end of October 2022 that the full pre-demo phase for Carabanchel was completed, 608 passengers in total were transported).

9.2 General

9.2.1 The ecosystem

The Madrid Mega pilot site - within SHOW project - has four project members and three, externals to the project, as listed below and summarised in Table 40:

- four project members, local to the site, in alphabetical order:
    a) EMT – Madrid PTO and operator of the service - providing two 5m minibuses (Tecnobus - Gulliver) to the demo site.
    b) INDRA – industry - company providing the communication (cooperative infrastructure).
    c) IRIZAR – OEM – electric bus manufacturer providing one 12m bus (Irizar - i2ebus) to the demo site.
    d) TECNALIA – RTO –Madrid Mega Site pilot leader, CCAM decision and control technology, providing two passenger cars (Renault - Twizzy) to the test site.
- three external partners to SHOW project:
    a) Madrid City Council - local authority - providing the written agreement to ride on open roads within the municipality (this is essential for the upcoming Villaverde field trials in specific). It is also in charge of any actuation in the public space (road infrastructure).
    b) Dirección General de Tráfico (here and after DGT) - national public administration - in charge of the homologation requirements for manual and AV in Spain.
    c) AEVAC - Spanish Association for the Autonomous and connected vehicle – represents advice and dissemination stakeholder.

Table 40: Madrid Mega site: ecosystem.

Participating Entity	Internal to the Consortium	External to the Consortium	Role
EMT	√		PTO and operator of demo
IRIZAR	√		OEM
TECNALIA	√		Mega Site leader and technology provider/developer
INDRA	√		Communication tech
Madrid City Council		√	Public administration in charge of the city. Facilitator & enabler of the Madrid Mega site.
DGT		√	National Traffic Authority
AEVAC		√	Spanish Association for Autonomous mobility. Stakeholder.

9.2.2 The setting

The Madrid Mega Site is located in Madrid, Spain's capital city. Figure 109 shows where the city is, in the map of Europe and Spain. As for the two scenarios involved in the site, both are situated in the south of Madrid city, i.e. separated by 7 km (Figure 110). The characteristics of the environment are similar: peripheral areas of the city where there was a mix use of residential and industrial activities.

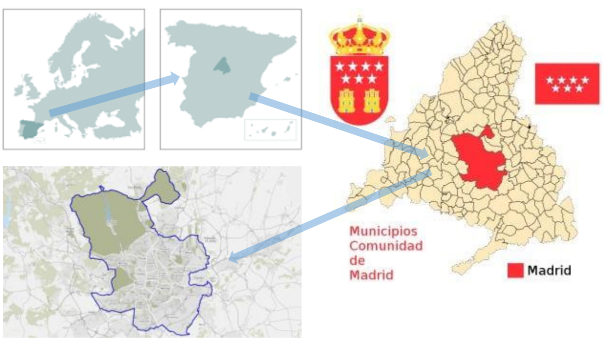


Figure 109: Madrid Mega site: city location, in Spain.

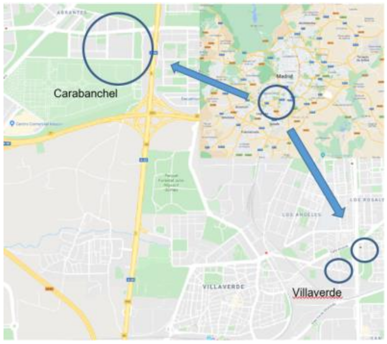


Figure 110: Madrid Mega Site: scenarios location, within the city.

The Madrid Mega site includes two different scenarios:

- Carabanchel scenario – EMT depot – private and semi-controlled
    - One of the five EMT bus depots, Carabanchel has a surface area of 65.000m^2 and houses 450 buses to serve 48 bus lines, including CNG and fully electric bus units. It is also where most of the electric fleet of EMT is based.
    - Semi controlled area with interaction with other non-autonomous buses and vehicles, as well as daily operations at the depot (manoeuvring, moving goods, people, etc.).
    - As for SHOW testing track, it includes a round trip of 800 metres connecting different facilities within the bus depot (refer to Figure 115).

Figure 111: Madrid Mega site: Carabanchel EMT depot view.

Figure 112: Madrid Mega site: Carabanchel EMT depot aerial image[3].

- Villaverde scenario – Madrid municipality – public and urban open traffic
    - The building of La Nave (Figure 113: Madrid Mega site: La Nave view (Madrid Innovation **HUB)** has 12,317 square metres to develop different activities, including facilities to promote start-ups, open innovation and

[3] Source: google earth, accessed on 28/09/22.

- public-private cooperation. The area around La Nave will become shortly the Sandbox for Mobility for the city of Madrid.
  - The itinerary connects La Nave (Madrid City Innovation Hub) with Villaverde Bajo Cruce Metro Station (intermodal area). With 800m per journey (1,6km line), including complex intersections.

Figure 113: Madrid Mega site: La Nave view (Madrid Innovation HUB).

Figure 114: Madrid Mega site: Villaverde aerial image[4], Avenida de Andalucía.

Therefore, the Madrid Mega Site includes a double perspective and a distinctive approach in each one of the scenarios:

- **Carabanchel scenario**: focuses on the improvement of operations within the bus depot from the perspective of automated bus depots management, exploring the potential of optimising operations and reducing costs and the space needed thanks to introducing automation of bus circulation within the depot, requiring less qualified personnel to manage depot operations and reducing operation times for routineer depot activities like parking, cleaning, charging, etc, but providing at the same time an internal mean of transport for employees. The traffic environment is equivalent to an urban one, with interaction with car/bus/trucks and pedestrians.
- **Villaverde scenario**: focuses on the improvement of the public transport connectivity between La Nave innovation hub and the intermodal area of Villaverde Bajo Cruce Metro Station. The traffic environment is urban with car/bus/moped/trucks traffic, pedestrians, cyclists and different types of PMVs such as e-scooters, etc. The itinerary includes complex intersections, and the traffic density varies also across day, with rush hours in the morning, around lunch and in the afternoon/evening.

The following two tables collect SHOW use cases deployed in Madrid Mega Site, per scenario (Table 41) and specific information at Carabanchel scenario (Table 42). It is worth mentioning at this point that the 5 stops service tested at Carabanchel (refer to 9.4.1) holds several use cases from cluster 1. This was not foreseen at the very beginning but due to the fact Villaverde scenario has been delayed because of the permits (refer to 9.3.1) it was agreed, by the local partners, to proceed this way.

[4] Source: google earth, accessed on 28/09/22.

Table 41: Madrid Mega Site: use cases, per scenario.

	SHOW Use Cases																
Scenario	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	1.10	2.1	2.2	3.1	3.2	3.3	3.4	3.5
Carabanchel Depot							☑	☑							☑		☑
Villaverde – La Nave PT	☑	☑	☑			☑				☑							

Table 42: Madrid Mega site: specific site information, at Carabanchel.

Variable Name	Value for the Site
Area type (In- or outside built-up area)	Outside built-up area
Incidents	None, so far (until end of May 2022). However, heavy rain may interfere the systems.
Traffic composition	Buses are dominant. Mixture of cars (service cars) and trucks, as well as VRU (pedestrians - employees).
Traffic conditions	The traffic density varies across the area and across the day, considering depot rush hours very early in the morning and evenings. Weekdays and usually in the morning (08:00 – 14:00) .
Traffic control	N/A in Carabanchel
Road type	Urban road type with one or two lanes (depending on the area), 5 intersections. The speed limit inside Carabanchel is 10 km/h, dropping to 5 km/h in the bus cleaning area, and 20 km/h on the bus testing circuit.
Road works	Ongoing works in the upper terrace for building inverted pantographs charging infrastructure.
Sight conditions	Clear, glare depending on time-of-day, but generally good sight conditions. Traffic may be hidden by parked buses.
Weather	Road: Mostly dry Weather: Mostly clear (sunny)

9.2.3 Field trials operation timing

Madrid pre-demo phase has started - initially in Carabanchel scenario - in May 2022 and is scheduled to finish in October 2022. Then again, several preparations actions have been carried out since January 2022, as described in section 9.4, i.e permits, training, ethics & GDPR as well as customisation to the attributes of a semi-controlled private depot, such as Carabanchel.

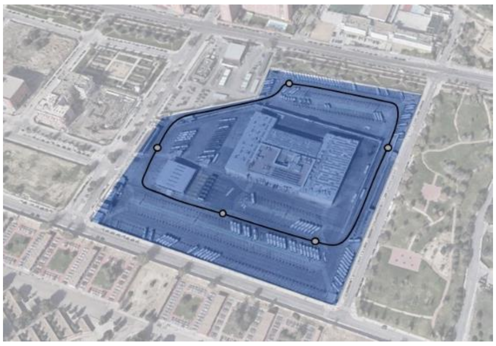


Figure 115: Madrid Mega site: EMT depot (in blue), 800m route outlined.

On the other hand, as for Villaverde scenario there are still permits - driving on urban open traffic - to be obtained before being able to operate in public roads. As part of Villaverde pre-demo activities, a high-level meeting was organized (May 2022) between Madrid City Council, with the special participation of the Innovation

Directorate of the municipality and site local partners, to duly inform about the achievements and testing plans.

Figure 116: Madrid Mega site: F2F meeting with Municipality Innovation Directorate, at Carabanchel (May 2022).

9.2.4 The Fleet

Carabanchel scenario has operated three AVs during the (full) pre-demo phase: two Gulliver and one i2eBus, refer to Table 43. As for the two Renault Twizy provided by TECNALIA, they have been devoted during development phase (WP7), so as to transfer AV algorithms verified (WP11.1) and technically validated (WP11.2) to minibus (Gulliver) and the 12m bus (i2eBus). Refer to Figure 117 for the three types of AVs at Carabanchel scenario. Furthermore, Table 43 organizes per pre-demo phase UC, Carabanchel's - Gulliver and i2eBus - deployed fleet characteristics, i.e model, SAE and TRL level, maximum capacity, enhanced technologies upgrades (derived from WP7) together with trials' speeds.

Figure 117: Madrid Mega site: AV fleet at Carabanchel scenario.

Table 43: Madrid Mega Site – Carabanchel fleet characteristics.

Test/Use Case [ID as of D1.2]	Deployed fleet characteristics								
	Vehicle brand & model	**Vehicle type**	**SAE Level reached for the field trials [1-5]**	**TRL level reached for the field trials [1-9]**	**Summary of upgrades held during the project (check also D7.1, D7.3 & D7.4)**	**HMI and Hand-over strategies (in consistency with D7.2)**	**Maximum speed reached during the trials (km/h)**	**Average speed during the trials (km/h)**	**Maximum capacity of vehicle**
UC1.1,1.2,1.3,1.6 UC1.7	TECNOBUS - Gulliver	Minibus	3-4	6	Enhanced • environment and perception (TECNEP01/02) • AV decision and driving functions (TECND01/02) • V2 comms protocols (TECNV201)	Shared control: managing the transition manual & automated driving modes, via the safety driver's HMI[5]	10 km/h	7.2 km/h (for the full period up to end of October 2022)	10 + 1 safety driver
UC1.1,1.2,1.3,1.6 UC1.8 UC3.3, 3.5	IRIZAR – i2eBus	Bus	4	6	Enhanced • environment and perception (TECNEP01/02) • AV decision and driving functions (TECND01/02) • V2 comms protocols (TECNV201)	Same as above	18 km/h	8.96 km/h (for the full period up to end of October 2022)	25 + 1 safety driver

[5] In compliance with the override tests considered at the ***instruction 15 / V-113***[5]

9.2.5 The Infrastructure

9.2.5.1 Infrastructure equipment (RSU)

One hybrid V2X road-side unit (RSU) has been installed in the Carabanchel depo. This device is responsible for sending relevant information from the CCAM traffic control center (C-ITS HUB) to the vehicles driving through the depo. During the pre-demo phase this road side unit sent the information regarding speed limits in the area to support the automated manoeuvres of the vehicles.

Figure 118: Madrid Mega pilot site: RSU installation, at Carabanchel

9.2.5.2 C-ITS Hub

The C-ITS Hub is real-time operation platform for infrastructures and fully automated incident response, which has been adapted for CCAM services deployment. The C-ITS Hub integrates information from various sources (public traffic operator authorities, road operators, weather experts, etc.) for managing the C-ITS services that can be customized and scaled according to the volume of information received and the deployment environment.

During the pre-demo phase this platform was responsible for sending the information regarding the speed limits to the RSU deployed in Carabanchel, that at the same time sent it to the vehicles.

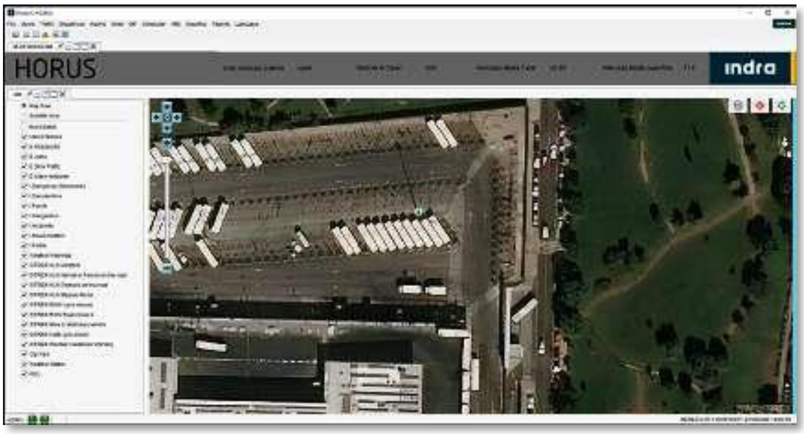


Figure 119: Madrid Mega pilot site: aerial view C-ITS Hub Platform, in Carabanchel

9.2.5.3 CCAM Services

The following services and messages were tested during Carabanchel scenario pre-demo phase:

- DENM Messages (Decentralized Environmental Notification Message)

These messages send via V2X contains information related to a road hazard or an abnormal traffic conditions, such as its type and its position. During the pre-demo phase was used to implement the road speed limit.

- MAPEM (Map extended Message) Messages

This message represents the topology/geometry of a set of lanes, for example considering an intersection MAPEM defines the topology of the lanes or parts of the topology of the lanes identified by the intersection. The implementation of this message has been tested internally during the pre-demo phase, as an advance to Villaverde scenario where it will be most probably tested.

- SPATEM (Signal phase and timing extended Message) Messages

This message allows disseminating the status of the traffic light controller, traffic lights and intersection traffic information. It transmits continuously in real-time the information relevant for all manoeuvres in the area of an intersection. The implementation of this message has been tested internally during the pre-demo phase, as an advance to Villaverde scenario where it will be most probably tested.

9.2.5.4 Charging, Storage and Maintenance

The infrastructure to charge, store and service site's fleet is provided by EMT. Several charging points are available in the training area (refer to stops 4 and 5 on Figure 120) and in the general parking area (between stops 2 and 3, at the bottom of on Figure 120).

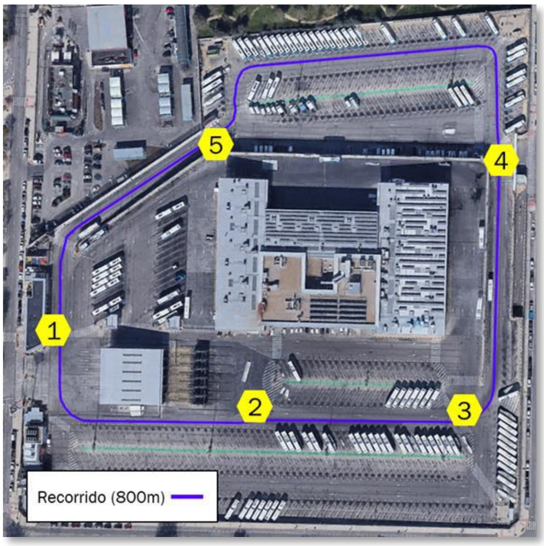


Figure 120: Madrid Mega Site: charging spots, at Carabanchel depot.

SHOW AVs are being stored and serviced alongside the rest of the vehicles, that EMT manages on daily basis.

Figure 121: Madrid Mega site: service and storage workshop, at Carabanchel depot.

9.2.6 Users & Stakeholders

At the time of writing, Madrid Mega site pre-demo phase has been focused on the set of UCs tested at Carabanchel. In accordance with deliverable D9.2 (& D9.3), Table 41 states the stakeholders involved. Until oend of May 2022 (period covered by this issue), there were 10 passengers' transport. Overall, until the end of the Carabanchel pre-demo phase (end of October 2022), there were 608 passengers transported. Table 45 lists Madrid end-users addressed, in this case: VRU – EMT employees at bus depot and AV drivers. Several drivers have been trained as well as operating the vehicles, together with other EMT personnel also taking part in the training sessions (refer to section 9.3.3).

Table 44: Madrid Mega Site: pre-demo stakeholders, in Carabanchel scenario.

Stakeholder	Target/ Org. Name
Vehicle users (end-users, drivers, and remote operator)	End users: EMT employees Drivers: Gulliver EMT Drivers: I2ebus - EMT and IRIZAR Drivers: Twizzy TECNALIA Remote operator: EMT personnel
Operators (public transport operators, private fleet operators etc.)	EMT
Mobility service providers	EMT
Industry (AV manufacturers, etc.)	IRIZAR (OEM)

Table 45: Madrid Mega Site: end-users addressed, in Carabanchel scenario.

End-user group	End-user representatives (individuals or organisations)
VRU – citizens / road users	AEVAC (Spanish Association for the Autonomous and Connected Vehicle): information campaign, in Villaverde
VRU – EMT employees at bus depot	EMT, employees' informing and training
AV Drivers	EMT and IRIZAR, drivers' informing and training

As for Villaverde, even though the permits are not yet finalized, a meeting was organized to involve Decision-making authorities in the process, inviting the City Council to the depot at Carabanchel, as stated previously (refer to page 151). Once the process to obtain the permits is completed, the stakeholders - expected to be involved - are listed next, in the Table 46.

Table 46: Madrid Mega Site: pre-demo stakeholders, in Villaverde scenario.

Stakeholder	Target/ Org. Name
Vehicle users (end-users, drivers)	End users: Commuters Drivers: Gulliver EMT Drivers: I2ebus - IRIZAR Drivers: Twizzy TECNALIA
Decision-making authorities or regulators	Madrid City Council (Villaverde District) DGT Consorcio Regional de Transportes de Madrid, CRTM (Madrid PTA)
Operators (public transport operators, private fleet operators etc.)	EMT
Mobility service providers	EMT
Industry (AV manufacturers, etc.)	IRIZAR (OEM)
Public interest groups and associations	AEVAC (Spanish Association for autonomous and connected mobility) AEDIVE (Spanish Association for the promotion of electric mobility) CERMI (Spanish Committee of Representatives of Persons with Disabilities) ANFAC (Spanish Association of Automobile and Truck Manufacturers) SERNAUTO (Spanish Association of Automotive Suppliers)

9.2.7 Business Models

The business model for the Madrid Carabanchel site is solely built on the scenario of automated bus depots management. The specific use case for the urban route between ‘La Nave’ and ‘Villaverde Bajo Cruce’ in Madrid does not feature values on which a business model could be built, and this is why the business model focuses on the unique initiative of EMT of automating their bus depot management in the EMT Carabanchel Depot.

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

As a publicly owned transport operator, EMT’s mission is to improve the service for the sake of the city and its citizens. While there are not really direct economic interests in implementing automation for EMT, it can potentially be a great technological advancement through which their operations can be improved and resources optimized, whilst boosting innovation, and all together contributing to providing better services and positive externalities or beneficial side effects.

Whilst looking at the proposed scenario in Carabanchel EMT depot, automation can mean an optimization in personnel costs, fleet parking space, increased safety and operation times, as well as improvements in CAPEX and OPEX over the long run, eventually resulting in benefits both for EMT, its employees, Madrid citizens and the city as a whole.

Refer to deliverables D2.1, D2.2 and D16.1 for further information on SHOW business models.

9.3 Preparatory Process

9.3.1 Permits

In the particular case of Madrid site, the difference between the two scenarios needs to be addressed:

- Carabanchel scenario - closed semi-controlled track - requires the acceptance from the depot daily operation but not special permits nor homologations to perform AD tests, due to the fact it is a private environment.
- On the other hand, the Villaverde scenario - public urban open traffic space - requires for special permits so that AD tests can be performed.

9.3.1.1 Considerations about IRIZAR i2ebus (12m bus)

As OEM, Irizar has been able to register their vehicle as a prototype vehicle. Registering the vehicle as a prototype has the following advantages:

- The vehicle can be modified with the equipment needed by the project or test case without extensions to type homologation or Technical Vehicle Inspection.
- The vehicle can be driven in public roads, without any special permits, as long as it is not self-driving or carrying passengers external to the OEM.

This facilitates the process of retrofitting the vehicle and turning it into a “legal to drive” vehicle. It does have some disadvantages:

- It does not allow, without any further permit, to perform self-driving test.
- The vehicle cannot be transferred to any other entity; it must remain property of the OEM.

The process to register a vehicle as a prototype is simple, but is dependent on the acceptance of the Ministry of Interior, through the DGT:

1) Preparation of the necessary technical documentation to be submitted to the Ministry of Industry (specific reduced form).
2) Preparation of the letter to be prepared by the manufacturer, to request the resolution of the Ministry.
3) Submission of the documentation to the Ministry.
4) Revision by the Ministry, which will validate, request modifications or deny the prototype.
5) With a favourable resolution, the following documentation must be redone:
    a. Reduced technical form of the vehicle
    b. Perform a Technical Vehicle Inspection to obtain a type A technical form
    c. Formal registration (license plate) of the vehicle

9.3.1.2 Considerations about the Gulliver (minibus)

While EMT is the owner of the Gulliver but not its OEM, the considerations to turn the vehicle, with all the needed modifications, into a “legal to drive” vehicle is completely different.

Since EMT is installing equipment on the vehicle that is not contained in the European Type homologation of the vehicle, the process to be followed is described in the Royal Decree 866/2010, which regulates the processing of vehicle reforms.

The three steps to be followed are:

1) A “Technical Project” needs to be written and delivered, whose purpose is to define and assess the modifications made to the vehicle.

2) Obtain a "Compliance report", issued by a third-part entity, usually homologation laboratories or engineering consulting services, expert on vehicle reforms. They will analyse the Technical Project for this purpose.
    a. If the entity deems it necessary to issue the Compliance Report, the applicant might be required to perform specific tests to ensure compliance to safety related European Regulations, provided the characteristics of the vehicle have been altered on relevant aspects for those Regulations. For example, R10 (EMC compliance) or R100 (Safety requirements for electric vehicles or vehicles with rechargeable batteries).
3) Fill out a "Workshop Certificate" form, whose purpose is to define the workshop where the modifications were carried out.

After this documentation is obtained, the vehicle needs to pass a Technical Vehicle Inspection. With all this, the vehicle will have an updated Technical Form, and will be able to be driven on public roads. For self-driving purposes, further permits are needed.

In the specific case of the Gulliver vehicle, all steps have been made, except for the third one, which requires the EMT to perform a specific test regarding R10 (EMC compliance), due to the new equipment that has been installed.

EMT (as a publicly owned company) needs to go through a public bidding process (tender), which needs redaction and approval phase, to select the laboratory where the R10 test will be performed. Once this tender is approved, the test passes, then the EMC certificate is obtained. Without this certificate EMT AV cannot pass the Technical Vehicle Inspection (MOT).

9.3.1.3 Permits to perform self-driving test at Villaverde scenario (urban open traffic)

In terms of official permits that are issued by relevant governing bodies, such as the DGT, there three main ways that have to be evaluated:

9.3.1.3.1 Authorization for extraordinary research tests or trials

The DGT can issue an ***"Authorization for extraordinary research tests or trials".*** This permit allows for a vehicle to perform SAE L2 tests and trials on public roads, even if the vehicle hasn't been homologation regarding self-driving.

This allows only allows for a limited degree of testing, and it is dependent on the acceptance of the DGT. The DGT also reserves the right to impose limitations or condition in order to issue the Authorization. Due to this, this option is likely to be dismissed.

9.3.1.3.2 Instruction 15/V-113

The vehicle can be tested at an authorized laboratory according to the tests defined in "Instruction 15/V-113: authorization of tests or research trials carried out with automated driving vehicles on roads open to traffic in general". If the vehicle performs correctly in every test defined in the instruction, the vehicle can then be homologated as a self-driving car and will be able to drive in any public road.

The main issue with this Instruction is that the scope of the test is not defined in relation to the ODD or the UCs that the vehicle is set to test. Since the test is not tailored to the necessities of the vehicle (therefore, making a favourable result quite unlikely), and that the cost of performing the test at an authorized laboratory might come up to 30-40k€, this option is likely to be dismissed.

9.3.1.3.3 “Sandbox” area defined by the City Council

With the approval of the City Council and the local traffic authority, it is possible to define an area within the city limits in which the vehicle can be allowed, for a certain time and with certain conditions, to perform self-driving test and trials.

Within that area, a non-homologated (for self-driving) vehicle will be allowed to self-drive and even carry passengers. These “Sandbox” areas are aimed to provide testing grounds as similar as possible to real-life scenarios, while ensuring the safety and security of road user. Therefore, these “Sandbox” areas are usually closed to traffic, or at least strictly regulated in that regard. One of the requirements, though, is that the vehicle has passed the Technical Vehicle Inspection (MOT).

Since this third option provides a good middle ground between technological readiness and available the legal framework, work is being done in this regard.

Together with the city council, an area on the southern part of the VILLAVERDE scenario is being delimited as a Sandbox area.

Figure 122: Madrid Mega Site: "La Nave" Sandbox area, Villaverde scenario

This Sandbox area is a circular route, 813 m in length. This topology has been defined with the City Council to ensure that the traffic flow in the arear is not disrupted too heavily and that the tests affect neighbours as little as possible.

The vehicle that will perform this route will be the EMT Gulliver. The IRIZAR i2eBus will remain in Carabanchel so that the 5 STOP SERVICE can continue and performing the testing of the Autoparking (UC3.x family).

9.3.2 Development/Customisation/Integration

This section briefly describes the integration and customisations taken in Carabanchel scenario, i.e. the ones performed on the fleet (derived from WP7) and depot signalling, as well as the local Data Management Platform (here and after DMP).

9.3.2.1 On Madrid mega site fleet and depot signalling

Madrid mega site AVs have been fitted with the required hardware in order to proceed with the testing procedures. This equipment includes externals sensors, such as LiDARS and cameras, localization elements, such as GPS receivers and specific control units and actuators. Once the vehicles had been fitted with all the necessary equipment, real testing commenced and with that an iterative process of trial, error and improvement was established between the different partners of the Mega Site. The infrastructure was also adapted and the RSU was installed alongside the developments performed in the vehicles.

The different s/w modules were integrated in the vehicles, and, for the day-to-day services, scripts were developed to allow the drivers to quickly and independently set up the system and commence the tests. This also allows for a low-level troubleshooting.

Furthermore, during the preparation phase both the bus and minibus were equipped with HMIs meant for the driver and passengers (Figure 123), AVs were identified as SHOW demo platforms with project standardized stickers (Figure 123), as well as GDPR compliant stickers (Figure 128).

Satisfaction passenger touch screen

Safety driver touch screen

Gulliver SHOW sticker

i2eBus SHOW sticker

Figure 123: Madrid mega site: Touch screens for passenger and safety driver (left) and project stickers (right).

Similarly, the infrastructure was also adapted, i.e. the services stops where prepared and installed all along the depot, making the 5 stops service aware to the depot community (Figure 124). For more information on the physical digital infrastructure (PDI), please refer to section 9.2.5.

Figure 124: Madrid mega site: Gulliver approaching signalized bus stop, at Carabanchel.

9.3.2.2 On Madrid Local DMP

Madrid Local DMP (here and after MLDMP) is in charge of collecting, monitoring and processing data concerning Madrid's fleet, as well as integrating with external services and integration with the SHOW DMP, which is basically the data collecting mechanism in charge of the KPIs calculation.

As for its architecture (Madrid's MLDMP), a containerized solution was implemented into a **server VM**, for ease of deployment and maintenance tasks. Docker was selected, for being an open-source solution and for providing ease for modularity and stability, as well as fast development and deployment. Several containers were instantiated, the most relevant to SHOW's integration:

- **Mosquitto broker**, is an open-source solution by Eclipse foundation which implements the MQTT protocol for IoT communication. It provides a lightweight communication for internet connected devices, and it is the protocol selected by the SHOW project as means for real-time communication.
  In Madrid each of the CAVs members send messages directly to the MLDMP broker. Upon reception the broker is configured in bridge mode, to connect with the SHOW Data Management Platform (here and after SDMP).
- **Influx database** is also an open-source software, developed by InfluxData, which is mainly use for storing time series information, and it is mainly focused on monitoring for sensors.
  In SHOW it was mainly selected due to its adaptability to the already defined message format (JSONs) and protocol (MQTT), and the nature of communication (IoT).
- **Dashboard** solution chosen was Grafana; which is an open-source analytics and visualization web application, and it provides the capability quickly deploy custom dashboards and integrate with various data formats.
  In SHOW, it was mainly chosen due to its ease for development, its modularity, and the compatibility with the backend deployed.

Alongside these containerized solutions, the server installed **Telegraf**, which is also open-source and from InfluxData, and its main tasks is to package data from the broker into the influxDB as well as monitoring data from the server itself.

In the vehicle's side the paho libraries for C++ were integrated into the AUDRIC® automation system available in each of the CAVs of Madrid fleet. A client was developed which complied with the JSON data format for SHOW data and collected information from different sources within the vehicle architecture (acquisition, actuation, perception, control), as well as external environment information captured using OpenWeatherMap API.

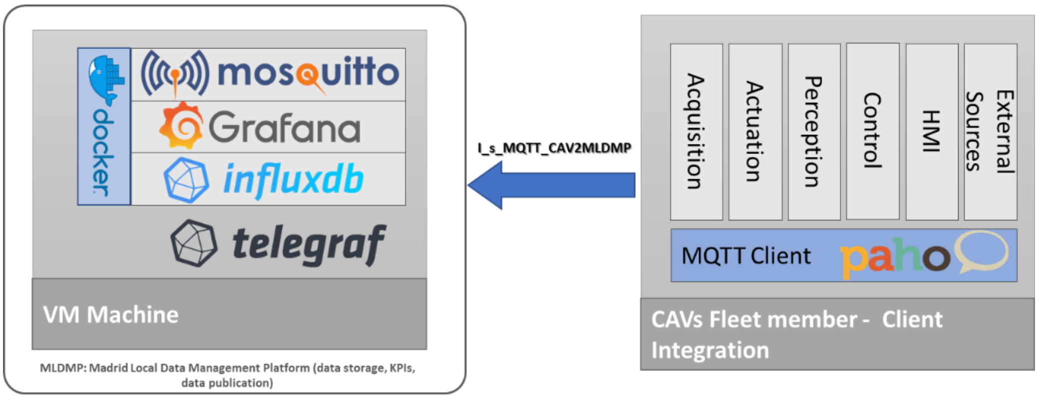


Figure 125: Madrid Mega site: MLDMP main technologies used.

There have two aspects on MLDMP:

1. In the server side, integration between containerized solutions was straightforward, mainly done by configuration files, using Docker Compose for deployment and configuring each container according to the needs of the project.

Connectivity with the SDMP was rstablished in bridge mode directly from the MLDMP, once provided with the appropriate cryptographic keys. During testing drops in connectivity daily were acknowledge which led to the necessity of re-establish communication in bridge mode manually. Finally, a daemon was setup to restart the mosquito broker container everyday outside of working hours for the fleet, which guarantees no loss of data.

Integration with the backend was mainly by capturing JSON messages received in the topic specify for Madrid's fleet. These messages were stored in a timeseries database, which allows for visualization of each of the sensors reported in these standard JSON messages.

2. In the client side**,** each of the vehicles was setup with the appropriate cryptographic keys for MLDMP connectivity using MQTT protocol and configured according to each of the vehicles' specific topics and description.

On the other hand, the integration of SDMP - with Madrid Mega site - was done mainly through the bridge communication of the mosquito broker. Messages were sent as received, in the specified topics:

- `show/<fleet-id>/<vehicle-id>/VehicleInfo`
- show/<fleet-id>/<vehicle-id>/location
- show/<fleet-id>/<vehicle-id>/speed
- `show/<fleet-id>/<vehicle-id>/passengers`
- `show/<fleet-id>/<vehicle-id>/internals`
- show/<fleet-id>/<vehicle-id>/mileage
- show/<fleet-id>/<vehicle-id>/weather

9.3.3 Training

Starting February 2022, theoretical and practical training sessions were imparted at the depot, i.e. Carabanchel scenario. Further training sessions followed during the pre-demo phase.

To ensure the continued service within the Carabanchel scenario, several drivers (Gulliver and i2eBus) have been trained in the safe use and basic troubleshooting of the integrated technology, so that the presence of technology providers can, progressively, be reduced for day-to-day operations. Gender issues were considered very relevant at this point.

Theoretical sessions covered concepts of Autonomous Driving, in general and in particular to SHOW scenarios. The aim was to present the technology to both workshop personnel and drivers.

Figure 126: Madrid Mega pilot site: Training - Theoretical sessions.

Practical sessions covered the specifics of each AV, presenting all three models that participate in the UCs: Twizy, Gulliver and i2eBus.

Figure 127: Madrid Mega pilot site: Training - Practical sessions.

9.3.4 Ethics & GDPR

In line with the work done in WP3 and WP18, several considerations and actions have been taken to ensure Ethical and Data Protection matters have been addressed at a site level. In fact, EMT performed a DPIA, as included in D3.5, which resulted in an estimation of reduced risk due to the fact that the images of the cameras are not stored. EMT lent its knowledge as a PTO to ensure compliance with the GDPR. In terms of Data Protection, even though Madrid AVs are fitted with outward facing cameras, there is no image recording on the vehicle. All video streams are being processed in real time, so no sensitive personal information is being stored or collected. Regardless, the vehicles have been fitted with a regulated sticker, to comply with GDPR.

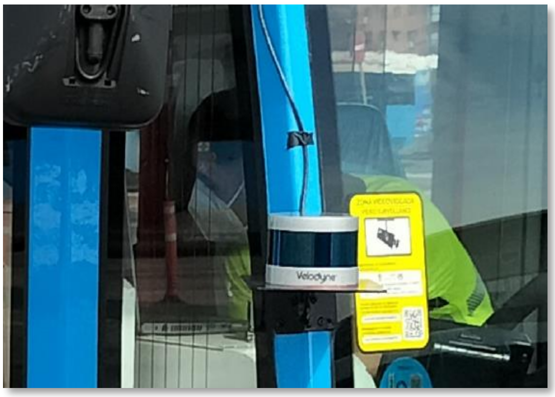


Figure 128: Madrid Mega pilot site: GDPR compliant sticker.

In terms of Ethical considerations, the questionnaire was filled and uploaded to the Sharepoint and the ethical checklist has been completed and signed-up.

9.4 Pre-demonstration study design, in Carabanchel depot

9.4.1 Test Scenarios

During the pre-demo phase there have been the following test scenarios executed:

5-stops service at Carabanchel EMT's depot (responding to UC1.1, UC1.2, UC1.3 & UC1.6)

Due to the fact there is a delay at Villaverde urban open traffic scenario (refer to 9.3.1.3), Madrid local partners figured out the 5 stops service to be implemented and validated, at Carabanchel scenario. This 5 stops service gathers most of the UCs from cluster 1 foreseen at Villaverde, i.e. UC1.1, 1.2, 1.3 and 1.6. This way, once Villaverde permission is obtained, most of cluster 1 UCs foreseen in Madrid have been tested - on a semicontrolled area – and there is not a starting from zero situation.

Hence, the 5 stops service route is a 800m long round trip (circular), gives public transport service to EMT employees as well as depot external visitors.

- UC1.1, there is always some level of traffic going inside the depot, i.e. varying from depot service non-autonomous vehicles, employees' vehicles, and other non-automated buses and minibuses. AVs fleet shall be able to traverse this scenario without safety incidents, in automated driving mode.
- UC 1.2 and UC 1.6 contains a complex scenario, which is considered during rush hours at the depot - increased density of traffic - given that most routes start and end at similar hours, making bus traffic much higher. AVs are expected to give service without safety incidents, and with minor delays or increased stops due to the traffic.
- UC 1.3, in this case, the 5 stops service consists of a round trip, which is integrated within EMT depot, and must overcome pedestrian crosses, and many other non-automated vehicles in its route without safety incidents.

Teleoperation at Carabanchel EMT's depot (responding to UC1.7)

In this test case, the Gulliver minibus has been teleoperated from the staff office. The teleoperation confirms that the AV fleet drives around the depot in safe conditions. EMT operators have been trained on this test manoeuvre to improve safety management, assuring that they can see Gulliver's context at all times.

Platooning at Carabanchel EMT's depot (responding to UC1.8)

In this use case, AVs perform a platooning manoeuvre in cooperative mode using V2V communication allowing for higher efficiency and better traffic flow. In Carabanchel depot scenario, the platooning will be used to move parked vehicles from one side of the building to the other, to reach their charging spots, when charging is required. This UC – at the time of writing – is at a verification phase, i.e. not at a pre-demo phase that will follow later.

Automated parking and depot management at Carabanchel EMT's depot (responding to UC3.3 & UC3.5)

Automated parking and depot management use cases, i.e the AV is able to park in its designated parking spot automatically (without driver's intervention) and is able to drive in automated mode to its designated parking area, prior to performing the parking manoeuvre.

9.4.2 Evaluation methods & data collection tools

The technical validation (SHOW activity A11.2) of Madrid mega site was successfully achieved before the pre-demo phase (refer to TECNALIA contribution to deliverable D11.2). All tests have been passed before moving to the pre-demo phase.

The Madrid local partners, using their social media and company internal channels, distributed the Netigate user acceptance surveys, before and during the pre-demo phase. For the one-question satisfaction survey, the dedicated HMI of the passengers - installed in Madrid's fleet (refer to Figure 123) – was also a main data collection tool.

Also, during the pre-demo phase preparation process (refer to section 9.3.2.2), the connectivity between MLDMP and SDMP has been successfully established, and messages are sent whenever a CAV is active, in Madrid pilot site. The full path of the data from Madrid's CAV to the SDMP is visualized in Figure 129. The data was logged and uploaded (real time) in MLDMP, which was simultaneously streamed to SHOW's SDMP (CERTH), were the relevant KPIs were calculated. In this direction, the list of KPIs related to the vehicle real time data were reviewed and confirmed with CERTH, to ensure KPIs' calculation and delivery to SHOW dashboard (RISE).

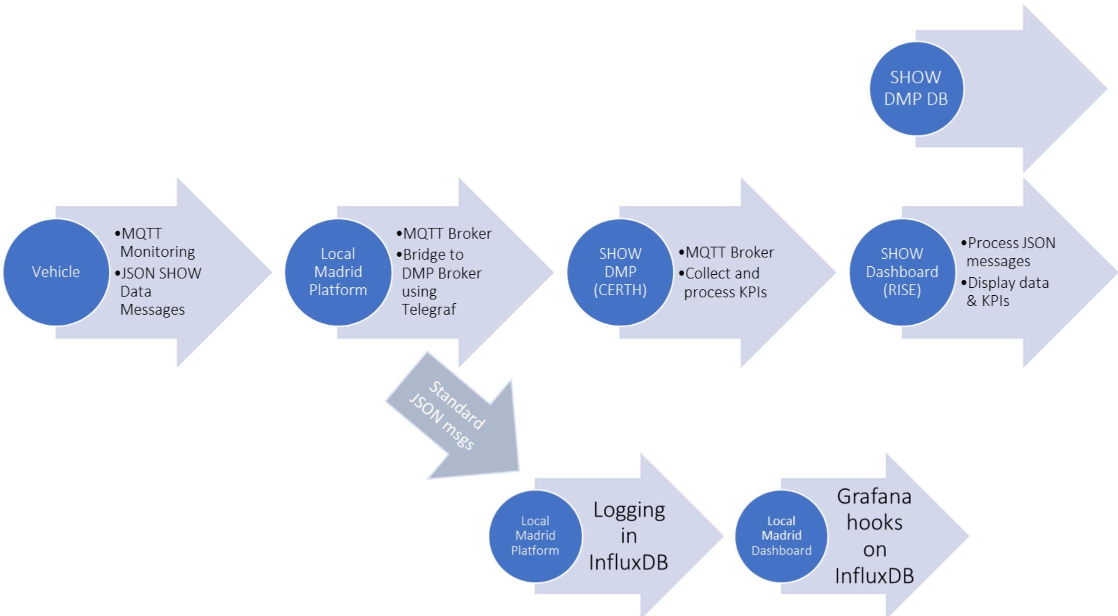
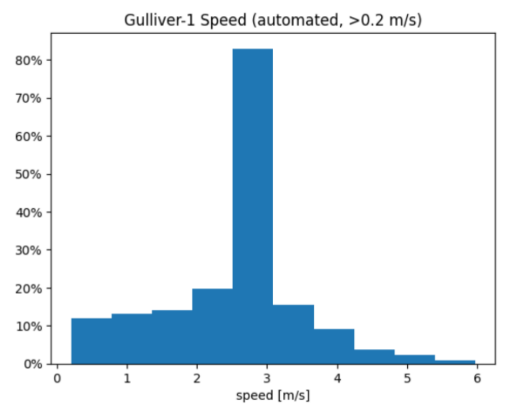
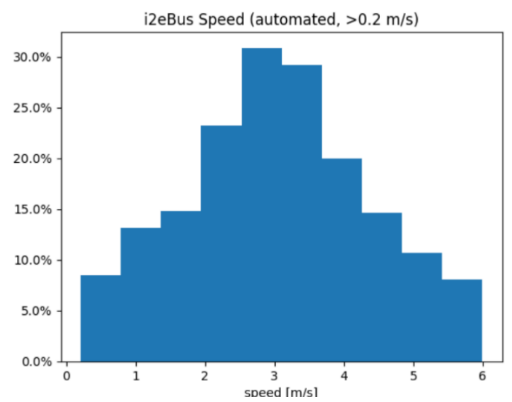


Figure 129: Madrid Mega site: AV data path representation.

During Madrid's pre-demo phase, MLDMP has been transferring data to SDMP; and additionally logged data has been processed also in the MLDMP (refer to Figure 130, Gulliver1 and i2eBus for number of passengers and speed example). This activity was used when trouble shooting during the integration with the SDMP.



- Average Speed Gulliver: 9,2km/h
- Total Passengers: 195[6]



- Average Speed i2eBus: 11km/h
- Total Passengers: 434.

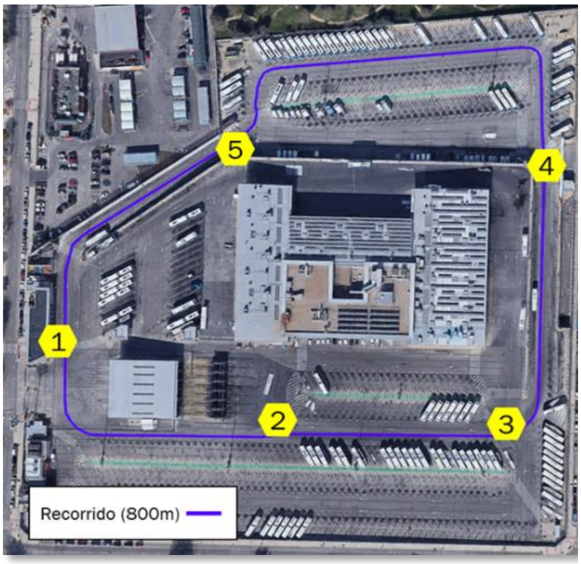
Figure 130: Madrid Mega site: Data collected from MLDMP, at Carabanchel.

9.4.3 Experimental process

At Carabanchel, the **5 stops** service (holding cluster 1 use cases: UC1.1, 1.2, 1.3 and 1.6) has successfully run – in weekdays and more than 10 times - for the full period of pre-demo. In Madrid pilot, at the time of writing, the 5 stops service has been tested inside Carabanchel scenario making use of one Gulliver minibus units and the 12m i2eBus. This service is meant primarily to move EMT's employees inside the depot; and, external visitors, additionally. The experimental process was as following:

- Early in the morning, considered rush hour inside the depot, both Gulliver and i2eBus safety drivers drive manually their AV outside boxes, towards the first stop, i.e. Main Building. Once at the first stop, the drivers start the service by using their dedicated HMI, changing to autonomous mode.
- The 5 stops service collects/drops EMT employees at any of the 5 stops, on a round trip basis. While driving around the depot, always at allowed speeds, it overcomes non-automated vehicles as well as pedestrians.
- As soon as a passenger gets on the bus, the safety driver takes this into account (occupancy); while when he gets off the bus, when applicable, he selects on the dedicated HMI his satisfaction (refer to Figure 123).
- The service runs until the afternoon. Then, the Gulliver bus is manually driven back to boxes for charging/maintenance. While i2eBus is parked automatically in its designated parking spot, until late afternoon, when is manually driven back to boxes for charging.
- *Wednesdays is a particular day at the depot as it is students' day visit. SHOW* is taking profit of this (almost) weekly event to present the project to young generations as well as a tour around the depot, visiting the different areas *(training, boxes, main building, …).*

[6] Number of passengers includes initial 150 passengers before SDMP integration (during pre-demo preparation phase). Same for i2eBus.



1. Main bus depot entrance
2. Main building personnel entrance
3. Upper terrace bus parking and charging area
4. Secondary bus depot entrance
5. Training area

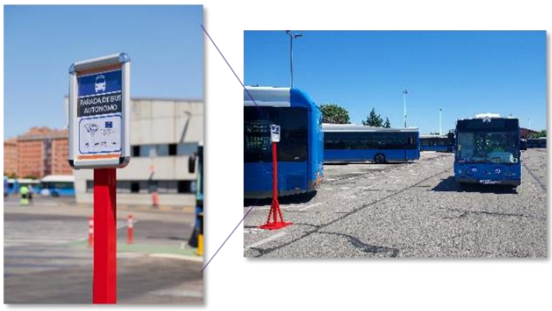


Figure 131: Madrid Mega pilot site: 5 Stops service, Carabanchel scenario.

The **Autoparking** use case at Carabanchel scenario is run by the 12m i2eBus IRIZAR bus. This use case is meant primarily to manage the depot and autopark the ebus during the day, once the 5 stops service is completed (sometime in the afternoon). For *this, i2eBus' safety dri*ver selects in his dedicated HMI the designated parking spot. Next, the 12m bus is able to drive in automated mode to the selected slot, prior to performing the parking manoeuvre; and next to park in the selected slot automatically *(no driver's interventi*on). Worth mentioning that at the end of their shift, if applicable, it has been considered that both safety drivers report (offline, writing on a notebook) any incident occurred. This use case has successfully run – in weekdays and more than 10 times - for the full pre-demo period. The **autoparking use case** has been discussed internally within EMT operation's responsible, so as to locate the three parking slots, i.e. parking 916 to parking 918.

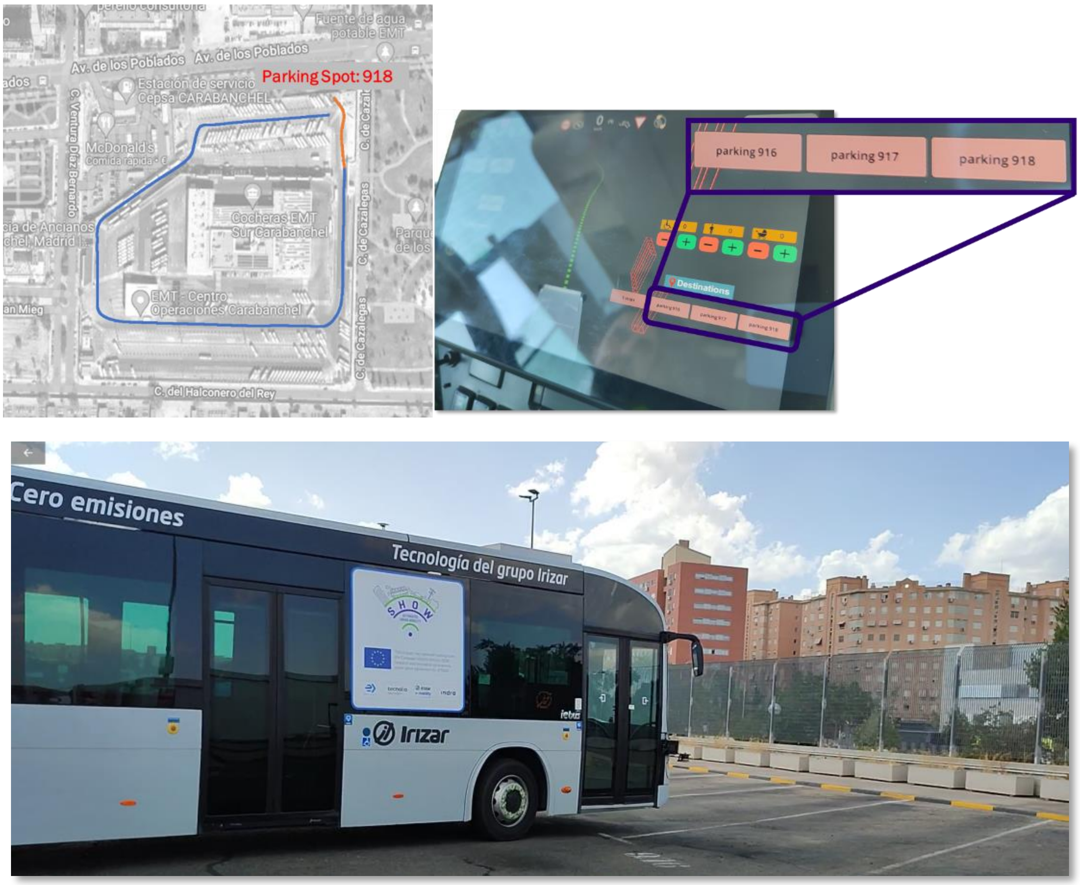


Figure 132: Madrid Mega pilot site: Autoparking use case, Carabanchel scenario.

The **telecontrol** use case is tested with a Gulliver which has been instrumented with *four cameras (AV's environment perception) and WiFi access* (able to communicate with the remote control desk). The *operative is primarily taken inside the depot's main* building, from a remote desk, where the technical personnel in charge is remotely controling the Gulliver inside boxes. This use case has successfully run – in weekdays and more than 10 times - for the full period of the pre-demo period. The remote control UC1.7 (teleoperation) is of great interest for EMT as it allows the possibility of managing buses at the bus depot without the need of a physical interaction with the vehicle. From the communication perspective, EMT has based this use case in the WiFi coverage that the Carabanchel bus depot has. The control desk has been installed in the main building of Carabanchel bus depot, in one of the staff offices, from which it is possible to take control or supervise automated or manual driving. This control desk could be potentially integrated into the central control centre (Servicio de Ayuda a la Explotación, S.A.E.) that EMT has at its main headquarters, from which all the on-street bus operations are managed.

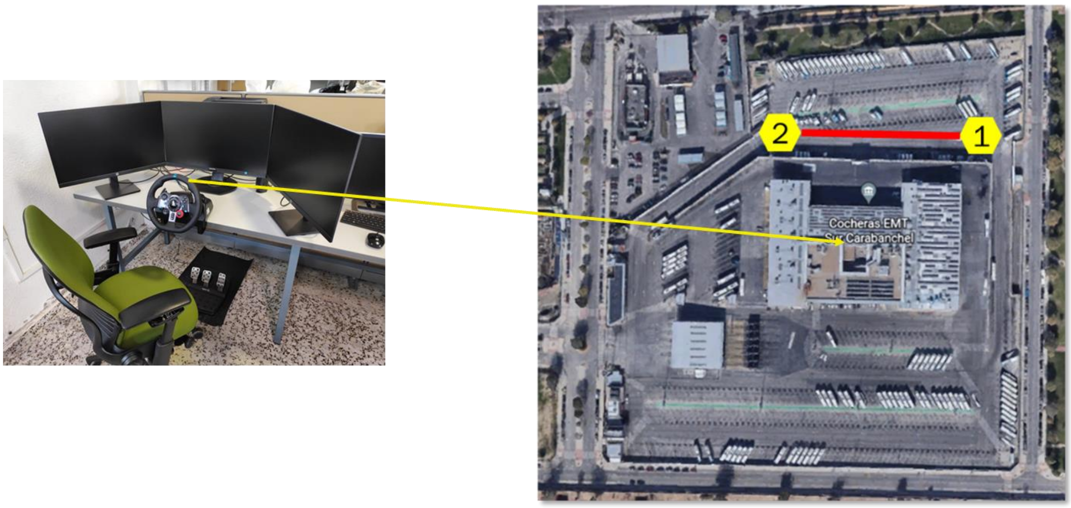


Figure 133: Madrid Mega pilot site: UC1.7 Teleoperation, Carabanchel scenario.

Figure 134: Madrid Mega pilot: UC1.7 specific cameras and WiFi antennas installed on Gulliver.

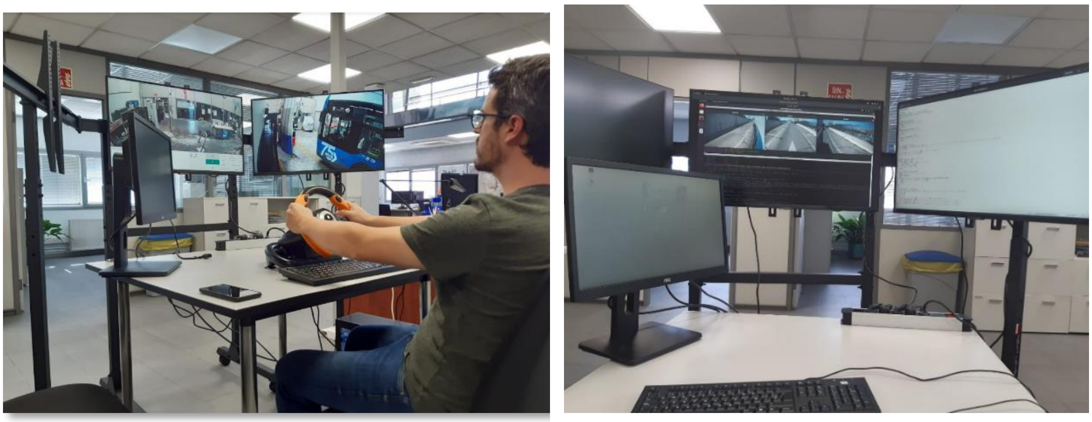


Figure 135: Madrid Mega site: UC1.7 remote control desk in operation.

9.5 Pre-demo phase field trials results

9.5.1 Overall performance results

Madrid's MLDMP - besides collecting/monitoring pilot data – is processing the logged data to calculate the addressed KPIs (in addition to the process done by SDMP). To monitor safety on board, bus drivers have been always in contact with the control dest whereas the events logged in the minibus are analysed to plan emergency actions and to detect risk events.

The data collected at Madrid Mega site are:

1. Online - this type of data is transferred to SDMP using MQTT protocol, in real time and it includes the following:
    - Autonomous/manual mode
    - Position (lat, lon, orientation) (GPS System)
    - Speed in RT
    - Acceleration in RT
    - Passengers on board in RT (occupancy)
    - Mileage in RT (Km Travelled)
    - Weather description[7] (temperature, humidity, preassure, etc.)
    - Connectivity (hardcoded)
    - Battery level (percentage input from safety driver, hardcoded)
    - State of Battery, i.e. charging, not charging (hardcoded)
    - Internal Event, Alarms (input from safety driver, hardcoded)
    - Number of hard-braking events
2. Offline - this type of data is uploaded in CKAN platform and it includes the automated average AV speed, the number of passengers and the incidents/ conflicts that is noted by AV safety driver reports. Each safety driver is writing on a notebook at the end of their shift the incident/conflict, when applicable. In addition, connectivity delays, WiFi coverage and logs related to the field of vision are recorded

Also, as stated, the passenger satisfaction is collected by using a dedicated HMI; when leaving the bus, the passengers rate their satisfaction level.

Overall, test scenarios have performed well, though in some cases, there is room for improvement (see more in section 9.5.4). The key consolidated KPIs for the pre-demo phase of Madrid (until end of May 2022) are provided in section 11.

9.5.2 End-user acceptance

9.5.2.1 Demographics

The so far sample (data logged until end of May 2022) of the Madrid test site analysed herein consists of **10 completed responses** (1 respondent did not complete their demographic information). It consists of men only (100%), with a mean age of 40. The oldest respondent is 54, while the youngest is 26. Education levels are mostly high, with all respondents having at least one higher education degree. 22% have a bachelor's degree, 67% have a master's degree, 11% a PhD degree. The distribution over geographical area is relatively equal between urban (44%) and peri-urban (56%).

[7] Openweather API, for Carabanchel scenario (api.openweathermap.org/data/2.5/weather?0097f46564fcfb2e1fbeb9ae9f8f9ced&q=Carabanchel)

Table 47: Distribution of age in Madrid test site.

Age	
Mean response	39.78
Standard deviation	11.01
Median	43.00
Minimum	26
Maximum	54
Number of responses	9

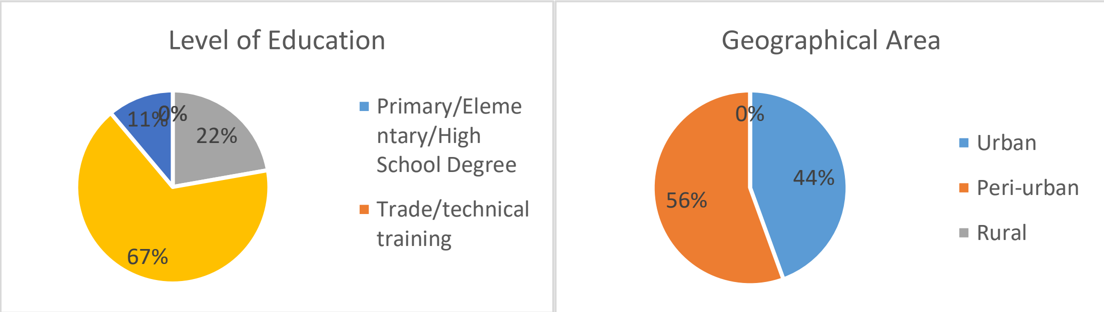


Figure 136: Distribution of the level of education and geographical area of respondents in Madrid.

9.5.2.2 End-user acceptance results

The average acceptance score (on a 9-point likert scale) is above average, with a mean of 7.25 and median of 8. Comfort is rated the highest, with an average score of 7.5, but overall, the mean score of all metrics is in the range of 7-7.5.

Table 48: Descriptive data of acceptance in Madrid.

Descriptive data	Mean response	Standard deviation	Median	Minimum	Maximum	Number of responses
Satisfaction	7.30	1.16	7.50	5	9	10
Usefulness	7.00	1.25	7.00	5	9	10
Ease of use	7.20	1.14	7.00	5	9	10
Ease of learning	7.20	1.40	7.00	5	9	10
Reliability	7.00	1.49	8.00	4	8	10
Safety	7.40	1.58	8.00	4	9	10
Adequacy	7.20	1.62	7.50	4	9	10
Comfort	7.50	1.27	8.00	5	9	10
Intention to re-use	7.30	1.57	8.00	4	9	10
Recommendation Intention	7.40	1.65	8.00	4	9	10

We see that the mean score differs depending on the geographical area of the respondents. Indeed, **respondents in urban areas rate the various acceptance metrics lower on average than those in peri-urban areas**. Ease of use is an exception, with similar mean scores (7.25 and 7.20 respectively). In reliability and safety, we observe the opposite, with respondents in urban areas giving a higher average score than those in peri-urban areas. The possible correlation between gender and the acceptance metrics cannot be evaluated, as the current entire sample is composed of men. One respondent provided further comments beyond the survey questions, stating the reason why they decided to use the service is mostly curiosity and interest in new technology, with comments such as “The technology interests me and I want to test the new development”.

9.5.3 Stakeholders acceptance

The 5 stops service interviews where basically done to EMT employees and eternal visitors. Autoparking use case interviews where basically done with EMT depot operation management and highlevel responsible at EMT depot.

The stakeholders (9 in total) answering the surveys composed entirely of males (100%), with a mean age of 41. The eldest participant is 54 years of age, whereby the youngest is 26 years old. The educational qualifications are predominantly higher: all interviewees hold at least a higher education qualification (22% have a bachelor's degree, 67% a master's degree and 11% a PhD) as summarized in Figure 137. 67% of there are transport operators and OEMs (from EMT and IRIZAR), 22% of them Tier1/ technical providers (INTRA and TECNALIA) and 11% of authorities (Madrid municipality, Madrid PTA (CRTM) and DGT). Their competence fields are mainly engineering studies, urban mobility, urban buses operations, automated driving and maintenance. The interviewees have an average of more than 10 years (in their work fields), with a mean of around 2 years of work experience in automated service vehicles.

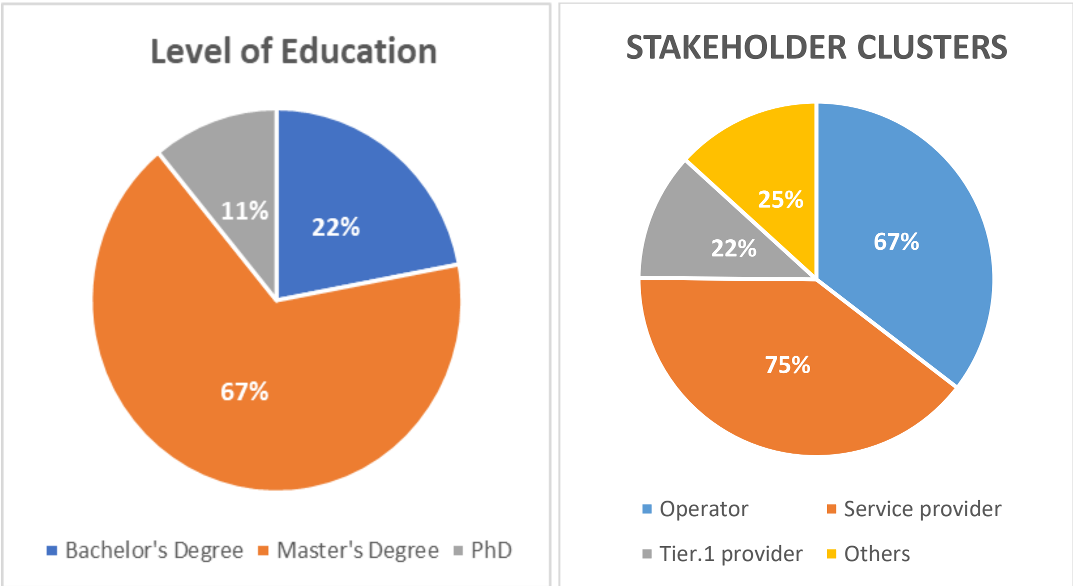


Figure 137: Distribution of level of education and stakeholders clusters of respondents in Madrid.

The key consolidated findings as of the interviews with all 4 respondents are as follows:

- The majority of interviewees stated that there are more positive than negative aspects in the services experienced. On the basis of the descriptive data analysis (Table 49), the outcomes indicated that the interviewees **had the highest level of agreement on the usefulness of automated vehicles**; on the opposite, they averaged very low on the automated vehicles being undesirable (which strengthens the overall positiveness in their view).

Table 49: Descriptive data of stakeholders' level of agree on automated vehicles/service in Madrid.

Descriptive data	Mean response	Standard deviation	Median	Minimum	Maximum	Number response
Usefulness	4.11	0.33	4.0	4.0	5.0	9
Pleasant	4.00	0.0	4.0	4.0	4.0	9
Poor	1.78	1.09	1.0	1.0	4.0	9
Good	4.11	0.60	4.0	3.0	5.0	9
Effectiveness	3.67	0.71	4.0	3.0	5.0	9
Irritating	1.67	1.0	1.0	1.0	4.0	9
Supportiveness	3.67	0.5	4.0	3.0	4.0	9
Undesirable	1.56	0.88	1.0	1.0	3.0	9
Vigilance	1.78	0.67	2.0	1.0	3.0	9

- Based on the overall outcomes of the interviews, it has been seen that the mean scores of each level of agreement with automated vehicles varies across different stakeholder groups (Figure 138). For example, it is noticeable that the mean values of the utility rating differ between the stakeholder clusters (rated higher by authorities). Still, usefulness is being rated with similar scores across all groups; mean scores of 4.0; 4.5 and 4.0 respectively and similarly for pleasantness. Effectiveness is viewed rather differently with average scores, again with authorities providing the higher score (3.5 and 5.0).

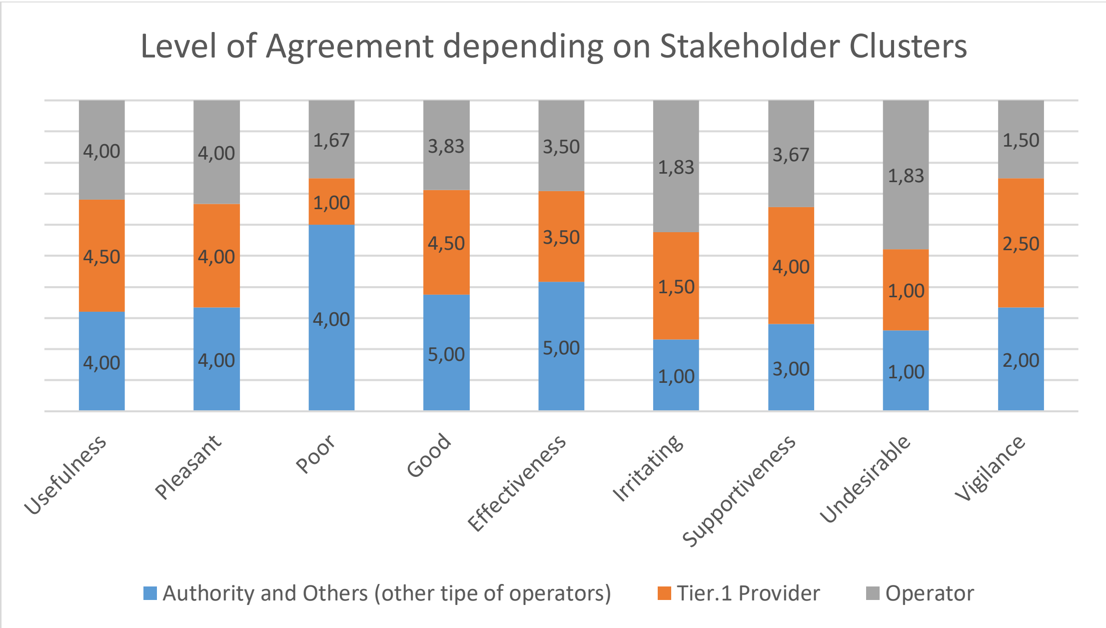


Figure 138: Level of agreement of AV service across stakeholder clusters.

- According to the view of the stakeholders who have been actively engaged in the project, the SHOW project demonstrations/testing activities are **bringing diverse possibilities or novel opportunities for cooperation with numerous partners having different competences and technical know-how.** They also stressed that the project is likely to trigger an interest in both stakeholders and society in the achievement of automated mobility in a favourable direction and will also assist understanding how the technology is advancing and, through direct experience, comprehending the state-of-the-art in automated mobility. On the contrary, the interviewees had less pleasant experiences at project demonstrations due to the COVID-19 pandemic that made some processes cumbersome, but also due to some unexpected notifications, sensor configuration errors noticed, outage of the

GPS signal and associated disruptions, waiting times and time delays. Further to that, some of them **shared the concern of the impact of automated mobility to jobs**.

- According to those stakeholders that have not actively participated in the trials and have only attending this, the post positive aspects relate basically to positive impacts on road safety, the potential of tele-operation and the technologies advancements. Still, they did report some negative aspects that relate mostly to the challenges in integration, the accurate logging of failures and incidents and the feeling that there is a limited control of the vehicle and the operations.
- Overall, main concerns shared relate to feasibility and acceptance, potential negative impacts to employment, maintenance issues and lack of general in-depth technical and (applicable) driver experience. It was specifically shared as a concern that, currently, society is not ready to move-forward with the automated mobility paradigm and technology is not always mature enough to meet the quality of service needs recognized in mobility. In addition, the **up-scaling in a real-world environment might be seen as ambitious** given the current state of the art.
- One of the **key contributions of the project, apart from offering big visibility in automated mobility, is seen to be its significant impact on know-how and competencies and its unique characteristic to consolidate supplementary experiences from different contexts, technologies and ecosystems under layered complexity.** It also paves the way for further development and demonstration and the gradual automatisation of fleets and technologies. Despite the concerns about the impacts on employment, the **benefit of replacing repetitive and labour-intensive tasks** is commonly recognized.
- All stakeholders anticipated themselves getting further involved in the near future in automated mobility field. It was highlighted that more **cross-cutting platforms have to be established on European level to assist the CAV penetration and the same is valid for application guidelines regarding operation and maintenance.**

9.5.4 Research Questions answered for the site

Table 50: Madrid (Carabanchel) pre-demo response to SHOW research hypotheses and Use Cases.

Research Questions	Relevant Use cases	Overall response
How will road safety, traffic efficiency, mobility, and user acceptance be affected by AV operation (passenger or cargo) in a real city environment when operated in normal speeds, normal/smooth traffic context, without any traffic or other environmental complexity? Also, interfacing to any of the following modes: PT, DRT, MaaS and LaaS.	UC1.1: Automated passengers mobility in Cities under normal traffic & environmental conditions – **Madrid specific: 5-stops service at Carabanchel *EMT's* depot**	Within Carabanchel EMT depot, overall, road safety and traffic efficiency have increased by using the 5 stops service, in normal conditions. The main challenge has been the coexistence of automated and non automated vehicles. In this direction, the presence of a safety driver adds a plus in this situations. There have been no extreme weather conditions, hence, there have been no significant differences. The

Research Questions	Relevant Use cases	Overall response
		overall acceptance results reflect the above.
How will road safety, traffic efficiency, mobility, and user acceptance be affected by AV operation (passenger or cargo) in a real city environment when operated in normal speeds but within a complex traffic or environmental context (e.g., curvatures in roundabouts, etc.)? Also, in cases of additional restrictions applied (e.g., heavy traffic, extreme weather conditions, etc.).	UC1.2: Automated passengers mobility in Cities under complex traffic & environmental conditions - **Madrid specific: 5-stops service at *Carabanchel EMT's* depot**	As for complex conditions, during Carabanchel's pre-demo 5 stops service, it is worth mentioning the rush hours timing where safety drivers' occasional interventions were needed. There have been no extreme weather conditions, hence, there have been no significant differences
How will road safety, traffic efficiency, mobility, and user acceptance be affected by AV operation (passenger or cargo) in a real city environment when interacting with not automated (not connected) vehicles and/or VRUs?	UC1.3: Interfacing non automated vehicles and travellers (including VRUs) - **Madrid specific: 5-stops service at Carabanchel *EMT's depot***	Same as previous. In this case the complex conditions during rush hours are coming from pedestrians walking around the depot.
How will road safety, traffic efficiency, mobility, and user acceptance be affected by AV operation in a real city environment when operated in mixed flows with AV and non-AV vehicles?	UC1.6: Mixed traffic flows - **Madrid specific: 5-stops service at *Carabanchel EMT's* depot**	Same as UC1.2.In this case the complex conditions during rush hours are coming from the coexistence of automated and non automated vehicles driving within the depot.
How will road safety, traffic efficiency and user acceptance be affected by AV operation connected to a control centre for teleoperation and remote supervision in a real city environment?	UC1.7: Connection to Operation Centre for tele-operation and remote supervision - **Madrid specific: Teleoperation at Carabanchel EM*T's* depot**	The so far pre-demo phase is showing good potential for teleoperation functions. The main challenges have been the instability of the WiFi connection/ delays in signal reception and the need of a wider field of vision for the teleoperator. However, some improvements are being implemented iteratively already, related to the

Research Questions	Relevant Use cases	Overall response
		improvement of the connectivity and the cameras' location (in order to improve the field of vision). Regarding connectivity, new signal repeaters are being installed to avoid "blackout" or weak coverage areas. In addition to that, it is foreseen that the minibus dashboard will add indications and information to the remote driver. The information is not saved, just processed continuously. Therefore, there are no GDPR constraints. The users of this UC, who were EMT employees, were overall satisfied with the functionality and the possibilities offered.
Can platooning of passenger transport at higher speeds contribute to improved traffic efficiency, energy consumption and environmental impact of transport?	UC1.8: Platooning for higher speed connectors in people transport – **Madrid specific: Platooning at *Carabanchel EMT's* depot**	Not applicable for this period.
How will efficiency be affected by the use of AVs self-parking functions?	UC3.3: Automated parking applications – **Madrid specific: Automated parking and depot management at *Carabanchel EMT's* depot**	Within Carabanchel, the use of CAV services has increased safety and efficiency of EMT's depot operations by decreasing the time allocated for parking. AUTOPARKING tests dealt with this pre-demo response.
How will traffic efficiency and safety be affected by automated services at AV depot areas?	UC3.5: Depot management of automated buses – **Madrid specific: Automated parking and depot management at**	Within Carabanchel, the use of CAV services has increased safety and efficiency of EMT's depot operations by (1) reducing human

Research Questions	Relevant Use cases	Overall response
	***Carabanchel EMT's* depot**	mistakes, (2) optimizing the use of space in the parking area and (3) decreasing the time allocated for parking.

9.6 Lessons learned - recommendations

Lessons learned derived so far (end of May 2022) and towards the continuation of the pre-demo phase of Madrid and the final demo phase following, are as follows:

- AV permits: Madrid has taken profit of Carabanchel scenario to already start testing cluster 1 use cases on a semi-controlled area (EMT depot) and learn for Villaverde urban open traffic area.
- Teleoperation use case: During pre-demo the main challenges have been the instability of the WiFi connection, and potential delays in signal reception and the need of a wider field of vision for the teleoperator. Before Demo phase, the following improvements are foreseen: (a) improve cameras location (in order to improve the field of vision), (b) as well as technical connections, i.e new signal repeaters are being installed to avoid "blackout" or weak coverage areas. Finally, an enhanced Gulliver minibus dashboard will add indications and information to the remote driver.

9.7 Conclusion

Table 51: Readiness level of Madrid towards final pilots.

Readiness level towards final evaluation round of SHOW				
1 - Not ready at all – A lot to do more	**2 – Not ready – Significant corrections/development/integration and optimisation is still required**	**3 – Half ready; good basis but a series of additional development/integration and optimisation is still required**	**4 – Quite ready to go – several optimisations are still required**	**5 – Almost ready to go – only minor optimisation is required**
		X		
Ranking justification – what needs to be done in short	Test cases and services have been so far successfully tested at Carabanchel, where unexpected incidents did not occur. Additional verification and optimisation is required when testing at Villaverde scenario (2023) – see also in previous section.			
Estimation of time required for getting 100% ready for the final field trials	2 months (for Villaverde) – for Carabanchel, iterative optimisation during operation and until the end of the pre-demo but also following final demo phase – see also in previous section.			

10 User Acceptance consolidated results

This section presents the consolidated results of the pre-demo phase of the test sites addressed in the current issue of D11.3. It should be reminded that the passengers who tried the automated mobility services in the context of the pre-demo phase of the test sites was only a portion of the overall number of passengers that tried the service. Also, that only those that provided full answers to the Netigate surveys of SHOW have been considered. This totals to **45 complete answers and 24 in addition coming from the pre-pre-demo trials of Turin.** (for the specific period of analysis the current issue covers; those numbers will be enhanced in the next issue for some of those sites in addition to further sites that will be added). In addition, safety drivers and other specific participants (i.e. recruited VRUs) were involved in each case.

Overall, **the acceptance levels of the passengers that tested the services across pilot sites are medium, with general average scores ranging from 6.8 to 8.0 (in a Likert scale 1-9).** Brainport is the site that was most positively evaluated, followed by Gothenburg and Madrid. Still, it should be stressed that Brainport trials were conducted in a controlled environment and is not comparable in reality with the real life trials happening in the other test sites.

Linköping stands out with much lower scores (average acceptance score of 4.28), largely due to some responses with very low scores linked with experiences of hard braking events.

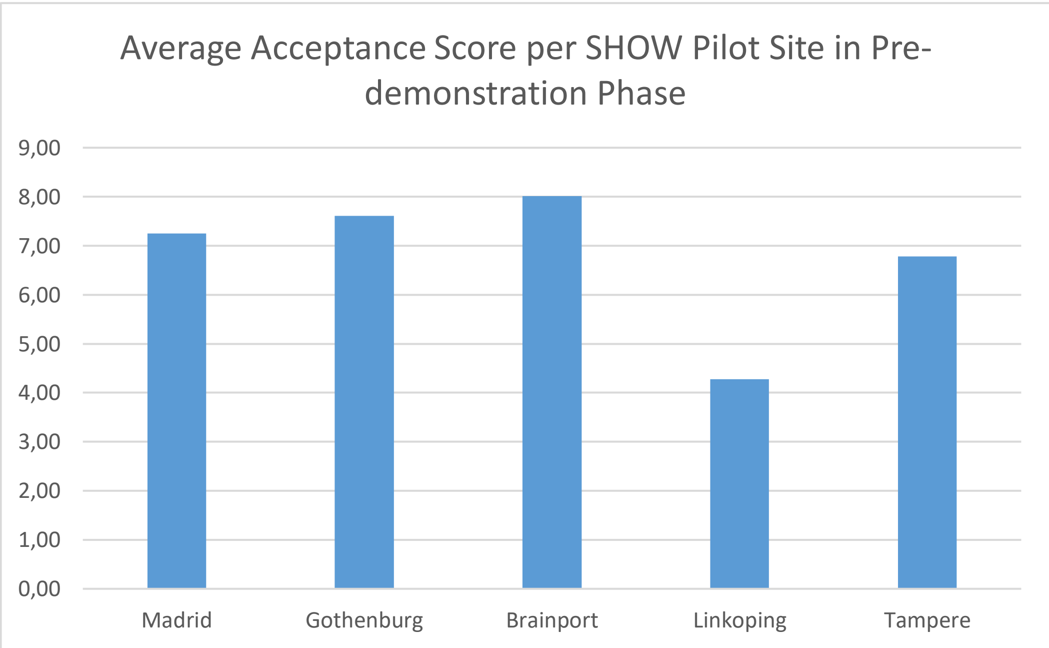


Figure 139: Overview of the average general acceptance score per SHOW Pilot Site in their pre-demonstration phase.

We see that factors are not evaluated the same across the sites. In some sites, like Madrid and Brainport, the scores are relatively consistent for all acceptance factors at around 7-7.5 and 7.4-8.5 respectively, indicating that participants had a generally positive experience with no clear stand-out characteristic that they could find positive or negative.

Accordingly, the standard deviations were relatively low, especially in Brainport (less than 1). In other sites, more distinct patterns can be seen with significant differences across the different factors. We see, for example, that **usefulness is a consistently positively evaluated factor in most of the sites** (average of 7 in Madrid, 8 in Tampere). Meanwhile, **Adequacy** is scored the lowest in Brainport and Linköping, highlighting that a weakness of the service is that it may not match the needs of the participants (which is highly justifiable for Brainport as we said due to the controlled nature of the context). In Gothenberg, the usefulness of the service and adequacy are evaluated similarly with scores of 6.57 and 6.62 respectively, showing again that the utility of the service for the mobility needs of participants may not necessarily be clear to them. **The most positively rated factors overall are comfort, ease of learning, safety, ease of use, and intention to recommend AVs use to other people.** It should be stressed, though, that when we refer to safety in those cases and as we consider subjective ratings, we, in reality, mean the **perception of safety in particular** by the respondents. It it thus important to correlate to the actual typical safety performance indices, as we have done for the first time in this issue (see section 11) and which will go much more in depth of course in the large scale field trials analysis.

Table 52: Mean scores of the acceptance factors in each pilot site.

Acceptance Factors	Madrid		Gothenburg		Brainport		Linkoping		Tampere	
	Score	Strd Dev.	Score	Strd Dev.	Score	Strd Dev.	Score	Strd Dev.	Score	Strd Dev.
Satisfaction	7.30	1.16	8.14	1.17	8.00	0.82	4.22	3.27	6.00	1.26
Usefulness	7.00	1.25	6.57	2.82	8.29	0.49	4.33	3.39	8.00	1.26
Ease of use	7.20	1.14	8.21	1.12	8.14	0.69	4.67	3.67	6.83	2.14
Ease of learning	7.20	1.40	8.38	0.65	8.00	0.58	4.33	3.28	6.83	2.23
Reliability	7.00	1.49	7.50	1.79	7.86	0.69	3.78	3.03	7.20	0.45
Safety	7.40	1.58	7.14	2.35	8.57	0.53	4.22	3.19	7.20	1.30
Adequacy	7.20	1.62	6.62	2.69	7.43	0.79	3.56	3.13	6.20	2.17
Comfort	7.50	1.27	7.93	1.14	7.43	0.98	4.22	3.15	6.00	1.87
Intention to re-use	7.30	1.57	7.50	1.40	8.29	0.76	4.89	3.76	6.00	2.74
Recommendation Intention	7.40	1.65	8.07	0.92	8.14	0.38	4.56	3.47	7.60	1.34
General Score	**7.25**	1.37	**7.61**	1.81	**8.01**	0.73	**4.28**	3.19	**6.8**	1.77

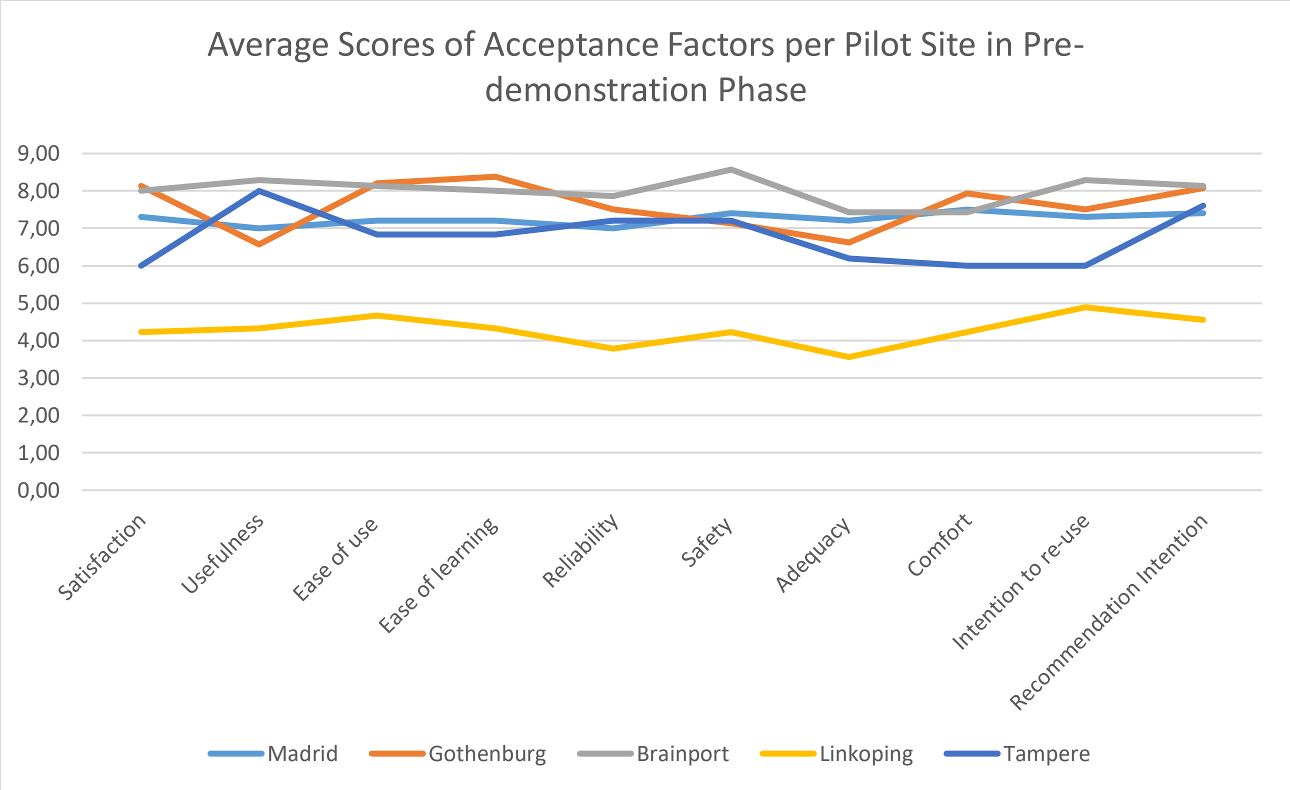


Figure 140: Overview of the average acceptance factors per SHOW pilot site in the pre-demonstration phase.

It was not always possible or safe to identify correlations between the characteristics of the participants and the score due to limited sample sizes at this phase. We can only have some first insights that definitely need to get reconfirmed from the results of the final open to public large scale field trials.

In general, we do not see any significant correlation between gender and acceptance levels. Similarly, the influence of education levels could not be evaluated due to the over or under representation of the different education levels in the samples.

Geographical areas are associated with different scores in some sites. For instance, in Madrid and Brainport, **respondents living in urban areas rate the various acceptance metrics lower on average than those in peri-urban areas. This might be due to the fact that urban centres residents have already many more mobility alternatives and is thus a more challenging comparison, which is not the same for people living in peri-urban areas.**

Based on these first results, we can reach a few conclusions (always with some reservation, as mentioned, due to the small size of the sample). The first one is that the occurrence of safety-critical events like conflicts and hard braking can have a significant impact on the acceptance levels, as we have observed negative evaluations linked with such events (even if all the rest features were well received). It is thus important for pilot sites, and in collaboration with the OEMs/ vehicle demonstrators providers/ developers, to follow-up and smoothen this as much as possible prior to opening to public.

Furthermore, what we observed in the analysis process is that the usefulness and adequacy of these automated mobility services may not always be clear for participants, and they may not see how they can satisfy their mobility needs. This implies that **an overall awareness about automation is still lacking.** The general public has not understood what is the benefit to be brought for them specifically and on societal level more generally speaking. It also implies that **for travellers, pure technology, when not accompanied by a complete, comprehensive and mature service, is not having high potential for acceptance.**

Nonetheless, participants still seem to have a generally positive view of the services, and have a high intention to re-use and to recommend them to others.

In addition to the full user acceptance survey, the **one question regarding satisfaction** was also ranked by the same passengers individually (scale: 0 to 100 – most positive)[8]. The results, reflected in the following figure agrees overall with the results of the more in-depth user acceptance survey. **Brainport again ranks first**, while **Linköping scores the lowest**. Still, overall, average satisfaction across all the test sites is quite high – **84.8%** - especially considering this was a pre-demo phase with not the highest level of services and vehicle features maturity.

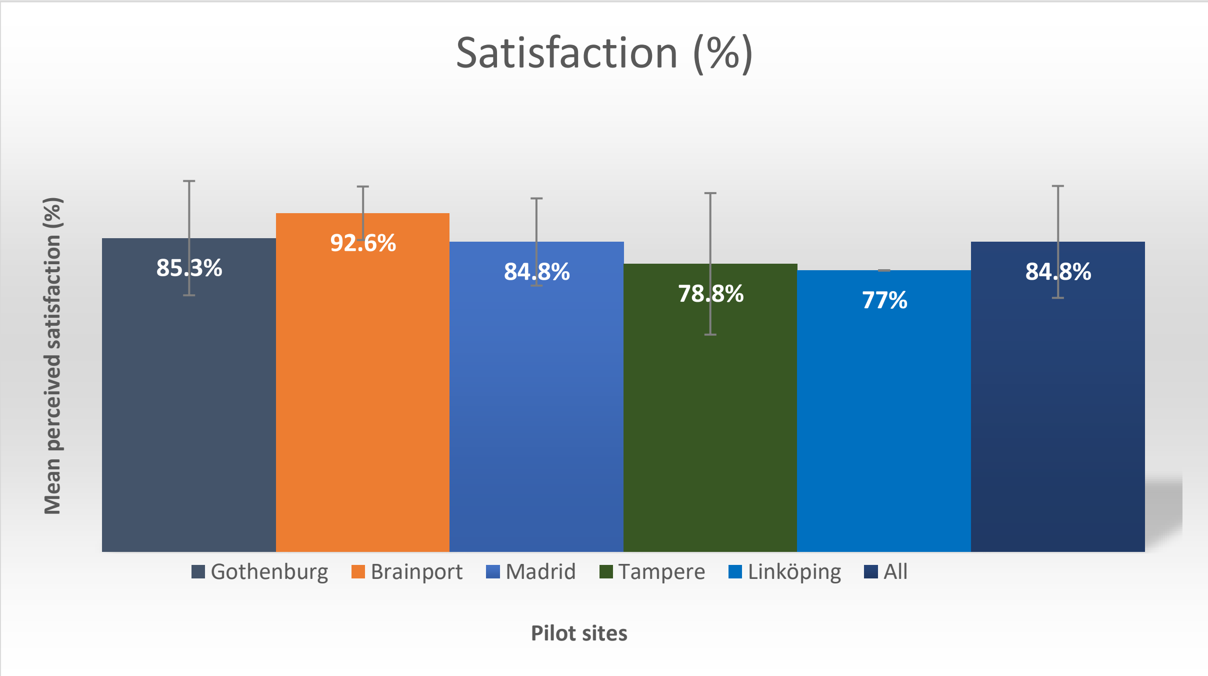


Figure 141: Mean perceived satisfaction (1 question; ranking from 0-100) of passengers trying the SHOW automated services in the pre-demo period of the test sites.

In addition to passengers**, 26 stakeholders** representing OEMs, operators, technology providers and authorities were interviewed in this phase. Overall and across all the test sites, stakeholders favored the automated services deployed. Most of them agreed unanimously that the automated vehicles are useful and pleasant, still not all of them agreed on their effectiveness and robustness. Technical features (i.e. hard-brakings, communication issues, need for higher speed in some case – though not always and in all cases) but also quality of service issues were raised (reliability, integration to public transport, etc.). Also, stakeholders do not seem yet convinced for the cost-effectiveness of the service and, especially, as long as a safety on-board operator is required (which is currently a typical requirement in national legislation in several European countries). Furthermore, in Tampere, the need for electrification of the automated services was also raised (due to the fact that apart from the obvious benefits to the environment, it also affects the easiness of integration). Maintenance issues were also raised – connected also to the cost-effectiveness aspects of the services' deployment. The impact of automated mobility to jobs was also raised in Madrid.

[8] In Tampere case, for this 1 satisfaction question, respondents were more that the ones responding to the full survey; equal to 19. For the rest site, the same apply.

The importance of clarifying the governance models, regulation and achieving to convey a clear message to the general public on what is expected out of shared automated mobility was also stressed.

First/ last mile connectivity when there is lack of service and inclusiveness in mobility (with the condition that some features will get improved) and especially for passengers that are unable to walk or cycle, were seen as the key benefits that shared automated mobility could bring.

The value of SHOW in the area of stakeholder collaboration and lessons learned from real-life deployments Europe-wide was in all cases appraised as the key competitive advantage of the project. All stakeholders shared their intention to get more involved in automated mobility in near future and as part of their business.

11 Performance data and correlation with subjective data

11.1 Overview of key performance data

The SHOW Data Management Platform (DMP) includes all the mechanisms and format relevant to the collection, storing and processing of the logged data during the project. There are three ways of connection with the pilot sites. The differentiating criterion of the three ways is the calculation of the KPIs, mandatory action for all the sites. Each pilot site can be connected either in real-time via the MQTT broker or by providing historical datasets in CKAN platform. In the aforementioned workflows, the DMP team is responsible for the calculation of the KPIs. The third way of connection is the provision of ready calculated KPIs that is the way preferred by a few sites. Still, it has to be stressed that whichever the way of data/KPI provision is, in all cases the KPIs have been calculated upon the same specific algorithms/formulas that have been defined from the impact assessment task force of the project (A9.4: Impact assessment framework, tools & KPIs definition & WP12: Real – life demonstrations).

The current status (by the time of this issue writing) is that 5 test sites have completed the connection with the DMP; Linköping, Tampere, Gothenburg, Brainport and Madrid. Linköping and Tampere utilize a hybrid type of connection providing some data attributes via MQTT and some other within CKAN platform. Madrid site sends data using the MQTT broker (MQTT) as well as offline (CKAN). Gothenburg and Brainport sites are calculating locally the KPIs values following the commonly agreed formulas.

The full KPIs list is described in the latest submitted issue of D9.3. In first phase, the calculation is concentrated on 8 major KPIs relevant to, mainly the vehicle and traffic efficiency data; listed below.

1. **Average speed**
2. **Acceleration variance**
3. **Kilometres travelled**
4. **Number of passengers**
5. **Hard breaking events.** It is defined as the number of incidents in which the acceleration of the vehicle is negative and more than $3m/s^2$.
6. **Road accidents.** It describes the accidents that lead to at least a slight injury of passengers or pedestrians.
7. **Conflicts.** It describes a critical traffic situation in which two (or more) road users approach each other in such a manner that a collision is imminent and a realistic probability of personal injury or material damage is present if their course and speed remain unchanged.
8. **Illegal overtaking.** It describes the times in which a car overtakes illegally the AV.

Until the end of the project, all the applicable to each test site and their services KPIs will be calculated on the basis of all performance data logged. The following table reports the aggregated values for the above 8 KPIs for each test site presented in this issue.

Table 53: Key aggregated KPIs for the pre-demo period.

Test site	Type of Connection	Average speed (km/h)	Acceleration variance (m^2/sec^4)	Number of passengers	Kilometres Travelled	Hard Breaking events (3 m/sec^2)	Road accidents	Conflicts	Illegal overtakings
Linköping	MQTT+CKAN	5.55	0	401	1800	340	0	72	0
Tampere	MQTT+CKAN	11.3	0.1	12	1293	580	0	0	0

Test site	Type of Connection	Average speed (km/h)	Acceleration variance (m2/sec4)	Number of passengers	Kilometres Travelled	Hard Breaking events (3 m/sec2)	Road accidents	Conflicts	Illegal overtakings
Gothenburg	Ready KPIs (CKAN)	4.5	Not available	1260	7220	66	0	79	0
Brainport	Ready KPIs (CKAN)	38.16	0.7	12	18.8	0	0	0	0
Madrid	MQTT + CKAN	4.8 (for up to end of May 2022)	Not available for until end of May 2022	10 (until end of May 2022)	Not available for until end of May 2022	Not available for until end of May 2022	0	Not available for until end of May 2022	Not available for until end of May 2022

One of the first remarks on the above table is that average speed appears to be low, apart from the Brainport case that was a controlled environment and was naturally higher.

There are **three main reasons** for a low average speed at this phase, as follows:

1. It should be noted that the average speed shown in the following table is including speeds relevant to **scheduled stops slots** which will not be the case for the final average speed calculation that will exclude them to be more realistic. In specific, in the final calculation and for speed ≤ 1km/h, data logged 3 seconds before and 8 seconds after the scheduled stops will be excluded. This means that the average speed shown in the above table **is lower than the actual operational average speed.**
2. It should be reminded that those values **refer to the pre-demo phase of the sites**. That aimed to serve as a rehearsal and thus, the test cases were not operated in full operational extent. Test conductors and, often, upon the instruction coming from the OEMs, had to be cautious as it was the first time they tried the vehicles and the services in a real life environment with surrounding traffic. This implies that the average speed is expected to show increase in the final demo phase of the sites. As it can also seen in the fleet tables of each site, the maximum speed reached is very much higher.
3. All the services, apart from Brainport, **run in urban dense contexts, including peak hours**. Low speed was usually imposed by the typical traffic patterns.

Another key remark is that although no accidents were noticed in the pre-demo phase, **a quite considerable number of hard-brakings and conflicts were logged in some cases**, which relates to the perception and actuation functions of the AVs. According to Jun et al (2007) study, a typical average number of hard-brakes per km (on daily basis) when no accidents noticed was 0.17 hard brakes per km, and when an accident was recorded, the ratio was 0.13 hard brakes per km[9]. If we consider only the peak hours, the numbers turn to 0.09 and 0.11 hard brakes per km respectively. If we consider the “worst” ratio from the table above, this corresponds to Tampere and equals to **0.45 hard brakes per km** (although someone should be cautious minding also the bias in the logging of data across the sites), which is much bigger. Future s/w upgrades by all OEMs tried iteratively to deal with this with the expectation to lower

[9] The study studied the relationship of crash involvement with deceleration for 167 car drivers in total using a GNSS positioning system (indirect measurement of deceleration). A threshold of 2.68m/s² (6mph/s) was used to identify hard brakes. The study did not refer to automated vehicles but, for this reason, should serve as a solid reference for comparing with a “natural” value.

this number within SHOW; it will be interesting to attend how those values will be decreasing in the coming months. Still, it has to be noted that the threshold imposed for hard-braking in SHOW is quite “high” corresponding **to 3m/sec^2.** For example, AASHTO (2011) sets a_x = 3.4 m/s^2 as a **“comfortable”** threshold, while Jun et al (2007), above, had set a threshold of **2.68m/s^2** for defining hard-braking. Still, the above value has been set due to the respective threshold set by EuroNCAP (though for passenger vehicles). In future analysis of SHOW, we are exploring the potential to even increase the value to **4m/sec^2**, as per **IDIADA recommendation which is using this value to** homologate heavy-duty vehicles. This is mainly due to that this kind of vehicles take more time than a passenger vehicle to perform a full brake. They usually have a first phase of pre-braking where they don’t brake with the full jerk and then when they get to **4m/sec^2** they full brake. The regulation UNECE R131 stays that Emergency Braking is also detected from **4m/sec^2 [10].**

Another interesting metric is **acceleration variance** and while deeper analysis has to be conducted for this reason to get a proper insight (the average in this case is not explaining a lot if it is not accompanied by distributions) – that is planned for the final data analysis – it can be seen that the average is rather acceptable. According to Carmona et al. 2015 a threshold value of 1m/s^2 standard deviation of acceleration (corresponding to 1m^2/sec^4 variance) is used for passenger cars to identify the aggressive behavior (discomfort) from normal driving. One could argue that for public transport, that should be lower but even in that case, the values currently emerging are seen as rather acceptance. Still, and it should be stressed again, more data and deeper analytical analysis on final operational trials data have and will be done in SHOW to verify this at the end.

Illegal overtaking at this phase is 0 – when log is available- but this is something that changed in the course of the project and as one can see in the dynamic KPI overview that can be public accessed through the project Dashboard at https://www.bing.com/search?q=SHOW+dashboard&cvid=2fa6a75e2aae4136b0da996940e4571a&aqs=edge.0.69i59j0l3j69i65l2j69i60l3.5583j0j1&pglt=41&FORM=ANNTA1&PC=DCTS.

The above results should be only seen as a first insight and should by no means serve as close to final values as the data they correspond to, are not belonging to a sufficient time period but also the period itself they are corresponding to, is not the final operational period of the project test sites.

11.2 Correlation of performance data and subjective data

This section includes the first attempt for correlating performance and subjective data. In specific, two different sources of information have been considered. The first one is the **acceptance survey data (collected in Netigate)** and the second one is the **vehicle data (collected in the DMP)**. Within the acceptance survey and as it has been seen, we have compiled information regarding **how the user felt during the trip** and, specifically for this analysis we have focused in **two topics**: **the comfort level** and the **safety perception level**. From the vehicle datasets we have analysed the values from **three signals**: **speed**, **acceleration** and **number of hard brakings** (always, when available).

From the previous expertise in other projects like SUAAVE (https://www.suaave.eu/) and AUTOPILOT (https://autopilot-project.eu/), it is already known that a **relation can be established between the user comfort and safety perception and the driving performance**, as this gets revealed through technical values from the vehicle such as the speed or the acceleration. A trip with a smoother speed and acceleration profile will be strongly

[10] UNECE R131: When the system has detected the possibility of an imminent collision, there shall be a braking demand of at least 4 m/s^2 to the service braking system of the vehicle. This does not prohibit higher deceleration demand values than 4 m/s^2 during the collision warning for very short durations, e.g. as haptic warning to stimulate the driver’s attention. The emergency braking may be aborted, or the deceleration demand reduced below the threshold above (as relevant), if the conditions prevailing a collision are no longer present or the risk of a collision has decreased.

related with higher values in comfort level or a lower number of hard brakes can also be related with higher values for the user safety perception.

In SHOW project, for the pre-demo phase we have established the following correlations:

1. **Comfort level with acceleration profile and number of hard brakings**. With higher number of hard brakings and high level of variations in the acceleration values during a test ride, the comfort level of the user is expected to be low. Other factors could affect this value for sure, but, what it is expected is that by reducing the number of hard brakes and with a smoother acceleration profile the comfort level and the perception of this on behalf of the passengers would increase positively. Actually, in Eboli et al. 2016, a simple approach to the estimation of comfort is found, where the comfort is estimated based on the frequency rate of accelerations above a selected threshold acceleration. By this estimation we can find the ratio of discomfort in the trip. This – along with other established correlation approaches - will be used more systemically later in the project, when the analysis of data originating from the final large scale trials will be available.
2. **User safety perception level with speed and acceleration profile** and **number of hard brakings**. Similarly to the comfort level, the user safety perception is important to facilitate the adaptation of CAV to the people that are not used to them. If the user feels safe during a trip, s/he would probably recommend and take more trips using automated vehicles. Here, we are looking for smoother speed and acceleration profiles in order to prove that the perceived safety is rational to the actual safety.

Similarly to Carmona et al. 2015 mentioned above, according to a cumulative study from Bae et al. (2019) for longitudinal acceleration the thresholds for comfort in public transport are from -0.9 m/s^2 to 0.9 m/s^2, for normal -2m/s^2 to 1.47m/s^2, whilst below -2m/s^2 and above 1.47 m/s^2 is aggressive.

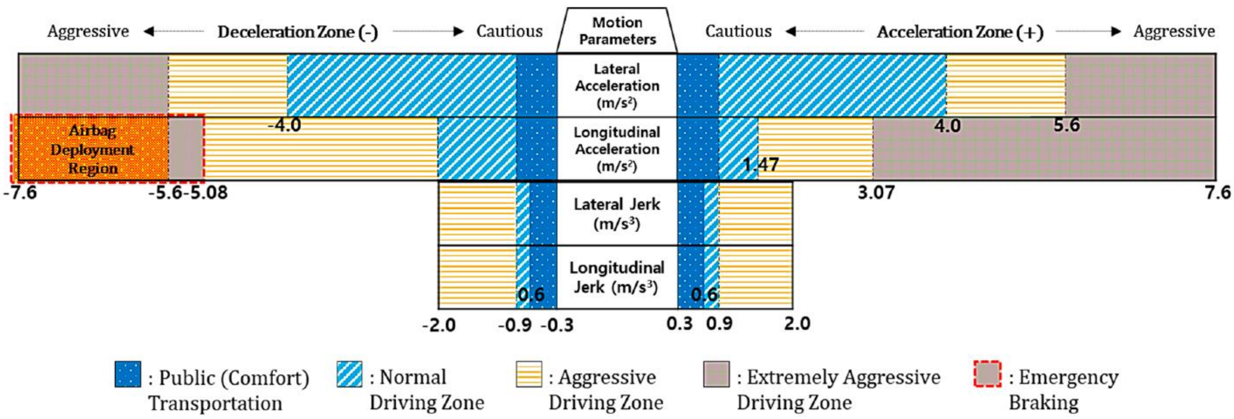


Figure 142: Thresholds for comfort driving in public transport (Source: Bae et al. (2019)).

In the following sections, some first insights are provided following the principles above. Of course, this serves only as a first outlook and though it will be complemented in a similar way for all the sites with their pre-demo data for the next issues of D11.3, the deep and more reliable analysis will be applied on final demo results that will be included in Deliverable 12.9: Real life demonstrations pilot data collection and results consolidation. The Madrid part will be added in the next issue of D11.3 when the full data of its pre-demo phase will be available.

11.2.1 Brainport test site

The figures below represent a dataset for a test run during the pre-demo phase in Brainport.

The number of hard brakes during the test session was 0. This, together with the smooth speed profile and an acceptable acceleration profile as seen in the graphs below conduces to high values on safety and comfort.

We can observe better values on the safety perception than in the comfort level. This could be mainly due to an acceleration profile that is not smooth enough. In order to improve the comfort score, the acceleration profile of the vehicle should be smoother and not exceed +-1m/s^2 (more or less).

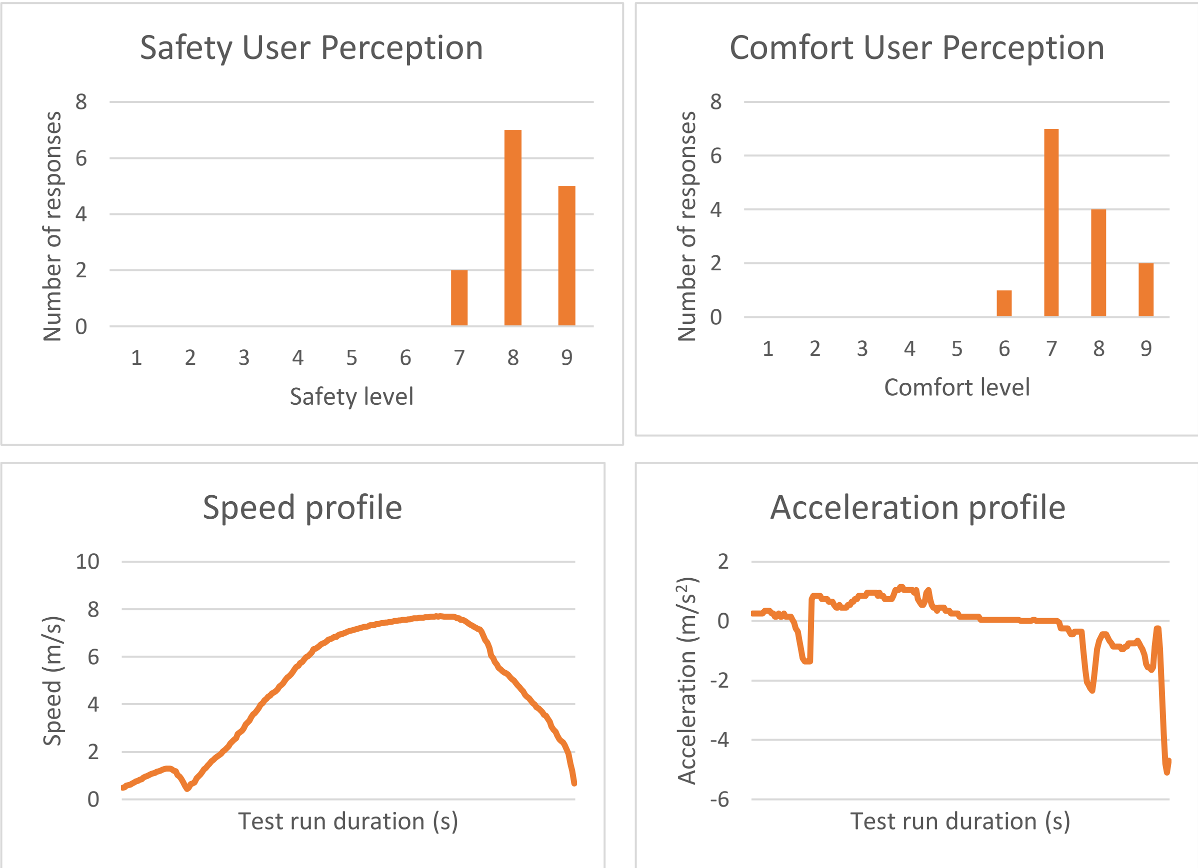


Figure 143: Correlation between subjective and objective data – Brainport pre-demo.

11.2.2 Gothenburg test site

Looking at the relation between safety and comfort and the vehicle data available we can assume that:

1. The safety perception and the comfort values are identified with higher numbers (7 and 9) which indicates a good level of these subjective measurements. We have two low values from Safety User Perception that could be probably related with the test session #8 which has a high number of hard brakes compared to the rest of test sessions. This could explain why most of the users have high scores on safety perception except for two that have very low score.
2. Regarding the vehicle data available at the moment of the analysis, we have taken into consideration the number of hard brakes for each test session and the average speed of each test session.
3. The number of hard brakes is around 50 in most of the test sessions (except in one test session which probably is caused due to some malfunction or external factor). The low number of hard brakes is directly related to the safety perception and comfort, meaning that a low value in the hard brakes implies high values in comfort and safety perception.

4. The average speed is also around 5.5m/s. We do not seed a high range of different values in the figure, so this means that the speed and the reaction of the vehicle was similar in the different test executions. This affects directly to the safety perception of the user, as the vehicle is driving at constant speed despite different situations that may face in each run.

Below the figures representing the subjective and the objective data correlated can be found:

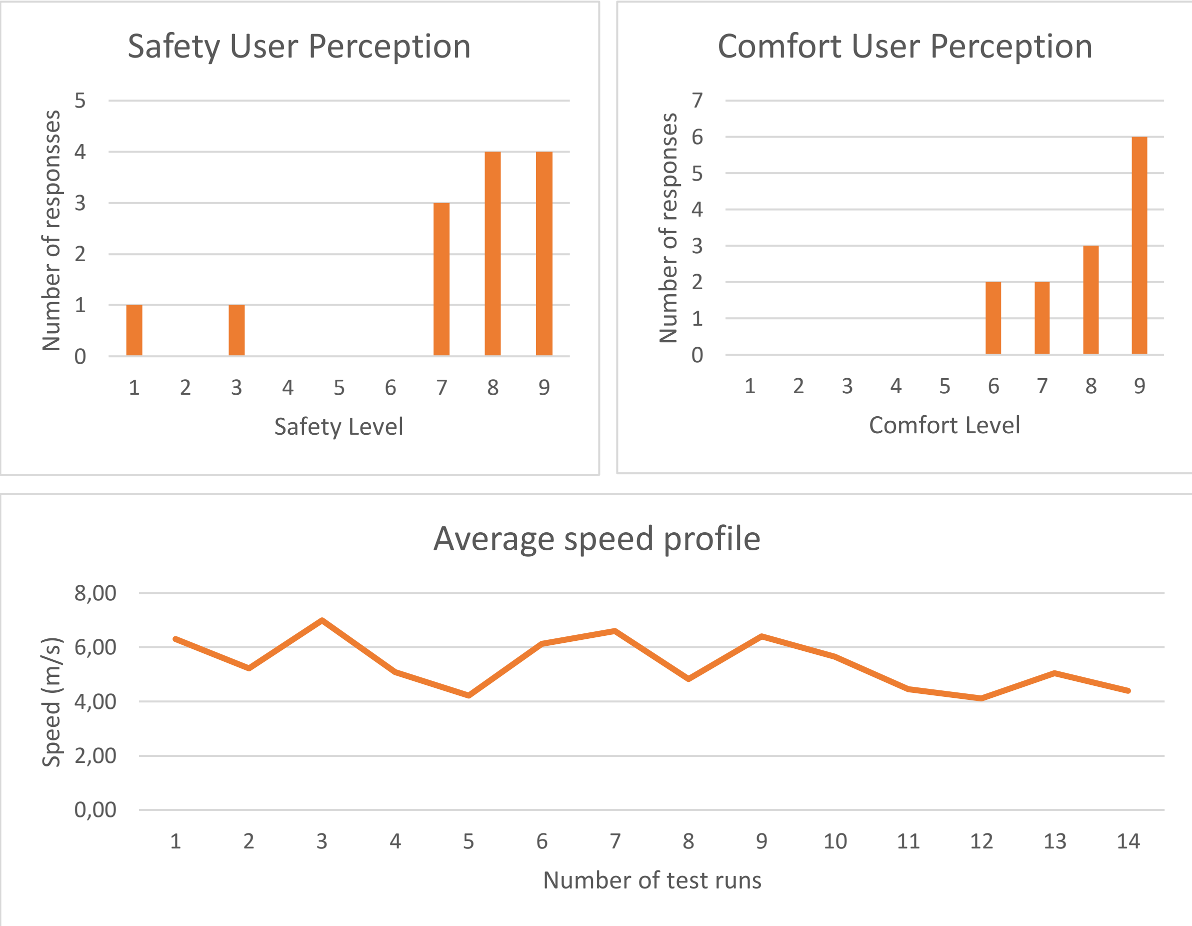


Figure 144: Correlation between subjective and objective data – Gothenburg pre-demo.

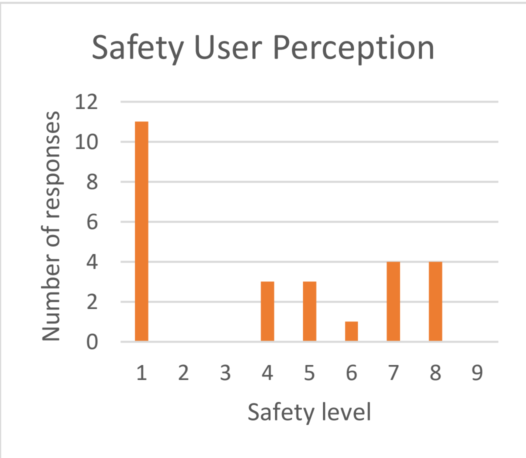
Table 54: Number of hard brakes from Gothenburg.

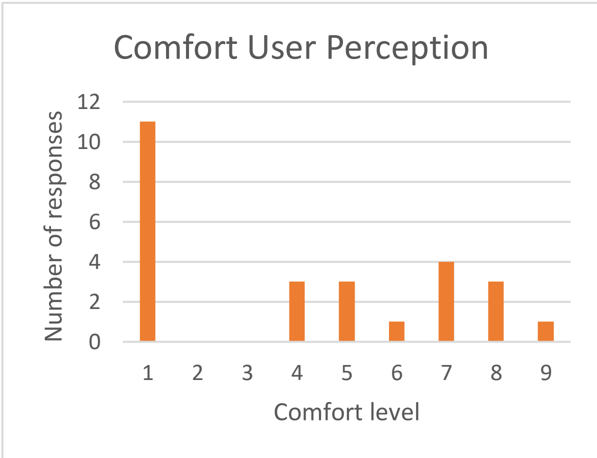
Test run	Number of hard brakes
Test session #1	46
Test session #2	36
Test session #3	46
Test session #4	19
Test session #5	29
Test session #6	36
Test session #7	36
Test session #8	160
Test session #9	65
Test session #10	51
Test session #11	54
Test session #12	38
Test session #13	12
Test session #14	66

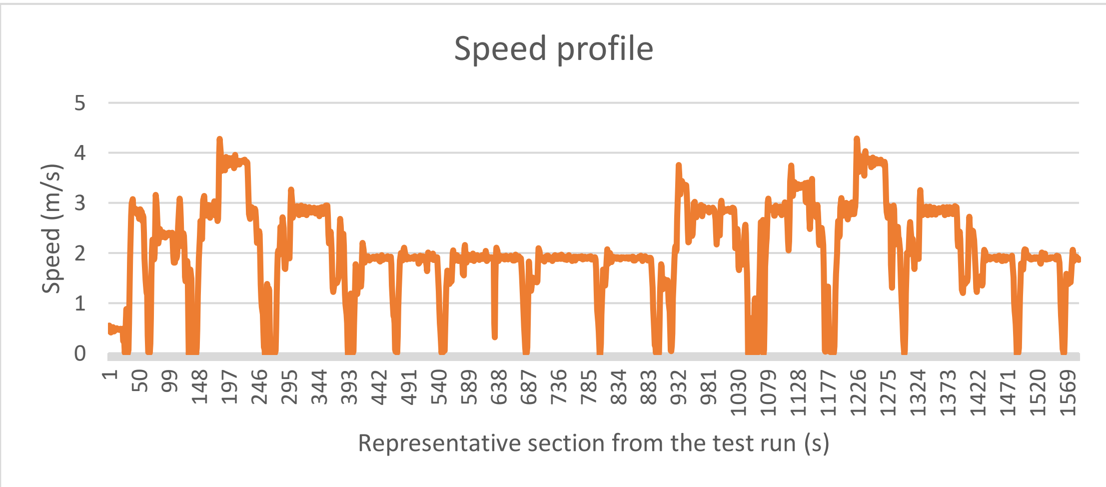
11.2.3 Linköping test site

In this case, we observe high variations in the speed and acceleration profiles. This affects directly the level of comfort and safety of the participants. Most of the users did not feel neither comfortable nor safe during the trip as seen in the figures sbellow.

The high acceleration values are directly rerlated to the safety perception of the user. The user probably feels that the vehicle is not able to detect the hazards early enough and despite the vehicle being safe, it is not driving smoothly enough. If the vehicle could anticipate better the hazards, the safety percepction and consequently the comfort values of the user would increase accordingly.







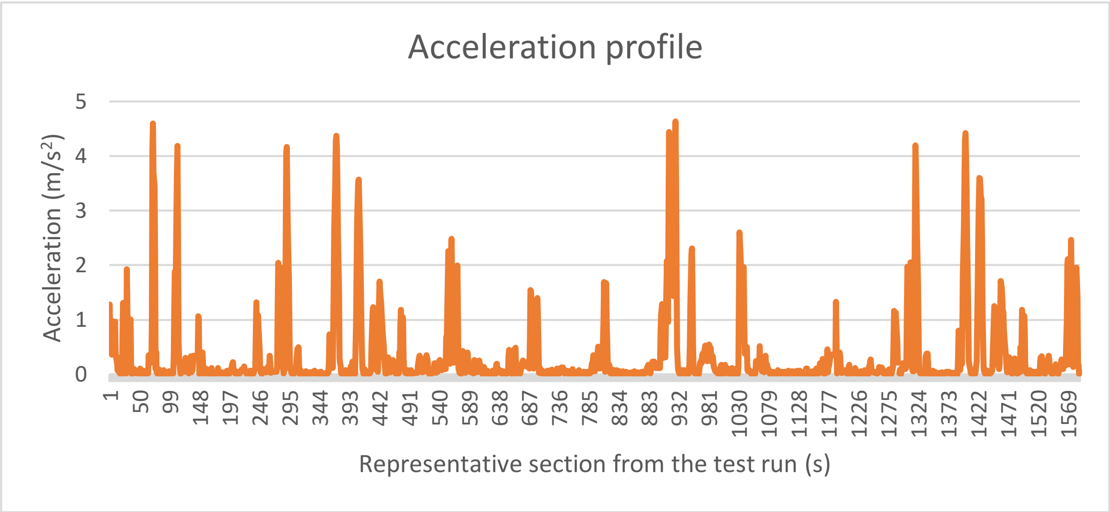
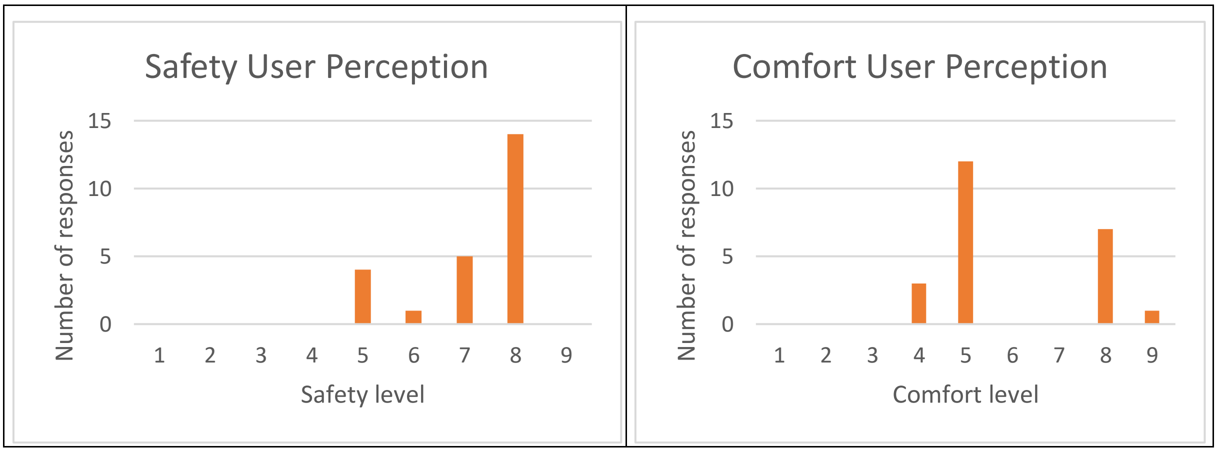


Figure 145: Correlation between subjective and objective data – Linköping pre-demo.

11.2.4 Tampere test site

Looking at the relation between safety and comfort and the vehicle data available, we can assume that:

1. The safety user perception is high enough to be considered that most of the user felt safe during the test. However, if we look at the comfort level, we could stay that the users didn't feel much comfortable during the test execution.
2. The speed profile is not smooth enough as we can see variations from +-20km/h nearly every minute. However, the acceleration profile looks smooth with most of the accelerations with less than $1m/s^2$. Finally, the number of hard brakes for this test session was 24, an acceptable number compared to other test sites.
3. The main reason for the low comfort score is mainly due to the high variance in the speed profile which causes the user, despite feeling safe, not being comfortable enough.



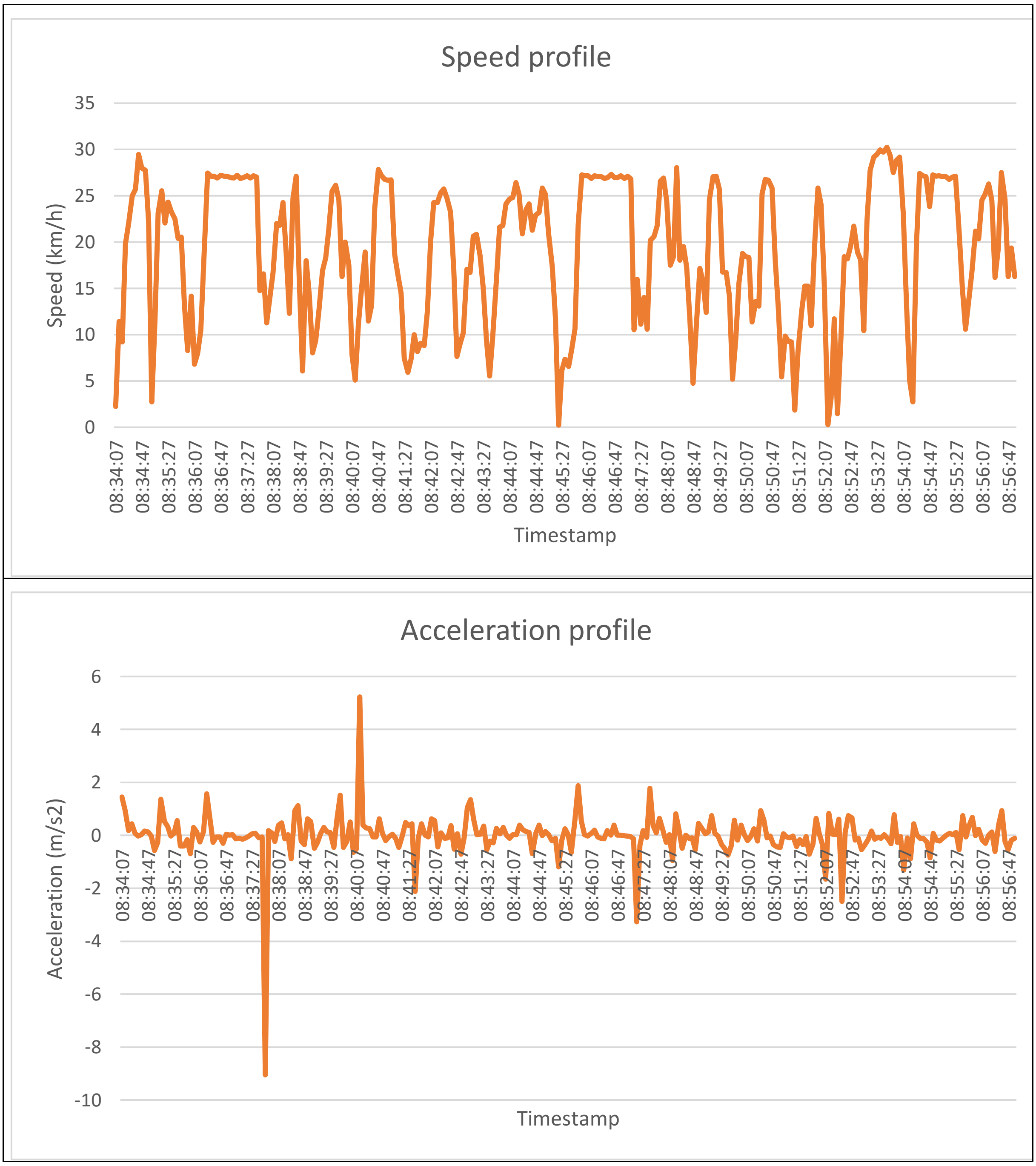


Figure 146: Correlation between subjective and objective data – Tampere pre-demo.

12 Conclusions

The current Deliverable reports the pre-demo phase of **Tampere (Finland), Gothenburg and Linköping (Sweden), Madrid (Spain) and Brainport (the Netherlands) test sites of SHOW.** It also reports a very initial short demonstration that occurred in the **Turin test site of SHOW** at the very beginning of the project. It reports in detail all preparatory activities and actual field trials conduct occurring at the test sites. **Covering the corresponding pre-demo period (up to end of May 2022) of the aforementioned test sites, 1945 passengers tried the different automated mobility services of SHOW.**

The current issue also analyses the results collected through SHOW subjective tools by **69 passengers** who tried the automated mobility services across the test sites addressed in this issue during their pre-demo phase and, in addition, **26 stakeholders** being interviewed representing OEMs, operators, technology providers and authorities. In some cases, more dedicated surveys were conducted from test sites. Also, further to the subjective results, the first performance results collected through the Data Management Platform of SHOW have been aggregated and discussed. First insights reveal a general positive tendency from both passengers and stakeholders towards shared automated mobility, while at the same time a series of technical, quality of service, acceptance, operational and business wise weaknesses have been recognized. The high frequency of hard-brakings and the reliability/ feasibility of service when a safety driver is not on-board seemed to be the most commonly shared concerns by both passengers and stakeholders. The fulfillment of mobility service gaps and the inclusiveness in mobility are so far the key benefits recognized from SHOW experience regarding shared automated mobility potential.

The safety drivers view was introduced in the form of a subjective tool later in the project evaluation process (see below); as such the systemic analysis of results coming from them will be included in the results of test sites that had it available either for the pre-demo period already and, definitely, for the final demo phase.

One of the key scopes of the pre-demo evaluation phase of SHOW has been from the beginning a full rehearsal of the first version of the evaluation protocols, tools and mechanisms that were applied. Indeed, this was served very well from the very first trials and it achieved to reveal all the weaknesses and shortcomings that were recognized.

The specific aspects that were raised were related to namely the subjective tools used (in terms of content and format/means) as well as the performance data collection process and mechanisms. Indeed both were favoured a lot from the feedback provided by the test sites. In summary, the key feedback provided concerned the following:

- Specific IT expertise is frequently missing from the test sites which makes (performance) data collection stringent in some cases. This is true for example the cases where the OEMs are not directly involved in the process. In addition, data collection feasibility and applicability differ across test sites. For example, in Madrid, it became obvious that it was more than enough to upload the offline data at CKAN platform, on a biweekly basis. This approach is going to be used during the demo phase. Finally, KPIs (requesting for specific data entry) were not precise enough. All relevant aspects were streamlined in 2022 for all the test sites in SHOW and with the support of CERTH which led to a systemic, smooth and test site specific data collection across the sites and their fleets through alternative ways. The KPIs underwent several revisions and specific – commonly shared to all – formulas have been defined.
- AV permits are very specific to the different countries of experimentation. This should be taken into consideration for the final experimental plans, as sometimes it is the legislation that prevents to experiment a use case further. In specific, in Gothenburg, this is the case for UC1.7 “Connection to operation centre for tele-operation and remote supervision”. Though 5G, communication is established between the operation centre and the shuttle, but remote control of the vehicle was not authorized by the Swedish state.

- The initial version of the questionnaires revealed to be tiring (due to length) and not totally comprehensive for test users. This led to their revision – see below – where detailed comments were collected by all test sites having started operations on all types of surveys.
- More specific questions to the test site operations need to be included. As it is not feasible to extend further the common to all questionnaires (based on the comment above) and, also, not creating 20 or more different versions of questionnaires for each type of survey, this was addressed by adding focus groups in MAMCA workshops where specific to the test site questions will be posed. See more below.
- It was recognised that repetition of the same scenarios over time may result in different answers from the same users; this is considered natural as the learning curve changes. In this context it was reconfirmed that the large scale field trials of SHOW should attract general public in a way so that the same passengers would try the service over and over again (this is already part of the SHOW plans).

The feedback provided resulted in the following:

- Two rounds of revisions in the subjective surveys were added until they reach their final content. In addition, two more surveys were added, namely the safety drivers survey and the VRU survey (for specific sites testing dedicated solutions for them); all provided in the latest issue of D9.3.
- Revision of experimental plans of the final demo phase emerged (final ones in latest issue of D9.3). In this context, another evaluation layer has been added. In the context of the MAMCA workshops that will be realized in each test site, the attending focus groups will be consisting by passengers – observers and stakeholders that will have been involved in the test site operations in more depth and will be able to answer in more detail specific to the test site operations questions (that cannot be reflected by default in the common to all surveys).
- The process of the performance data collection was understood and streamlined by all; in this context, additional interfaces have been built to accommodate all partners/ test sites needs, additional KPIs were defined (final ones in latest issue of D9.3) and the project Dashboard has been now public with the first KPIs published for a big number of test sites and with all running sites on-boarded.

In the next period, further insight in the performance data collected will be on-going, in order to ensure that it is of that quality and logged in a way so as to ensure a reliable and in-depth analysis. Indicatively, the hard-brakings logging will be revisited as well as the synchronization of the subjective and performance data (in order to enable later concise correlation between them). The later was specifically addressed by adding timestamps in the subjective surveys.

Overall, the results reported in the current (and upcoming updates) of this issue have been/ will be used to optimize features, evaluation protocols and services towards the final large scale field trials of the test sites.

It should be stressed that the sample serving for the statistical analysis of data and as included in this issue is quite small to allow solid conclusions about any aspect. Still, the first tendencies have been revealed and an overall positiveness has been also recognized. The reader should also not neglect that the pre-demo phase of SHOW aimed to serve mainly as a rehearsal – in all aspects – and due to the several bias inherent in this phase, the results of pre-demo phase are not seen applicable for drawing formal conclusions yet.

The first update of this issue will follow in Spring 2023 and will cover the full pre-demo phase of the following SHOW test sites:

  - Full pre-demo period taking place in Carabanchel (Madrid)
  - Karlsruhe (Germany)
  - Pörtschach (Carinthia) & Graz (Austria)
  - Brno (Czech Republic)
  - Tampere pre-demo phases (2 & 3).

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Appendix I: Progress monitoring checklist

- **Identification & alignment contributors & stakeholders**
- **Planning & scheduling (experimental plan) of Pre-Demo activities**
- **Emergency Services ("FABULOS" project Checklist integration)**
- **Event Diary (logbook for noteworthy events not covered by data logging)**
- **Information of the public about the Pre-Demo evaluation activities**
- **Ethical procedures / privacy (e.g.: surveys, interviews)**
- **Required authorizations**
- **Vehicles commissioning & Risk Assessment**
- **Required resources / tools**
- **Physical & digital infrastructure**
- **Data handling (acquisition, storage, analysis) & necessary interfaces made**
- **Technical Validation**

&

- **Use Cases readiness**
- **Vehicle securement & readiness**
- **Pre-demo expected launch time**

Appendix II: SHOW Use Cases[11]

UC1 Family: Automated mobility in cities

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
UC1.3: Interfacing non automated vehicles and travellers (including VRUs)
UC1.4: Energy sustainable automated passengers/cargo mobility in Cities
UC1.5: Actual integration to city TMC
UC1.6: Mixed traffic flows; AVs and non AVs mixed in the same traffic flows
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
UC1.10: Seamless autonomous transport chains of Automated PT, DRT, MaaS, LaaS

UC2 Family: Automated mixed mobility in cities

UC2.1: Automated mixed spatial mobility
UC2.2: Automated mixed temporal mobility

UC3 Family: Added Value services for Cooperative and Connected Automated mobility in cities

UC3.1: Self-learning Demand Response Passengers/Cargo mobility
UC3.2: Big data/AI based added value services for Passengers/ Cargo mobility
UC3.3: Automated parking applications; namely AVs self-parking functions
UC3.4: Automated services at bus stops
UC3.5: Depot management of automated buses
UC3.6: COVID-SAFE Transport

[11] For description of the generic Use Cases, please check D1.2: SHOW Use Cases. Experimental cases corresponding to them for each test site are described in D9.2: Pilot experimental plans, KPIs definition & impact assessment framework for pre-demo evaluation and in the current document corresponding sections.

Appendix III: Turin pre-acceptance study survey template

The survey used to assess users' acceptance in Turin (pre)-pre-pilot is available in the next pages.

This survey is conducted by LINKS Foundation in collaboration with ITC ILO, the Municipality of Turin, Torino CityLab, Reale Mutua and Reale Lab as part of the H2020 SHOW project funded by the European Commission (H2020 Research and Innovation Programme, Grant Agreement No 875530).

Autonomous shuttle Olli within the ITC ILO campus

A. General information

1. What is your gender?
   - ☐ Male
   - ☐ Female

2. Which is your age group?
   - ☐ 18-24
   - ☐ 25-35
   - ☐ 36-45
   - ☐ 46-60
   - ☐ > 60

3. What is your educational background (including ongoing education)?
   - ☐ Primary / Middle school
   - ☐ High school
   - ☐ Bachelor Degree / M.Sc. / Ph.D

4. What is your employment status?
   - ☐ Employed
   - ☐ Self-employed
   - ☐ Unemployed
   - ☐ Retired
   - ☐ Student
   - ☐ Other (please, specify): ________________________________

5. Which transport mode do you mostly use for daily commuting?
   - ☐ Private car
   - ☐ Urban public transport (bus, tram, metro)
   - ☐ Extra-urban public transport (train, bus)
   - ☐ Motorcycle / moped (owned)
   - ☐ Bicycle (owned)
   - ☐ Monowheel, scooter or similar (owned)
   - ☐ Shared transport (car/moped/bicycle/scooter)
   - ☐ None, I go walking
   - ☐ Other (please, specify): ________________________________

6. When it comes to trying a new technology product, you are generally...

- ☐ Among the first
- ☐ Among the last
- ☐ I prefer to wait for someone to try it, but I'm not one of the last

7. Do you learn quickly and intuitively to use new technologies?
   - ☐ Yes
   - ☐ No

8. What is your level of knowledge about automated vehicles?
   - ☐ none
   - ☐ superficial: I heard about it (newspapers, media, web, friends, ...)
   - ☐ medium: I deal with mobility / out of personal curiosity / ...
   - ☐ high: I deal with autonomous driving / for personal interest / ...

9. Do you have any experience with automated vehicles (apart from the shuttle operating in ITC ILO)?
   - ☐ Yes, in a car as a passenger
   - ☐ Yes, in a car as a driver
   - ☐ Yes, on public transportation
   - ☐ No

B. OLLI shuttle

1. Have you already had the opportunity to experience the Olli autonomous shuttle on the ITC ILO campus in Turin?
- ☐ Yes → Go to SECTION C (below)
- ☐ No → Go to SECTION D (next page)

C. OLLI shuttle (if you answered ‘YES’ to the question B1)

1. How do you rate your overall experience with Olli?

	1	2	3	4	5	
very negative	○	○	○	○	○	very positive

2. What were your concerns WHILE using Olli in the ITC ILO campus?

(on a scale from 1: no concerns at all; 5: high concerns)

	1	2	3	4	5
Safety: potentially dangerous driving choices (for example, sudden braking, excessive acceleration, high speed, etc.)	○	○	○	○	○
Safety: protection of other vulnerable users in the campus (e.g. pedestrians, cyclists, etc.)	○	○	○	○	○
Health: fear of increasing the chances of contagion from Covid19	○	○	○	○	○
Technology: technical problems that can lead to loss of time (e.g. blocking of the driving system, updating of the system following unexpected stops, etc.)	○	○	○	○	○
Cybersecurity: possible loss of control of the vehicle (for example, hackers who take control of the autonomous driving system from outside and divert the vehicle)	○	○	○	○	○
Data privacy: possible unauthorized access to users' personal data	○	○	○	○	○
Use: need to change the usual mobility behaviors (for example, book the vehicle)	○	○	○	○	○
Accessibility of the vehicle: possibility for any user to use the vehicle (e.g. people with disabilities)	○	○	○	○	○

3. Do you think you would use Olli to move on the road in real traffic conditions? (mixed traffic with autonomous and non-autonomous vehicles)

- ☐ absolutely not
- ☐ partially disagree
- ☐ partially agree
- ☐ absolutely yes

4. What would be your concerns when using Olli in mixed traffic with respect to the use you have experienced in the campus? (indicate the 3 most important)

- ☐ Safety: increased chance of accidents (e.g. due to high traffic)
- ☐ Safety: greater difficulties in protecting vulnerable road users (e.g. due to the increased number of pedestrians, cyclists, etc.)

- ☐ Safety: greater difficulties in protecting passengers on board (for example due to the presence of minors among passengers)
- ☐ Technology: higher probability of technical problems occurring (e.g. due to the greater probability of unexpected stops, etc.)
- ☐ Cybersecurity: greater chance of losing control of the vehicle (e.g. due to attacks outside the driving system)
- ☐ Data privacy: greater possibility of unauthorized access to users' personal data
- ☐ Use: greater need to change the usual mobility behaviors (for example, book the vehicle)
- ☐ Vehicle accessibility: greater difficulties in accessing the vehicle for all kinds of users (e.g. people with disabilities)
- ☐ Occupational risk: possibility of job loss by current drivers of public transport
- ☐ Cost of public transport: possibility of increasing the costs of public transport (for example, the inclusion of new, very expensive, autonomous vehicles in the public transport fleets could generate an increase in ticket costs)
- ☐ Other (please, specify): ________________________________

Go to section E (next page)

D. OLLI shuttle (if you answered ‘NO’ to the question B1)

1. Why haven't you used Olli to move around the campus, yet?

- ☐ because I haven't had the chance, yet
- ☐ because I don't need it for my movements in the campus
- ☐ because I don't care
- ☐ because I don't feel safe
- ☐ Other (please, specify): ________________________________

2. What are your concerns about using Olli in the ITC ILO campus?

(on a scale from 1: no concerns at all; 5: high concerns)

	1	2	3	4	5
Safety: potentially dangerous driving choices (for example, sudden braking, excessive acceleration, high speed, etc.)	◯	◯	◯	◯	◯
Security: protection of other vulnerable users on campus (e.g. pedestrians, cyclists, etc.)	◯	◯	◯	◯	◯
Health: fear of increasing the chances of Covid19 contagion	◯	◯	◯	◯	◯
Technology: technical problems that can lead to loss of time (e.g. blocking of the driving system, system update following unexpected stops, etc.)	◯	◯	◯	◯	◯
Cybersecurity: possible loss of control of the vehicle (for example, hackers who take control of the autonomous driving system from outside and divert the vehicle)	◯	◯	◯	◯	◯
Data privacy: possible unauthorized access to users' personal data	◯	◯	◯	◯	◯
Use: need to change the usual mobility behaviours (for example, book the vehicle)	◯	◯	◯	◯	◯
Accessibility of the vehicle: possibility for any user to use the vehicle (e.g. people with disabilities)	◯	◯	◯	◯	◯

Go to section E (below)

E. OLLI shuttle

1. For what types of transport would you like OLLI to be mostly used in the future? (only one answer)

- from home to public transport stop
- transport in congested urban centers
- transport in peripheral and rural areas
- transportation in protected areas (e.g. university campuses, closed hospital areas)
- transport for disadvantaged users (e.g. disabled, elderly, minors)
- I don't know
- Other (please, specify): ________________________________

2. In order to prevent accidents, you would prefer that on an autonomous passenger transport shuttle:

(scale from 1-totally disagree to 5-totally agree)

	1	2	3	4	5
there was always a steward / driver on board who could take direct control of the vehicle	○	○	○	○	○
there was a remote supervisor who could take control of the vehicle remotely	○	○	○	○	○
there was no driver or supervisor present, but there was the possibility of contacting an operator in case of need	○	○	○	○	○

3. In order to ensure the personal safety of users, you would prefer that on an autonomous passenger transport shuttle:

(scale from 1-totally disagree to 5-totally agree)

	1	2	3	4	5
there was always a steward on board able to speak, listen to passengers, respond to their requests and monitor their safety	○	○	○	○	○
there was a remote supervisor able to speak, listen to passengers, respond to their requests with audio-video connection in real time	○	○	○	○	○
there was no supervisor present, but there was the possibility of contacting an operator in case of need	○	○	○	○	○

F. Opinions about autonomous driving

1. Do you think that autonomous driverless vehicles (private and public) will be fully part of daily mobility in the future?

☐ Yes ☐ No ☐ I don’t know

2. What is your general opinion on the use of autonomous and driverless road vehicles on public roads?

	1	2	3	4	5	
high concerns (totally disagree)	○	○	○	○	○	no concerns at all (totally agree)

Thanks for your collaboration!!!