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SHared automation Operating models for Worldwide adoption

SHOW

Grant Agreement Number: 875530

D11.2: Demos safety, reliability and robustness validation and commissioning
Part 1: Linköping, Gothenburg, Tampere and Brainport

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Legal Disclaimer

Executive Summary

The aim of this deliverable D11.2 is to present the results of all SHOW demonstrators' verification and validation phases collected during A11.2 Demos safety, reliability and robustness validation and commissioning. Systems and use-cases have been verified and validated using the technical validation framework defined in A11.1 (and reported in D11.1). The aim of this activity is to perform a full technical walkthrough on functions and services level before the pre-demo evaluation phase (A11.3). Only professional users (from the SHOW Consortium entities) will participate in this later phase. As needed, optimisation will follow upon the results obtained in all different aspects and before moving to the pre-demo evaluation.

The technical assessment of SHOW encompasses two distinct phases, which are described as follows:

1. **Technical verification & commissioning phase,** on individual technical aspects, including the typical vehicles commissioning and other standard processes required from the legislation perspective, among other. This phase addresses four key technical aspects, namely: **automated driving vehicle Safety**, **Performance**, **Communications** and **Cybersecurity**. This phase is conducted in either OEMs' test-sites or at the JRC Ispra site. It includes 6 safety test scenarios, 7 communication test scenarios, 8 performance test scenarios and the description of the measures adopted against 17 cybersecurity threats.
2. **Technical validation/commissioning on integrated service level phase**, which corresponds to a full and in-depth technical validation and commissioning on the planned integrated service level in each site. This Phase follows the successful completion of the former one. Validation is applied on Use/Demonstration case level of each site as planned and described in D9.2 experimental plans and it aims to address **Safety**, **Performance** and **Quality of Service**. This phase is conducted in context, meaning in the exact same real-life context that the pre-demo and final demo phases will be conducted. It does not require to be carried out in the exact location where pre-demo and demo phases are carried out but the same conditions must hold.

The results are presented using the templates prepared in A11.1 for the reporting of results across all test sites and across both technical verification and validation phases as listed above. A summary of the technical verification and validation of each site is provided in the report, while the filled-in templates are provided in the Appendices.

It is worth underlining here that the verification and validation procedure described in D11.1 has been developed thanks to a wide consultation of the project partners. As such it therefore includes tests and procedures requested in the different EU Member States represented in the project. For this reason, by fulfilling the requirements laid down in D11.1, the pilot sites could benefit from a smooth interaction with the local authorities for the deployment of the different systems. From this point of view, the value of both D11.1 and of the present deliverable go beyond the SHOW project and can be of support for all the pilot deployment of automated mobility systems in Europe until a complete harmonized procedure will be developed.

In spite of the methodological support provided by the procedure described in D11.1, the different pilot sites could not all progress with the same pace. The present deliverable is therefore including a complete report of the following specific sites: Linköping, Gothenburg, Tampere and Brainport. For this reason, it has been labelled as D11.2 Part 1. As new pilot sites will have completed this phase, additional parts will be added to the deliverable in subsequent versions that will follow.

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0.2	01/03/2022	Added partial results from sites: Rouen, Gothenburg, Linköping, Madrid, Carinthia, Brainport, Karlsruhe, Tampere, Brno and Trikala	JRC, pilot site leaders
0.3	11/03/2022	Streamlined content, added missing information and removed results for sites that are not complete.	JRC
0.4	16/03/2022	Final contributions to all sections	JRC, pilot site leaders
1.0	30/03/2022	Version sent for internal peer review.	JRC
2.0	23/05/2022	Peer reviewed version sent for final submission//Quick check//Submitted.	JRC, IDIADA, CERTH/HIT, pilot site leaders

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Abbreviation List

Abbreviation	Definition
A	Activity
ADS	Automated Driving System
AV	Automated Vehicle
CAM	Cooperative Awareness Message
CPM	Collective Perception Message
D	Deliverable
DENM	Decentralized Environment Notification Message
GLOSA	Green Light Optimal Speed Advisory
GNSS	Global Navigation Satellite System
HMI	Human Machine Interface
HR	Hit Ratio
HW	Hardware
I/O	Input/Output
MAPEM	MAP (topology) Extended Message
NA	Not Applicable
OBU	On-Board Unit
OEM	Original Equipment Manufacturer
RSU	Roadside Unit
SPATEM	Signal Phase And Timing Extended Message
SW	Software
TLA	Traffic Light Assistance
UC	Use Case
VRU	Vulnerable Road User
V2X	Vehicle-to-Everything
WP	Work-package

1 Introduction

1.1 Purpose and structure of the document

The goal of this document is to present the results of all SHOW demonstrators' safety, reliability and robustness validation and commissioning collected during activity (A) 11.2. Real life demonstrators have been validated using the technical validation framework defined in A11.1 (and reported in deliverable (D) 11.1). This aim of A11.2 is to perform a full technical walkthrough on functions and services level before the pre-demo evaluation phase (A11.3). Only professional users (from the SHOW Consortium entities including the European Commission (EC)'s Joint Research Centre (JRC) as leader of A11.2) will participate in this phase. As needed, optimisation will follow upon the results obtained in all different aspects and before moving to the pre-demo evaluation.

The deliverable includes 4 main chapters and two appendixes containing the following information:

Chapter 1 – Introduction.

Chapter 2 – Methodological approach.

Chapter 3 – Results from the SHOW Technical Verification and Validation in each SHOW Pilot site

Chapter 4 – Conclusions and next steps

Appendix I – Results from Technical verification & commissioning on integrated service level

Appendix II – Results from Technical validation & commissioning on integrated service level

1.2 Intended Audience

This document serves SHOW partners and the European Commission to monitor the proper conduct of the technical verification and validation of the SHOW demonstrators in context, in each SHOW Test Site, as a proof of validation of their safety, reliability and robustness and prior to them moving in the first phase of field trials with users. The document can also serve as guidance to all pilot deployments of automated mobility systems which have no clear guidance from national or local legislations.

1.3 Interrelations

The work presented in this document belongs to SHOW Work-Package (WP) 11, which is a central activity in SP3 interacting with WP9: Pilot plans, tools & ecosystem engagement (constituting an input), WP10: Operations simulation models platform & tools (as input and output, as the two activities interact) and being a prerequisite for WP12: Real-life demonstrations of the same SP. D11.2 has used the following input:

Input:

- Technical validation protocol defined in A11.1 (D11.1: Technical validation protocol, [1])
- SHOW Use Cases (UCs) (D1.2: SHOW Use Cases, [2]), which are recalled below:
    - UC1: 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 Vulnerable Road Users, VRUs)
    - UC1.4: Energy sustainable automated passengers/cargo mobility in Cities
    - UC1.5: Actual integration to city TMC
    - UC1.6: Mixed 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: Automated mixed mobility in cities
    - UC2.1: Automated mixed spatial mobility
    - UC2.2: Automated mixed temporal mobility
- UC3: 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
    - UC3.4: Automated services at bus stops
    - UC3.5: Depot management of automated buses

Output:

- Technical verification and validation is required in order to deploy the real-life demonstrators in WP11/A11.3 pre-demo and WP12 final demo phases respectively.

2 Methodological Approach

2.1 Overall approach

The technical assessment of SHOW encompasses two distinct phases, which are described as follows:

1. **Technical verification & commissioning phase,** on individual technical aspects, including the typical vehicles commissioning and other standard processes required from the legislation perspective, among other. This phase addresses four key technical aspects, namely: **automated driving vehicle Safety**, **Performance**, **Communications** and **Cybersecurity**. This phase is conducted in either OEMs' test-sites or at the JRC Ispra site. It includes 6 safety test scenarios (4 included in D11.1 and 2 introduced in the present document), 7 communication test scenarios, 8 performance test scenarios and the description of the measures adopted against 17 cybersecurity threats.
2. **Technical validation/commissioning on integrated service level phase**, which corresponds to a full and in-depth technical validation and commissioning on the planned integrated service level in each site. This Phase follows the successful completion of the former one. Validation is applied on Use/Demonstration case level of each site as planned and described in D9.2 experimental plans [3] and it aims to address **Safety**, **Performance** and **Quality of Service**. This phase is conducted in context, meaning in the exact same real-life context that the pre-demo and final demo phases will be conducted. It does not require to be carried out in the exact location where pre-demo and demo phases are carried out but the same conditions must hold.

The results are presented using the templates prepared in A11.1 for the reporting of results across all test sites and across both technical verification and validation phases as listed above. A summary of the technical verification and validation of each site is provided in the report, while the filled-in templates are provided in Appendixes I and II covering the verification and validation respectively.

Given the varying status of development of the different SHOW pilot sites, the present deliverable is including a complete report of the following specific sites: Linköping, Gothenburg, Tampere and Brainport. For this reason, it has been labelled as D11.2 Part 1. As new pilot sites will have completed this phase, additional parts will be added to the deliverable subsequent versions.

We apply the methodology defined in A11.1 (D11.1) consisting of two phases which are mandatory to all SHOW test sites: one on technical verification level on individual technical aspects and one full technical validation and integrated service commissioning level that follows given the successful completion of the former one. The distinction between the two phases follows below:

- **Technical verification & commissioning phase**. The technical verification in SHOW is accommodated by a series of test cases. A Test Case in the SHOW context is a concrete scenario with PASS/FAIL criteria. It is a set of requirements and variables against which the system is tested and assessed. The results determine whether the system complies with the respective requirements and satisfies the acceptance criteria. The test cases are tangibly described through a series of test scenarios on key aspects common and parametric to all sites and be UCs and operational context agnostic (as much as possible). This phase results have been reported by each site on the basis of the template provided in D11.1. The test scenarios are designed to ensure that the corresponding project objectives will be addressed. Still, as they relate to commonly met aspects in road automation, it may be the case that some of the sites have already tested them – partially or fully – in the context of audit processes required for vehicles homologation (granting of approval by an official authority), commissioning (analysis of the design, installation and operation of the systems, with the intent of achieving the maximum design efficiency and expected operational performance) or test sites permits (official document giving the test site authorization to perform the tests). Depending on the formality in each test site, this latter phase may also belong to the next technical validation phase. The pilot site leader is requested to collect and provide the results of the respective tests, all the relevant information as well as the evidence for the test conduct to the JRC. For this phase, the pilot site will need to coordinate the work of a series of entities, such as the vehicle provider, the site operator, a technical entity working on integrating solutions, etc. The JRC is then responsible to audit the information provided, request additional information or additional evidence about what has been delivered. Only when the JRC considers the information package complete, this phase ends and the details are included in the present deliverable. The validation phase can then take place.

- **Technical validation/commissioning on integrated service level phase**. The technical validation in SHOW follows the technical verification phase and considers as a prerequisite that technical verification has been successful. It can either address specific test cases which focus on technical aspects considered as relevant by the pilot sites (as demonstration site specific UCs) or specific SHOW UCs [2]. A UC represents a specific scenario in which a solution, usually the system that is being developed, needs to be implemented. The UC describes various operational conditions in which the system shall respond. These conditions can be interactions from the system's user, other traffic participants or road and other environmental conditions. For test objects having several functionalities it is expected to have several UCs. As such, this phase operates on Use/Demonstration Case and site operational level. The demonstration cases for the pre-demo phase are provided in D9.2 [3]. The assessment that will be conducted on this level will be conducted on test site level, and regardless the type and number of entities that will be involved in that, it is the test site obligation to make sure that it will be conducted following the principles provided in D11.1 and to report results using the template provided in the same document. The successful outcome of this phase will directly mean a Pass to the pre-demo phase that will follow in A11.3.

The methodology described in D11.1 covers the following aspects related to the verification phase:

1. Safety. To ensure that vehicle is safe to drive on public roads.
2. Performance. To ensure a minimum level of vehicle and devices performance.
3. Communications. To ensure a good communication between vehicles and devices.
4. Cybersecurity. To cover and mitigate all the possible cybersecurity risks.

In addition, the two following safety tests have been added to the procedure to take into account a crucial aspect of partial automation which is the handover to the safety driver. These two test scenarios have been added after the completion of D11.1 and upon drafting of this deliverable.

Table 1: Addition n.1 to the verification procedure described in D11.1: Safety test scenario 05

Test scenario identifier	STS05
Test scenario description	Handover to driver when approaching end of ODD
Reference requirement	SHOW_01_012
Pass/Fail criteria	The AV drives in a motorway and approaches end of ODD (exit motorway). The driver is informed in advance and able to safely take over control

Expected Test Sequence

Step	Type	Description	Req.
0	Action	The AV is driving at constant speed in autonomous mode in motorway and approaching end of ODD.	SHOW_01_010
1	Verify	The AV is driving at constant speed on lane	
2	Action	A notification is shown to the driver to prepare to take over	SHOW_01_012
	Verify	The notification is shown	
3	Action	The driver safely takes over	
4	Verify	Measured via indicators like: time until eyes on road, time until hands on steering wheel, time to take over, speed / lateral position variation after takeover, situation awareness ratings	

Table 2: Addition n.2 to the verification procedure described in D11.1: Safety test scenario 06

Test scenario identifier	STS06
Test scenario description	Handover to driver due to emergency
Reference requirement	SHOW_01_013
Pass/Fail criteria	The AV drives in a motorway and there is a sudden system malfunction. The driver is asked to take over.

Expected Test Sequence

Step	Type	Description	Req.
0	Action	The AV is driving at constant speed in autonomous mode on motorway.	SHOW_01_010
1	Verify	The AV is driving at constant speed on lane	
2	Action	There is a system malfunction / loss of connectivity.	

Test scenario identifier	STS06		
3	Verify		
4	Action	An alert is presented to the driver to “Take over now”	SHOW_01_012
5	Verify	The alert is presented	
6	Action	The driver can quickly and safely take over	
	Verify	Measured via indicators like: time until eyes on road, time until hands on steering wheel, time to take over, speed / lateral position variation after takeover, situation awareness ratings	

Instead, for the validation phase, it considers:

1. Safety. To ensure that no accident or incident is anticipated for any user involved in any way in the operations.
2. Performance. To ensure that all the targets for the planned operations are met.
3. Quality of service. This aspect is optional and depends on the requirements/targets set by each pilot site.

The methodology only focuses on procedures, not on technical results. For this reason, test case definitions and verification descriptions are based on a generic approach and take the appropriate check points into consideration.

The result of the tests from the methodology will be PASS / NO PASS / PARTLY PASS.

2.2 JRC Ispra site

In order to allow all project partners to apply the verification methodology laid down in D11.1, a technical verification and commissioning site has been established within the project. In particular, the Ispra site of the EC JRC has been made available to carry out verification activities required by the different vehicles and systems included in the project. Access to the Ispra site was open to all project members, although it was considered from the beginning to be particularly suitable for vehicles and systems developed by research and academic institutions without access to in-house testing capacity.

On this basis, the vehicles/systems that will be transferred to the Ispra site are the passenger vehicles and droids that will support the on-demand and first and last-mile services of the Trikala satellite site, provided by CERTH/HIT and Yape respectively.

A description of the JRC Ispra site and of the infrastructure and equipment available for the technical verification of the SHOW vehicles and systems is provided in D11.1 and repeated here again for the reader’s convenience.

The JRC is the European Commission's science and knowledge service. Its scientific staff and research infrastructures are deployed over six campuses (or 'sites') in five EU countries. The site part of this project is the Ispra site, in the province of Varese (Italy), which is the 3rd largest premise of the European Commission after Brussels and Luxembourg, and located 60 km northwest of Milan.

Figure 1: Schematic representation of the JRC-Ispra site and its functional zoning

The site features a daily population of roughly 2.200 Commission staff in over 100 buildings, 36 km of internal roads, and all the logistical services that are necessary to run a small town, including energy generation and water provision. All this in a fenced-in area of 167 ha providing a safe and secure, yet real environment, in which the JRC applies Italian law (related to safety, transportation, highway code and such like) under its own responsibility. A schematic representation of the site is reported in Figure 1.

The infrastructure available for testing is described in the next sub-sections.

2.2.1 Road infrastructure

The whole road network included in the functional zones 1, 3, 4, 5 can be used for validating safety and drivability of the vehicles included in the project. This area includes a wide variety of infrastructural elements, from straight road segments to curves, to roundabouts, various types of zebra crossing areas, different layouts of parking areas, different types of asphalt conditions, etc.

In order to ensure the safe execution of the tests, during the project, a specific procedure has been set up to reserve one or more parts of the infrastructure to the exclusive use of the tests. In this case, with the support of the site management department, the interested portion of the road network will be closed to external traffic and the access to it safeguarded by dedicated operators. However, in the case that the technology readiness level of the vehicle/system would require a more controlled environment, the area of the Ispra site highlighted in Figure 2 can be used for testing in urban driving conditions. This area is composed of a 600m long closed circuit with three intersections and a roundabout. The area is normally closed to road traffic and therefore is has higher flexibility for hosting vehicle tests.

Figure 2: Urban track of the JRC Ispra site.

The only infrastructural element currently unavailable on site are traffic lights and variable message signs. This may represent a problem since many Automated Driving Systems (ADSs) will rely on these elements and the capability to communicate with them in order to safely and efficiently merge with the traffic flow especially in urban contexts. In order to allow testing static and cooperative interaction with signalized intersections and variable message signs as described in test case CTC05, in collaboration with the SHOW partner n.35 (Swarco Mizar), as specified in the amendment request n.1 to the grant agreement, cooperative traffic lights to regulate two intersections of the JRC urban track are being installed as specified in Figure 3.

The cooperative system will allow testing several types of C-ITS services for both the automated systems to be validated and the other road users, in order to test interoperability and efficiency of the strategy adopted and to assess the potential benefit of traffic management 2.0. Among the C-ITS services that the cooperative system will enable, the Green Light Optimised Speed Advisory (GLOSA), the time to green and the ADSs prioritization are among the most interesting ones for SHOW related solutions.

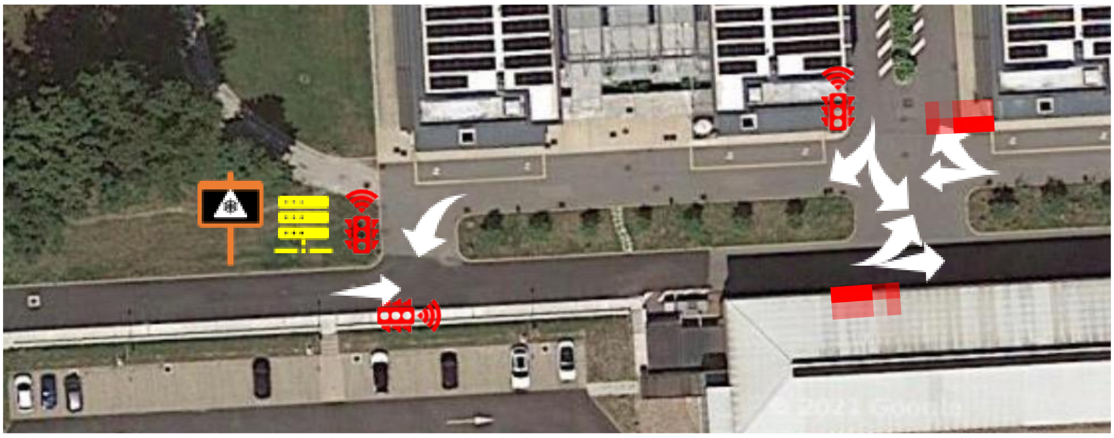


Figure 3: Layout of the cooperative traffic lights, the road side unit and the variable message sign installed at JRC Ispra by Swarco Mizar.

2.2.2 Communication infrastructure

In terms of communication and network coverage, the site hosts an internal base-station of a 4G commercial operator. For this reason, latency and power of the existing system allows the testing of vehicle teleoperation and other remotely controlled services (although for the full deployment of the service on site a 5G network would be required). In addition, on site there is availability of both ITS-G5[1] and LTE-V2X[2] road site units to allow cooperative vehicle to infrastructure testing in case foreseen by the automated vehicle/service to be tested on site.

2.2.3 Testing equipment

Finally, in order to validate the capability of ADSs to safely interact with other road users, a series of soft targets for vehicle safety testing have been procured. This includes:

- a 2D soft vehicle target
- a 3D foam vehicle target
- a pedestrian dummy (adult)
- a pedestrian dummy (child)
- a dummy cyclist

Pictures of the available targets are included in Figure 4. All safety targets are compliant with EU standards for vehicle safety tests and allow the test of various types of driving scenarios without risks for vehicles, drivers and other road users.

Figure 4: Example of targets used for vehicle safety testing

[1] https://cohdawireless.com/solutions/hardware/mk5-rsu/
[2] https://cohdawireless.com/solutions/hardware/mk6c-rsu-evk/

3 Results from the SHOW Technical Verification and Validation in each SHOW Pilot site

Chapter 3 reports the verification and validation results of the SHOW demonstrators highlighted in bold underline in the complete list of SHOW pilot sites below:

Table 3: Status of verification and validation results of SHOW demonstrators. Please note that the sites included in the Table may be subject to change depending on the evolution of the project.

MEGA SITES	Verification (IN PROGRESS / COMPLETED)	Validation (IN PROGRESS / COMPLETED)	Date of completion of both phases
France - Rouen	IN PROGRESS	IN PROGRESS	
Sweden – Linköping	**COMPLETED**	**COMPLETED**	**October 2021**
Sweden – Gothenburg	**COMPLETED**	**COMPLETED**	**December 2020**
Spain - Madrid	IN PROGRESS	IN PROGRESS	
Austria – Graz	IN PROGRESS	IN PROGRESS	
Austria – Salzburg	IN PROGRESS	IN PROGRESS	
Austria – Carinthia	IN PROGRESS	IN PROGRESS	
Germany – Karlsruhe	IN PROGRESS	IN PROGRESS	
Germany – Monheim	IN PROGRESS	IN PROGRESS	
SATELLITE SITES	**Status (IN PROGRESS / COMPLETED)**	**Status (IN PROGRESS / COMPLETED)**	**Date of completion of both phases**
Italy – Turin	IN PROGRESS	IN PROGRESS	
Greece – Trikala	IN PROGRESS	IN PROGRESS	
Finland – Tampere	**COMPLETED**	**COMPLETED**	**December 2021**
Czech Republic – Brno	IN PROGRESS	IN PROGRESS	
The Netherlands – Brainport	**COMPLETED**	**COMPLETED**	**November 2021**

The results are presented using the templates prepared in A11.1 for the reporting of results across all test sites and across both technical verification and validation phases as listed above. A summary of the technical verification and validation of each site is provided in the report, while the filled-in templates are provided in Appendixes I and II covering the verification and validation respectively.

As it is possible to observe in the list above, given the varying status of time progress of the different SHOW pilot sites, the present deliverable is including a complete report of the following specific sites: Linköping, Gothenburg, Tampere and Brainport. For this reason, it has been labelled as D11.2 Part 1. As new pilot sites will have completed this phase, additional parts will be added to the deliverable.

The following sections provide the results reporting per site.

3.1 Pilot site Sweden – Linköping

3.1.1 Description of pilot site Sweden – Linköping

The key objectives of the Linköping site are the following:

- Improve user experience for all users (end users)
- Test cooperation including multiple OEMs and multiple operators here defined as OEM, PT providers, PT operators.
- Prove a robust, safe, and reliable operation of a fleet of electric automated vehicles with a solution for connected traffic tower for last/first mile service, using the SAFE platform. (OEM, industry and service providers).

Participating entities are: Navya (OEM), Easymile (OEM), Transdev Sweden AB, VTI, Rise, Linköpings Muncipality, Region, Akademiska hus, Linköpings University.

The testing environment is described in Figure 5. It consists of two parts: the area around Campus with both traffic that interact with other vehicles and a dedicated area through the Campus area in close collaboration with only pedestrians and bicyclist (see red area in Figure 5. The second area (in pink) is connected to the campus but consists of a residential area with a school and a retirement home at the end point.

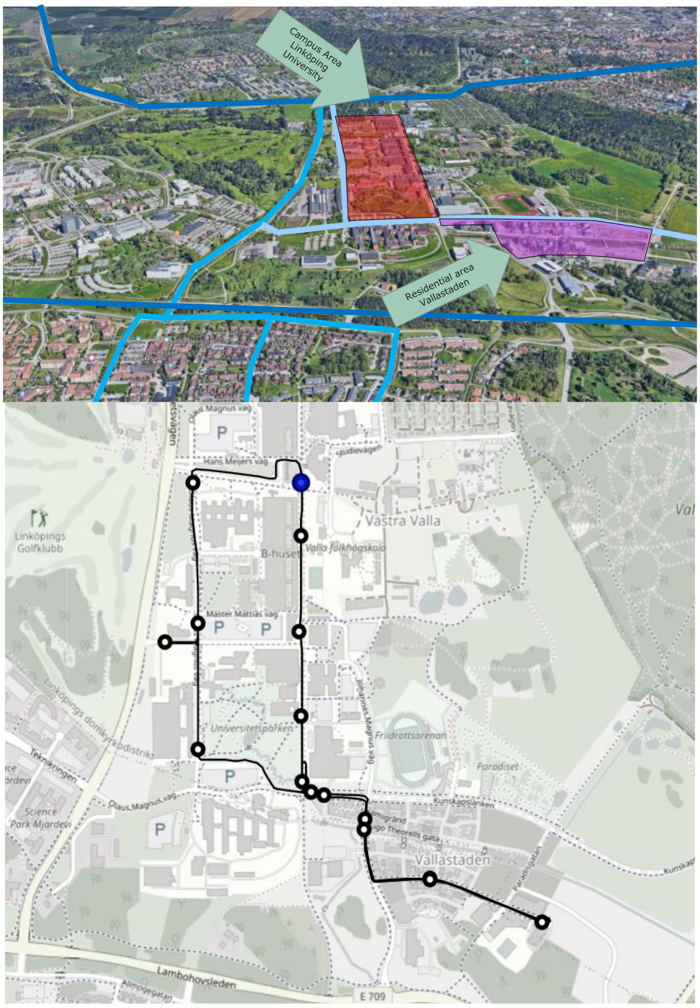


Figure 5: Linköping site

Figure 6: AV shuttles at the Linköping site

Figure 7: Bus stop at the Linköping site

Figure 8: Ground and aerial view of the Linköping site

The Linköping site has already completed the pre-demo phase in December 2021. The technical verification and validation were conducted beforehand, in December 2020. However, since the specific procedure has been delivered only in July 2021, a new verification phase has been carried out in October 2021 to cover the remaining tests.

Table 4: Main status of pilot site Sweden - Linköping

Key dates for pre-demo and actual demo	Vehicles (type & number) involved in operation	Use Cases (UC) addressed
Pre-demo phase conducted in November - December 2021; Launch of final demo expected: February 2022	1 Navya DL4 shuttle L4, 2 EasyMile EZ10 gen 2 shuttles	UCs: 1.1; 1.3; 1.6; 1.7; 3.1& 3.2 (only for final demo phase); 3.4

3.1.2 Summary of results – Technical verification – pilot site Sweden – Linköping

The complete description of the results of the 21 tests carried for verifying the ADSs are reported in Appendix I.1. Results reported hold for both the automated shuttles operating on site (Navya and Easymile). Different evidence for the two systems has been provided. It is worth mentioning that for the different tests, providing detailed information about the fulfilment of the related requirements goes beyond the scope of the present document as it would require per each test an extensive description of the conditions under which it has been carried out, which would make the deliverable unmanageable.

Some of the actions requested by the verification procedure were not applicable since the automated shuttles used in Linköping do not take into account road markings (as expected by STS01), do not use V2X communication for operating (as expected by CTS04, CTS05, CTS07, PTS02 and PTS08 for what concerns traffic lights), do not allow teleoperation (as expected by CTS01), do not exchange data with external providers (as expected by CTS02). All the other tests have been carried out either on site or are based on previous experience by the ADS developer. Concerning the cybersecurity requirements, mitigation measures for the 17 identified threats are also reported in the Appendix I.1.

From the information and the evidence provided, the verification phase can be considered concluded.

3.1.3 Summary of results – Technical validation – pilot site Sweden – Linköping

This section summarises the validation results considering the test/UCs listed below. Detailed information about the validation is reported in Appendix II.1. Some videos recorded during the verification and validation cases are available at the links reported in the following footnote to demonstrate the type of activities carried out[3].

- Test/UC 1.1 - 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.
- Test/UC 1.3 - 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 out boundaries of the area." The work is connected to the PT service.
- Test/UC 1.6 - 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.
- Test/UC 1.7 - 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). The work is a connected to the Control tower.
- Test/UC 3.4 - 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. A simple but integrated and connected "stop button" is placed along the route. The stop button (and potentially other sources like an app or Linköping MaaS) will signal the operation centre and create a stop order at the correct bus stop. The work is a connected to a DRT service.
- Test/UC 3.1 - 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 a connected to a DRT service.
- Test/UC 3.2 - Information, historical travel data and passenger information 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.

[3] https://show-project.eu/pilot-sites-sweden/

Table 5: Validation Outcomes: Aggregated technical validation outcome of pilot site Sweden - Linköping

Test/Use Case [as coded above]	**Number of iterations required for fully successful outcome:**	**Safety** results (in direct reference to the targets defined)	**Performance** results (in direct reference to the targets defined)	**Quality of Service** results (in direct reference to the targets defined above)	**Other (if applicable)** results (in direct reference to the targets defined above)	**PASS/ NOT PASS/ PARTLY PASS**
1.1	>5 iterations (160 laps a 4 km)	No injuries	All s were detected	No service interruptions occurred		PASS
1.3	>5 iterations (160 laps a 4 km)	No injuries	All s were detected	No service interruptions occurred		PASS
1.6	>5 iterations (160 laps a 4 km)	No injuries	All s were detected	No service interruptions occurred		PASS
1.7	>5 iterations (160 laps a 4 km)	Not Applicable (NA)	Connected to dashboard	Data is uploaded		PASS
3.4	>5 iterations (160 laps a 4 km)	NA	Veridict map was working	The solution is available and easy to use		PASS
3.1	NOT in the pre-demo					
3.2	NOT in the pre-demo					

3.2 Pilot site Sweden – Gothenburg

3.2.1 Description of pilot site Sweden – Gothenburg

The key objectives of the Gothenburg site are the following:

- Prove a robust, safe and reliable operation of a fleet of electrical automated vehicles with a 5G connected traffic tower for last/first mile service.
- Improve user experience for commuters to reduce usage of private vehicles.

Participating entities are: Keolis (operator of demo), Ericsson AB (providing 5G infrastructure/dashboard), RISE AB (demo leader), Navya (OEM), Vasttrafik (public transport authority) and the Gothenburg Traffic office (city transport planning authority).

The testing environment is described in Figure 9.

Figure 9: Gothenburg site

The Gothenburg site was made up of 4 stations for a total length of 2,5km. The maximum speed of the shuttles targeted on this site was 18km/h. The track type was an opened road counting 6 Stops managed with operator intervention. 15 priorities were counted.

Two Navya shuttles operated on this site. From technical point of view, their localization on the site was provided by GNSS and LIDAR sensors. The automated door opening at each station was disabled. The buzzer, not the horn, was used each time when an obstacle was detected. The automated ramp functionality was activated.

The site was split into 5 sections, each section considered certain specific features (see Figure 10), for a better management of the shuttle path. On each section were defined areas for a predefined speed. At every turn and every priority, the shuttle slowed down. Thus, the shuttle could observe if an obstacle entered the priority zone (pedestrian crossings or cycle paths), in which case it slowed down without hard braking suddenly. On the site, the road was wide enough to allow the shuttle to travel safely, except some section where it adjusted its speed from safety reasons. The turn signal was activated long before turning to warn vehicle early enough. Four priorities and one STOP&GO were programmed in this section.

Figure 10 : Site description.

In the Figure 11 are presented for the sections 1, around Regnbagsgatan E station, (a) the edges by speed, (b) the turn signals and (c) the priorities details.

		
(a)	(b)	(c)

Figure 11: Section 1 of the site. Area around Regnbagsgatan E station. (a) Edges by speed. (b) Turn signals. (c) Priorities details.

For some areas, the shuttle position was confused and not very precise. This kind of situation can be encountered frequently in towns. So, as an example, on section 4 on certain areas, the GNSS signal was not performant. Its imprecision disturbed the detection of the obstacle of the shuttle. Because the Hit Ratio (HR) was very high and the GNSS bad, it has been necessary to define two areas where the shuttle didn't consider the GNSS position (see Figure 12). In particular, it was observed that the GNSS signal is particularly weak (see the two red areas from Figure 12) under the trees and between buildings. Fortunately this did not reveal to be critical issue and the shuttle never stopped because of a lack of GNSS signal. The measured HR was very good and almost always between 90 and 100%. Thus, the shuttle could do the whole path even without GNSS.

Figure 12: Zone 4, areas where the GNSS signal is not reliable.

Every test carried out on site has been iterated at minimum 40 times.

The Gothenburg site has already completed the pre-demo phase from January to May 2021 and is reporting evidence of the previously completed technical assessment. In particular, the technical verification was conducted in November 2020 whereas the technical validation was completed in December 2020.

Table 6: Main status of pilot site Sweden – Gothenburg

Key dates for pre-demo and actual demo	Vehicles (type & number) involved in operation	Use Cases (UC) addressed
Pre-demo phase conducted in Jan.-June 2021; Launch of final demo expected: Spring 2022	2 NAVYA L4 shuttles already operated in pre-demo – those and one more to operate in final demo phase	UCs (in progress for final demo and already operated in pre-demo): 1.1; 1.2; 1.3; 1.6; 1.7; 3.4

3.2.2 Summary of results – Technical verification – pilot site Sweden – Gothenburg

The complete description of the results for verifying the ADS are reported in Appendix I.2. Some particularly relevant actions during this phase are reported hereafter.

Lane Markings & Traffic Signs (SHOW_01_001 to SHOW_01_005)

- Adding of totems / station panels to geo-locate the stations
- Adding of pedestrian crossings
- Adding of lane marking in order to separate lanes and parking area
- Adding of signs to prevent pedestrian from walking on the road
- Changing of some signalling to give the way to the shuttle

Figure 13: Totem at station

<u>Facilitation of the recognition by perception system (SHOW_01_006 to SHOW_01_008)</u>

- Adding of Lidars markers all along the path to improve the environment recognition
- Trees and hedges regularly pruned all along the pre-demo
- Adding of signs to prevent illegal parking

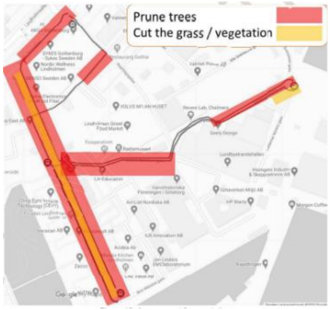


Figure 14: Located zones to prune trees and hedges

<u>Lane Markings & Traffic Signs (SHOW_02_008)</u>

- The required KPIs have been uploaded on the Show Data Management Platform

<u>Communication process supervision – safety driver (SHOW_03_003)</u>

- The safety drivers were constantly in contact with a remote supervision thanks to a dedicated conversation feed. In case of problem (hardware / software problems, environmental problem such as a disturbing parking), the safety driver directly sends a message to the supervision. Sometimes a photo is also attached to the message. The message is processed by the supervision who gives instructions to the safety driver.

However, it should be noted that the most frequent and most dangerous issues are all linked to specific internal process known by the safety driver. Moreover, the supervision can follow in real time the location and state of the different shuttles on a specific tool (Navyalead) developed by the manufacturer Navya.

<u>Connectivity (SHOW_03_011, SHOW_03_012, SHOW_03_013, SHOW_03_014)</u>

A SIM card is provided for each shuttle and for the GNSS base. The base was installed on top of the red building below. It is in the middle of the track and tall enough to distribute corrections on all the path. The GNSS Signal is weak sometimes, under the trees and between buildings, but it is not critical. The Shuttle never stopped because of a lack of GNSS signal.

<u>Cybersecurity</u>

A safety driver was always on board. This makes it possible to control cybersecurity risks very effectively: in case of any unexpected behaviour of the shuttle, the safety drivers have been taught to press the emergency stop button which stops mechanically the vehicle. Moreover, Ericsson which provided 5G infrastructure/dashboard, follows the cybersecurity standards: UN Regulation No. 155 - Cyber security and cyber security management system | UNECE as well as the ISO - ISO/SAE 21434:2021 - Road vehicles — Cybersecurity engineering.

3.2.3 Summary of results – Technical validation – pilot site Sweden - Gothenburg

This section summarises the validation results, considering the test/UCs listed below:

- UC1.1 First/last mile PT at Lindholmen/Gothenburg
- UC1.2: Automated passengers/cargo mobility in cities under complex traffic & environmental conditions
- UC1.3: Interfacing non automated vehicles and travellers (including VRUs)
- UC1.6 Mixed traffic flow
- UC1.7: Connection to Operation Centre for tele-operation and remote supervision
- UC3.4: Automated services at bus stops

Detailed information about the validation is reported in Appendix II.2. Some videos recorded during the verification and validation cases are available at the links reported in the following footnote to demonstrate the type of activities carried out[4].

Table 7: Validation Outcomes: Aggregated technical validation outcome of pilot site Sweden - Gothenburg

Test/Use Case [as coded above]	Number of iterations required for fully successful outcome:	Safety results (in direct reference to the targets defined)	Performance results (in direct reference to the targets defined)	Quality of Service results (in direct reference to the targets defined)	PASS/ NOT PASS/ PARTLY PASS
UC 1.1	40	No safety problems encountered	Successful performance 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 make the shuttles operations more unpredictable.		PASS

[4] https://show-project.eu/pilot-sites-sweden/

Test/Use Case [as coded above]	Number of iterations required for fully successful outcome:	Safety results (in direct reference to the targets defined)	Performance results (in direct reference to the targets defined)	Quality of Service results (in direct reference to the targets defined)	PASS/ NOT PASS/ PARTLY PASS
UC 1.2	40	No safety problems encountered	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 and it was necessary to heat up the system during 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, deep and large puddles small fragments such as snowflakes or leaves can make shuttles operations more unpredictable. The shuttle was cleaned every day, inside and outside. All lidars and sensors		PASS

Test/Use Case [as coded above]	Number of iterations required for fully successful outcome:	Safety results (in direct reference to the targets defined)	Performance results (in direct reference to the targets defined)	Quality of Service results (in direct reference to the targets defined)	PASS/ NOT PASS/ PARTLY PASS
			were carefully cleaned every day to prevent deterioration.		
UC 1.3	40	Good detection of VRUs by the shuttles	Successful performance in this test case which was conducted with selected passengers in the area (Ericsson employees): the shuttle can connect to other passengers in the surroundings of the shuttle, as on the route VRUs might be. When the shuttle is approaching, 15 to 20m, a yellow vest starts flashing. Connection via the Ericsson Control Center. 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.	Stakeholders named that the shuttles need to improve from a technical point of view (see more in D11.3).	PASS
UC 1.6	40	Violations of the traffic rules by other road users	Good operation of the shuttles along the 2.5 km long path.		PASS

Test/Use Case [as coded above]	Number of iterations required for fully successful outcome:	Safety results (in direct reference to the targets defined)	Performance results (in direct reference to the targets defined)	Quality of Service results (in direct reference to the targets defined)	PASS/ NOT PASS/ PARTLY PASS
		happened on a regular basis, this was probably related to the reduced speed of 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 occurred as well as during rush hours. At three points on the route, it was mandatory for the safety driver to take over the vehicle and verify the environment. According to the authority, the vehicles had to be driven in manual	Operating in mixed traffic flows can affect the performance of the system (during validation but also during pre-demo phase later, 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).		

Test/Use Case [as coded above]	Number of iterations required for fully successful outcome:	Safety results (in direct reference to the targets defined)	Performance results (in direct reference to the targets defined)	Quality of Service results (in direct reference to the targets defined)	PASS/ NOT PASS/ PARTLY PASS
		position for example at one intersection, as this posed a danger as the shuttles cannot sufficiently process information from vehicles approaching with around 50 km/h. Under operation in mixed traffic, the shuttles honked to warn other road users, stopped at pedestrian crossings/crossings, overtook and/or wait for free passage. It happened on the way that the shuttles broke abruptly. The safety driver needed to make passengers aware of this before riding.			
UC 1.7	40	NA	The AVs were successfully connected to the	Overall performance could be	PASS

Test/Use Case [as coded above]	Number of iterations required for fully successful outcome:	Safety results (in direct reference to the targets defined)	Performance results (in direct reference to the targets defined)	Quality of Service results (in direct reference to the targets defined)	PASS/ NOT PASS/ PARTLY PASS
			5G infrastructure in the Lindholmen area for remote communication and supervision.	improved by 5G infrastructure and remote functionalitie, particularly in dynamic or sensitive areas.	
UC 3.4	40	Safe stop at each station	Successful performance of autonomous driving functions at the bus stops: the vehicles/API have a functionality that assists to get back on the road.		PASS

3.3 Pilot site Finland – Tampere

3.3.1 Description of pilot site Finland – Tampere

The key objectives of the Tampere site are the following:

- Explore the issues related to shared mobility, automated transport, feeder & first/last km services and seamless integrated public transport system that have been essential and in the focus of Tampere.
- To align with the city aims that wishes to develop sustainable and integrated mobility services and a transport system that will attract private car users voluntarily to start using more environmentally friendly public transport services, city bikes, e-scooters, and walking.
- In this context, to evaluate the automated feeder transport services operating in SHOW.

Participating entities are: The City of Tampere, Sensible 4 Oy, VTT, Sitowise Oy. In addition to these SHOW-partners, Nysse – Tampere City Transport will act as an enabler and advisor while the regional business development organisation, Business Tampere, will act as a planner of the needed automated driving test environment. The testing environment is described in Figure 15 and Figure 16. The two routes are both in urban environment. 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 15: Test route at Sensible 4 locations in Espoo, Finland

The final open road tests were conducted on open roads at Tampere trial site, approximately 3.3 km long route with bus stops, four right turns and one roundabout.

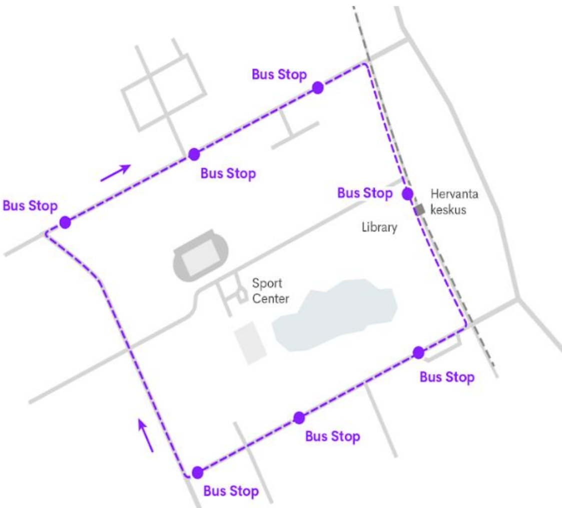


Figure 16: Test route at Hervanta, Tampere, Finland

Many of the verification tests as defined in the SHOW project have 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 vehicles are safe and approved for road operations in Finland.

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 autonomous 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. Both are SAE level 4 operational.

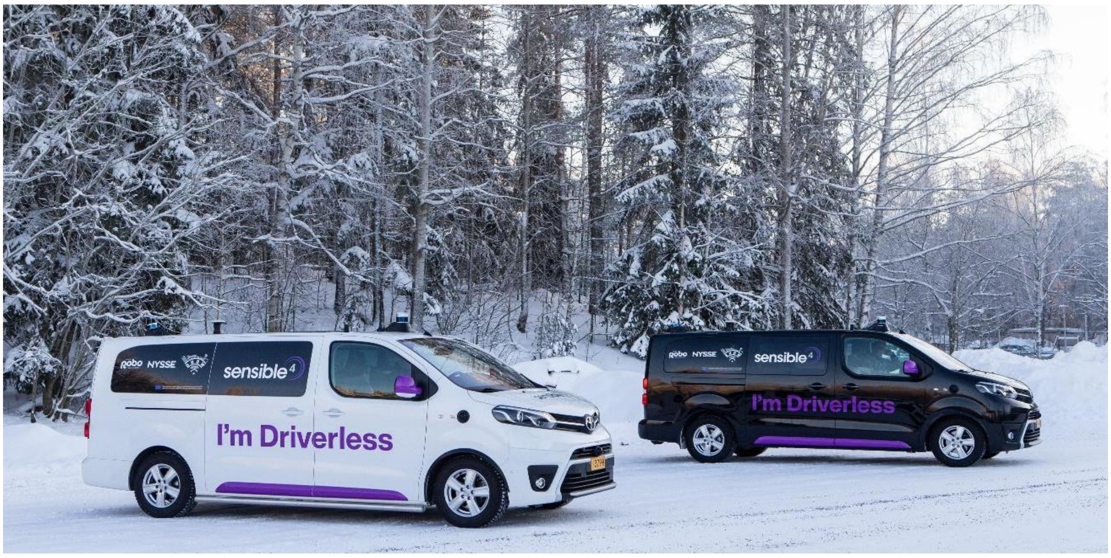


Figure 17: AV shuttles at the Tampere site

Figure 18: Safety driver conducting verification and validation drives at Tampere, Finland for SHOW project

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 communicate with Sensible 4 remote dashboard and SHOW dashboard through APIs. Architecture used is the SHOW architecture as described in the architecture deliverable.

4G/LTE connectivity ensured on the test sites commercially and in Tampere 5G through a test network not utilized in SHOW project. No new infrastructure has been added on either site for this pilot.

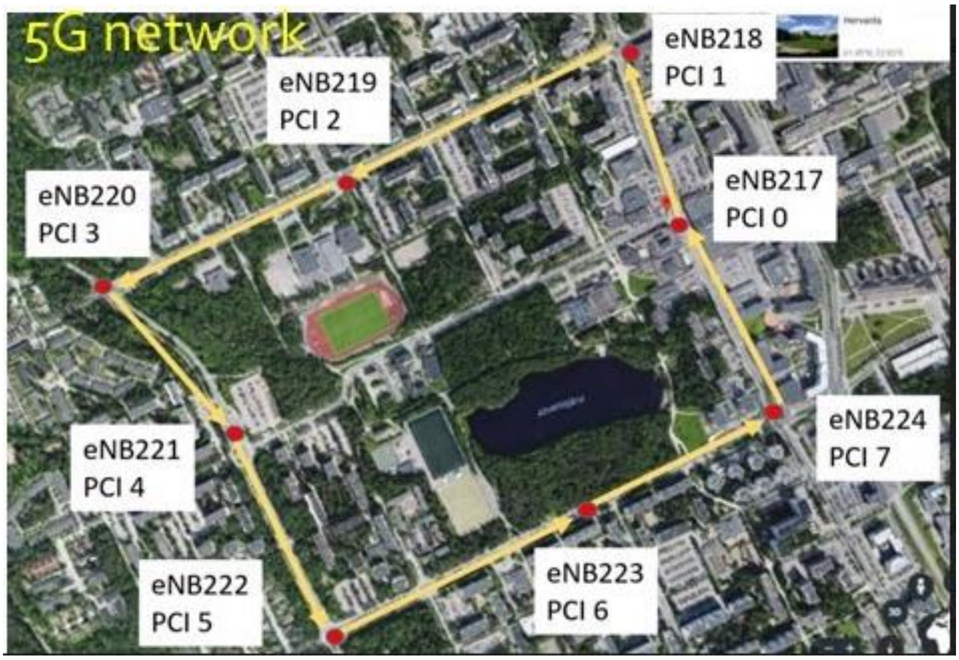


Figure 19: Tampere route 5G base stations

Each test has been iterated at minimum ten times. Some of the scenarios are already included in the fully functioning and ongoing Sensible 4 client projects elsewhere and the the tests have been conducted in varying conditions. For SHOW the conditions ranged from clear weather conditions to rain and heavy snow.

The Tampere site has completed the technical verification and the technical validation from 1 June 2021 to 22 December 2021 both in Espoo and Tampere in Finland (parts of the testing have been conducted in other projects well in advance but final tests have been conducted on-site at Tampere).

Table 8: Main status of pilot site Finland – Tampere

Key dates for pre-demo and actual demo	Vehicles (type & number) involved in operation	Use Cases (UC) addressed
Pre-demo phase launch on 21 December 2021; Launch of first phase of the final demo/pilot with Toyota Proaces started in January 2022. The second phase with AuveTech shuttle will start by the end of spring early summer 2022.	2 Sensible 4 Toyota ProAce vans, 1 AuveTech Iseauto shuttle, 3 AV shuttles	1.1; 1.2; 1.4; 1.7; 3.1

3.3.2 Summary of results – Technical verification – pilot site Finland – Tampere

The complete description of the results for verifying the ADS are reported in Appendix I.3. Overall, the vehicles have passed the tests as set to them and were proved ready for validation and demo operations. Each test was performed in an iterative manner. Many of the tests have been conducted, and are continuously being iterated as part of Sensible 4 QA, in prior and ongoing projects. Overall the technical verification was completed. Location specific testing was conducted as part of the technical validation phase (see below). Still, no issues were detected for the vehicles in similar tests conducted on other locations. Vehicles proved already from this phase to be safe and ready for operations in Tampere and Finland site overall.

3.3.3 Summary of results – Technical validation – pilot site Finland – Tampere

Tools utilized in validation actions are the full operational utilities used in Tampere pilot by SHOW partners. Vehicles were tested in operational environment in normal traffic, rush hour traffic and varying weather conditions from fair weather to rain and snow. The vehicles are capable of operating at a maximum speed of 30 km/h on the pilot route. Data logging systems are the local data platform operated by Sensible 4, as well as the SHOW dashboard. This section summarises the validation results, considering the test/UCs listed below:

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

Detailed information about the validation is reported in Appendix II.3. Some videos recorded during the verification and validation cases are available at the links reported in the following footnote to demonstrate the type of activities carried out.[5]

[5] https://sensible4.fi/company/newsroom/self-driving-pilot-in-finland-a-success-despite-extreme-weather-conditions/
https://www.youtube.com/watch?v=yMBrY0LxJFc

Table 9: Validation Outcomes: Aggregated technical validation outcome of pilot site The Finland – Tampere

Test/Use Case [as coded above]	**Number of iterations required for fully successful outcome:**	**Safety** results (in direct reference to the targets defined)	**Performance** results (in direct reference to the targets defined)	**Quality of Service** results (in direct reference to the targets defined)	**Other (if applicable)** results (in direct reference to the targets defined)	**PASS/ NOT PASS/ PARTLY PASS**
All above	10	No safety concerns found	Vehicles operate normally and are capable of the operations planned for them in the demo phase.	Service quality is at desired level. Two vehicles can serve passengers on the route at 7 min intervals. Test passengers have found the ride smooth and enjoyable (see more in D11.3).	-	PASS

The Tampere site was declared as almost ready to go at the end of this phase– only minor optimisation was required. Vehicles performed well and within parameters. There are minor adjustments to be done (that have been addressed before operation started). All validation scenarios have been passed.

3.4 Pilot site The Netherlands – Brainport

3.4.1 Description of pilot site The Netherlands – Brainport

The key objectives of the Brainport site are the following:

- Demonstrate cooperative automated driving technologies for bus lanes, with solutions for smooth and safe intersection crossing with normal roads, aimed for PT buses, and platooning with shared passenger cars.
- Utilize day 1 C-ITS services for safe and informed intersection crossing.
- Support L4 and cooperative driving technologies for crossing intersections with presence of other vehicles and VRU.

Participating entities are: Netherlands Organisation for Applied Scientific Research (TNO).

Test site

The verification and validation was carried out at the Aldenhoven Test Centre in Germany. An aerial overview of the location where the intersection crossing functions were tested, is depicted in Figure 20. At the test site, an intersection setup has been created with road barriers and a Road Side Unit (RSU). The scenario is 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 Collaborative Perception Message (CPM).

Figure 20: Brainport validation site. The Aldenhoven Test Centre.

Vehicles

The functionalities are implemented in two TNO carlabs (Renault Grand Scenic 2019) depicted in Figure 21. These carlabs have been developed to support SAE Level 4 automated driving, and for that purpose they are equipped with additional sensors and automated controls for accelerating, braking and steering. The standard sensor suite of the Renault is extended with additional radars and cameras and a variety of communication systems (ITS-G5, 5G, C-V2X) to utilize the RSU connectivity information.

Figure 21: Retrofitted level 3 automated vehicles at the Brainport validation site

A GNSS receiver, with an update rate of 10Hz, has been installed for improved localisation and also to allow for synchronization of measurement data using its time stamp. Finally, an in-house developed vehicle gateway provides the interface between the original vehicle systems and the automation systems. It runs at 100Hz and converts the acceleration and steering setpoints into actual drive, brake and steering actuation. The vehicle gateway processes the vehicle sensor data and presents these to the functionalities consequently interfacing with the control platform. These functionalities are running on dedicated processing platforms in the trunk of the vehicle, as depicted in Figure 22.

Figure 22: Sensor, communication and processing platforms located in the trunk of the TNO carlabs

Furthermore, the vehicle gateway is connected to the standard vehicle Human Machine Interface (HMI), namely digital display, buttons and levers. As a result, the developed control system can be operated like the stock ACC system. To guarantee safe and reliable operation, the vehicle gateway additionally contains several safety features. The vehicle gateway employs multiple Input/Output (I/O) for the communication with the vehicle systems. Because of the integrated low-level controllers, safety-related functions, and sensor preprocessing, the vehicle gateway allows for data collection to support evaluation of the intersection crossing controller, in a safe, reliable and efficient way.

The vehicles are equipped with all the necessary logging systems, so that the longitudinal position, speed and acceleration of the car are logged. The information sent by the RSU as received by the vehicle is logged as well. The variables, logging systems and timing of the logging are shown in the table below.

Table 10: Variables and logging systems/timing of pilot site The Netherlands – Brainport

Dependent variables	Logging system	Time of measurement
Position (GPS), Speed (CAN), Acceleration (CAN)	Safety axiomtek (storage in car)	10s before the stop line of the intersection until 5s after the stop line
Traffic light phase	Safety axiomtek (storage in car)	10s before the stop line of the intersection until 5s after the stop line
Subjective measures (questionnaire) [6]	On paper	Before the experiment, between UCs and after experiment.

The Brainport site has completed the technical verification in August 2021 at the Aldenhoven Test Centre (ATC) (Figure 23) whereas the technical validation was completed in November 2021.

Figure 23: Examples of tests carried out in the validation of the retrofitted automated vehicles included in the Brainport validation site

Table 11: Main status of pilot site The Netherlands – Brainport

Key dates for pre-demo and actual demo	Vehicles (type & number) involved in operation	Use Cases (UC) addressed
Pre-demo phase conducted in Q4 2021; Launch of final demo	3 passenger cars (3 TNO Carlabs retrofitted with	UC 1.1; 1.3; 1.8

[6] Not constituting objective of this Deliverable.

Key dates for pre-demo and actual demo	Vehicles (type & number) involved in operation	Use Cases (UC) addressed
expected: 2023 (robotaxi and bus operations limited to demonstration events; under exploration)	hardware enabling automated driving) + 1 bus (for the final demo phase)	

3.4.2 Summary of results – Technical verification – pilot site The Netherlands – Brainport

Considering the type of systems deployed in the site and their level of automation, only a subset of requirements and thus of the tests part of the verification procedure were applicable. In particular, the following table summarizes the applicable tests (and steps within them) and the number of repetitions performed per each of them. For all the applicable cases the tests showed that the system is able to fulfil the related requirements. Also concerning cybersecurity appropriate countermeasures have been taken against most of the threats. Only 4 of them were considered not applicable to the pilot.

Complete information about the tests carried out are reported in Appendix I.4.

Table 12: Applicable verification tests for the systems included in the Brainport pilot site

Test Scenario ID	Number of applicable steps	Number of repetitions	Result
STS01	2	6	Pass
STS02	All	30	Pass
STS03	All	4	Pass
STS04	All	2	Pass
CTS04	All	2	Pass
CTS06	4	6	Pass
PTS07	All	4	Pass

The applicable verification tests for the developed system in the Brainport demonstration site have been selected based on the degree of application to the developments within the SHOW project.

3.4.3 Summary of results – Technical validation – pilot site The Netherlands – Brainport

Following the activities carried out in November 2021, it was possible to successfully validate the system for the three considered use-cases. The validation has exclusively concerned safety and performance as there were no other objectives.

Detailed information about the validation tests carried out is reported in Appendix II.4. A video summarizing the validation results for the different UCs is available at the link provided in the next footnote[7].

Table 13: Validation Outcomes: Aggregated technical validation outcome of pilot site The Netherlands – Brainport

Test/Use Case [as coded above]	**Number of iterations required for fully successful outcome:**	**Safety** results (in direct reference to the targets defined)	**Performance** results (in direct reference to the targets defined)	**Quality of Service** results (in direct reference to the targets defined)	**Other (if applicable)** results (in direct reference to the targets defined)	**PASS/ NOT PASS/ PARTLY PASS**
UC1.1	5	PASS	PASS	NA	NA	PASS
UC1.3	5	PASS	PASS	NA	NA	PASS
UC1.8	2	PASS	PASS	NA	NA	PASS

[7] https://show-project.eu/pilot-sites-netherlands-brainport/

4 Conclusions and next steps

This deliverable has provided results from the SHOW demonstrators' safety, reliability and robustness validation and commissioning conducted in A11.2. Real-life demonstrators have been validated based on the SHOW technical verification and validation protocol (D11.1) by performing a full technical walkthrough on functions and services level before the upcoming pre-demo evaluation phase. In particular, the technical assessment of SHOW has encompassed two distinct phases: a technical verification phase on individual technical aspects of ADSs including safety, performance, communications and cybersecurity and a technical validation on integrated service level phase conducted in each respective SHOW pilot site. This deliverable reports the results from both phases.

Table 14: Status of verification and validation results of SHOW demonstrators (in bold those which have completed both phases and are reported in D11.2 Part 1). Please note that the sites included in the Table may be subject to change depending on the evolution of the project.

MEGA SITES	Verification (IN PROGRESS / COMPLETED)	Validation (IN PROGRESS / COMPLETED)
France - Rouen	IN PROGRESS	IN PROGRESS
Sweden – Linköping	**COMPLETED**	**COMPLETED**
Sweden – Gothenburg	**COMPLETED**	**COMPLETED**
Spain - Madrid	IN PROGRESS	IN PROGRESS
Austria – Graz	IN PROGRESS	IN PROGRESS
Austria – Salzburg	IN PROGRESS	IN PROGRESS
Austria – Carinthia	IN PROGRESS	IN PROGRESS
Germany – Karlsruhe	IN PROGRESS	IN PROGRESS
Germany – Monheim	IN PROGRESS	IN PROGRESS
SATELLITE SITES	**Status (IN PROGRESS / COMPLETED)**	**Status (IN PROGRESS / COMPLETED)**
Italy – Turin	IN PROGRESS	IN PROGRESS
Greece – Trikala	IN PROGRESS	IN PROGRESS
Finland – Tampere	**COMPLETED**	**COMPLETED**
Czech Republic – Brno	IN PROGRESS	IN PROGRESS
The Netherlands – Brainport	**COMPLETED**	**COMPLETED**

The present deliverable has been labelled as D11.2 Part 1 as it includes a reporting of the verification and validation results of the SHOW pilot sites which have completed both phases of reporting at the time of the current report issue, namely: Linköping, Gothenburg, Tampere and Brainport. As soon as new pilot sites will have completed both phases from the remaining sites (i.e. mega-sites: France – Rouen, Spain – Madrid, Austria – Graz, Austria – Salzburg, Austria – Carinthia, Germany – Karlsruhe, Germany – Monheim; satellite sites: Italy – Turin, Greece – Trikala, Czech Republic – Brno as well as the new test sites that are about to enter SHOW), additional parts will be added to the deliverable that will be released in subsequent versions.

The technical verification and validation of Linköping, Gothenburg, Tampere and Brainport pilot sites can be considered completed which signals that these sites proved to be ready to move to the pre-demo evaluation phase (to note that these sites have already completed the pre-demo phase by the time of writing this deliverable). Based on these results and before moving to the pre-demo evaluation (first round of pilot field trials with users – not open to public), an optimisation step has been applied. Not applicable tests/actions have been reported as appropriate (indicated as NA). It is worth mentioning that providing detailed information about the fulfilment of the requirements related to the different tests goes beyond the scope of the present document as it would require per each test an extensive description of the conditions under which it has been carried out, which would make the deliverable unmanageable.

Next steps will address the reporting of the remaining test sites in additional parts of this deliverable. As the technical verification and validation phases are completed in each site, their pre-demo evaluation phases (A11.3) will be carried out in order to prepare each site for the final real-life demonstrations of the SHOW project.

References

[1] SHOW (2021). D11.1 Technical validation protocol. Deliverable of the Horizon-2020 SHOW project, Grant Agreement No. 875530.

[2] SHOW (2020). D1.2 SHOW Use Cases. Deliverable of the Horizon-2020 SHOW project, Grant Agreement No. 875530.

[3] SHOW (2020). D9.2 Pilot experimental plans & impact assessment framework for pre-demo evaluation. Deliverable of the Horizon-2020 SHOW project, Grant Agreement No. 875530.

[4] SHOW (2021). D7.3: Interfaces to non-equipped participants. Deliverable of the Horizon-2020 SHOW project, Grant Agreement No. 875530.

Appendix I – Results from Technical validation & commissioning on integrated service level

I.1. Technical verification results of demo site Sweden – Linköping

Table 15: Safety Test Scenario STS01 - Linköping pilot site

Test Scenario STS01 / **Lane marking and traffic signs detection** / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Remove redundant lane markings at bus stops/bays to minimize any adverse effects on lane keep assist systems (if applicable).	NA	AVs do not take lane markings into account and do not have detection technology that complies to this requirement
1	Action	Ensure that there are no yellow and white mixed in pavement markings on construction site (if applicable).	NA	AVs do not take lane markings into account and do not have detection technology that complies to this requirement
2	Action	Improve longitudinal pavement markings at intersections (if applicable).	NA	NA
3	Action	Improve current pavement marking asset conditions to enhance brightness and quality of the lane marking (if applicable).	NA	NA

Test Scenario STS01 / **Lane marking and traffic signs detection** / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
4	Verify	Ensure that the AV is able to detect properly all the lane and pavement marks.	NA	AV do not take lane markings into account and do not have detection technology that complies to this requirement
5	Action	Maintain traffic signs in flawless conditions, namely replace worn out signs, maintain their proper position and make sure there is no obscured visibility.	NA	NA
6	Action	Establish unified system of machine-readable signs that for easier recognition.	PASS	Available in confidential AV OEM's Site Assessment Report. Lidar panels/landmarks have been deployed for localisation improvement
7	Verify	Ensure that the AV is able to identify properly all the traffic signs.	PASS	Available in confidential AV OEM's Site Assessment Report and Commissioning Acceptance Report

Table 16: Safety Test Scenario STS02 - Linköping pilot site

Test Scenario STS02 / **Dynamic and static objects detection** / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Ensure that there are no obstacles around the route, including intersections with incoming traffic, that are not part of the test.	PASS	Available in confidential AV OEM's Site Assessment Report and Site Description Report
1	Action	Ensure that there are no static and dynamic obstacles that are not anticipated to be on the route.	PASS	Available in confidential AV OEM's Site Assessment Report and Site Description Report. Test runs are carried out at the start of every operator shift.
2	Action	Attend to the vegetation maintenance on the side road and cleaning of the road.	PASS	Available in confidential AV OEM's Site Assessment Report and Site Description Report. We have extended our service and maintenance agreement with landlord around the driving site
3	Action	Ensure that all the parked cars are correctly parked and have pre-defined parking lot zones	PASS	Available in confidential AV OEM's Site Description Report and Commissioning Acceptance Report
4	Verify	The AV is able to detect the dynamic and static objects anticipated to be on the route.	PASS	As above

Test Scenario STS02 / **Dynamic and static objects detection** / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
5	Verify	The AV is able to avoid collisions with obstacles that could lead to a dangerous situation.	PASS	As above

Table 17: Safety Test Scenario STS03 - Linköping pilot site

Test Scenario STS03 / **Lane keeping and override** / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	The AV is driving at constant speed in autonomous mode.	PASS	Available in confidential AV OEM's Site Description Report and Commissioning Acceptance Report
1	Verify	The AV is not leaving its lane.	PASS	As above
2	Action	The driver wishes to perform an override.	PASS	As above
3	Verify	The driver can take back the control of the vehicle.	PASS	As above

Test Scenario STS03 / Lane keeping and override / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
4	Action	The driver activates the autonomous mode again.	PASS	Available in confidential AV OEM's Site Description Report and Commissioning Acceptance Report

Test Scenario STS03 / Lane keeping and override / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	The AV is driving at constant speed in autonomous mode in motorway and approaching end of ODD.	PASS	Available in confidential AV OEM site description report, commissioning acceptance report and vehicle manual document (for example shuttle path to storage is in manual mode)
1	Verify	The AV is driving at constant speed on lane	PASS	Available in confidential AV OEM site description report, commissioning acceptance report and vehicle manual document
2	Action	A notification is shown to the driver to prepare to take over	PASS	As above
3	Verify	The notification is shown	PASS	As above

Test Scenario STS03 / **Lane keeping and override** / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
4	Action	The driver safely takes over	PASS	Available in confidential AV OEM vehicle manual document
5	Verify	Measured via indicators like: time until eyes on road, time until hands on steering wheel, time to take over, speed / lateral position variation after takeover, situation awareness ratings	PASS	Available in confidential AV OEM site description report and vehicle manual document

Test Scenario STS03 / **Lane keeping and override** / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	The AV is driving at constant speed in autonomous mode in motorway.	PASS	Available in confidential AV OEM site description report, commissioning acceptance report and vehicle manual document
1	Verify	The AV is driving at constant speed on lane	PASS	As above
2	Action	There is a system malfunction / loss of connectivity.	PASS	Available in confidential AV OEM vehicle manual document

Test Scenario STS03 / **Lane keeping and override** / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
3	Verify		PASS	Available in confidential AV OEM vehicle manual document
4	Action	An alert is presented to the driver to "Take over now"	PASS	Available in confidential AV OEM vehicle manual document. Error message is shown with different types of operator actions to handle
5	Verify	The alert is presented	PASS	Available in confidential AV OEM vehicle manual document
6	Action	The driver can quickly and safely take over	PASS	As above
7	Verify	Measured via indicators like: time until eyes on road, time until hands on steering wheel, time to take over, speed / lateral position variation after takeover, situation awareness ratings	PASS	As above

Table 18: Safety Test Scenario STS04 - Linköping pilot site

Test Scenario STS04 / Loss of communication from sensors / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	The AV loses communication with its perception sensors.	PASS	Available in confidential AV OEM site description report, commissioning acceptance report and vehicle manual document
1	Verify	The AV performs a safe stop.	PASS	Available in confidential AV OEM site description report, commissioning acceptance report and vehicle manual document
2	Action	The AV recovers from the loss of communication and continues its route.	PASS	Available in confidential AV OEM vehicle manual document
3	Action	The AV loses communication with the GNSS.	PASS	As above
4	Verify	The AV performs a safe stop.	PASS	As above

Table 19: Performance Test Scenario PTS01 - Linköping pilot site

Performance test Scenario PTS01 / Cloud platform storage / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Perform a stress test in the cloud platform.	PASS	As above
1	Verify	Ensure that the data platform supports high volume of traffic with no affect to its performance.	PASS	We download vehicle data from both vehicles continuously (rate 1-2 per sec). Some minor communication problems have occurred but mostly working

Table 20: Performance Test Scenario PTS02 - Linköping pilot site

Performance test Scenario PTS02 / V2X communication performance / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Every V2X device that participates in the realization of site's UCs, should be able to transmit and receive all required V2X messages.	NA	Linköping Pilot site is not utilizing V2X system and its intelligence

Performance test Scenario PTS02 / V2X communication performance / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
1	Action	The devices under test are placed in a range close to each other (for example within 50 m radius) and start to operate normally. They log every transmitted and received during a predefined time period (at least 100 seconds).	NA	As above
2	Verify	The recorded log files are compared after the test and the maximum packet loss ratio should not exceed 10%.	NA	As above
3	Action	A pair of V2X devices repeat Action 1 with an increasing range from 100m to 400m, using a 50m increase step.	NA	As above
4	Verify	The recorded log files are compared after the test and the maximum packet loss ratio should not exceed 10% for every range distance tested. The longest distance that this condition is satisfied should be considered as the V2X communication range.	NA	As above

Table 21: Performance Test Scenario PTS03 - Linköping pilot site

Performance test Scenario PTS03 / GNSS performance / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Every device that incorporates a plain GNSS receiver or enhanced positioning services should be able to store/transmit the obtained positioning solution (including the timestamp with millisecond resolution).	PASS	From both vehicles we get timestamp, position, speed and more parameters 1-2 times per second via the vehicle manufacturers cloud API services.
1	Action	In case a positioning enhancement service is being implemented and utilized by some or all positioning devices it should operate normally during testing.	PASS	Available in confidential AV OEM site assessment report, site description report and vehicle manual document. Requirements for GNSS are fulfilled by technical redundancy (LiDAR prioritisation when GNSS signal strength is low).
3	Verify	The obtained positioning solutions are evaluated against the real position of the device at the time of generation. The mean solution's accuracy should be less than 5 m.	PASS	Available in confidential AV OEM site assessment report, site description report and vehicle manual document. Requirements for GNSS are fulfilled by technical redundancy (LiDAR prioritisation when GNSS signal strength is low).

Performance test Scenario PTS03 / GNSS performance / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
4	Verify	The obtained positioning solutions are evaluated against the real position of the device at the time of generation. The mean solution's accuracy should be less than 1 m.	PASS	Available in confidential AV OEM site assessment report, site description report and vehicle manual document. Requirements for GNSS are fulfilled by technical redundancy (LiDAR prioritisation when GNSS signal strength is low).

Table 22: Performance Test Scenario PTS04 - Linköping pilot site

Performance test Scenario PTS04 / Speed adaptation / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Verify	Verify with the FAV's OEM, integrator, or constructor which technology is chosen for speed adaptation: - Predefined speed zone in path And / or - Adaptive Cruise Control and traffic sign reading - Other …	PASS	Available in confidential AV OEM site assessment report, site description report and vehicle manual document. Approval from Swedish transport Agency (STA) is also given during FAT and SAT

Performance test Scenario PTS04 / Speed adaptation / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
1	Verify	If in the pre-defined speed zone in path, verify that the information is shared with the site authorities during the mapping of the site according to the risk analysis that is done by OEMs (items considered: ODD, traffic density, visibility, localization, etc.).	PASS	Available in confidential approved risk management matrix and OEM's ODD approved by STA. Also, reflected in approved pilot site driving permission from STA.
2	Verify	Verify that the vehicle can adapt its speed depending on the environment conditions on specific sections on the path, (the ACC shall be tested apart from this requirement).	PASS	Available in confidential AV OEM site assessment report, site description report and vehicle manual document. Approval from Swedish transport Agency (STA) is also given during FAT and SAT. Internal test protocol for vehicle functional verification has been carried out as well.
3	Action	This will be checked during the deployment on site.	PASS	Available in confidential AV OEM driving site commissioning report. Approval from Swedish Transport Agency is also given (SAR). Internal test protocol for vehicle functional verification has been carried out as well.

Table 23: Performance Test Scenario PTS05 - Linköping pilot site

Performance test Scenario PTS05 / AV arrival/pick up management / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	The AV is driving to priority node A. There is no obstacle on priority zones 1 and 3. An obstacle moving in the AV's opposite direction (cyclist at V = TBD m/s) enters the priority zone 2 when the AV arrives at node A.	PASS	Available in confidential AV OEM vehicle manual document, commissioning acceptance report and internal vehicle functional verification.
1	Verify	The AV shall stop.	PASS	As above
2	Verify	The AV shall start driving to the station when the bicycle is not on the AV's trajectory anymore.	PASS	As above

Table 24: Performance Test Scenario PTS06 - Linköping pilot site

Performance test Scenario PTS06 / Service provision / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Two or more OEMs / PTOs involved in the same route.	PASS	Linköping pilot site has a multi-brand approach, namely using EasyMile and Navya as OEM suppliers.
1	Verify	Ensure that the service provision used by the different OEMs / PTOs is the same when the operation transits from the Area of Operator A to the Area of Operator B.	PASS	All operational data from both vehicles are collected and stored in a common database for analysis and evaluation. A slightly modified version of the collected data is transmitted to the central SHOW DMP

Table 25: Performance Test Scenario PTS07 - Linköping pilot site

Performance test Scenario PTS07 / Data Registry protocol / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Analyze log files produced during a test scenario.	PASS	Except for some minor communication problems and occasional issues with OEM API access all data is collected every day the services are running

Performance test Scenario PTS07 / Data Registry protocol / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
1	Verify	Ensure that the data registry protocol principles and mechanisms are applied.	PASS	As above
2	Verify	Ensure that the actual data transfer to the platform through the given API is successful.	PASS	As above

Table 26: Performance Test Scenario PTS08 - Linköping pilot site

Performance test Scenario PTS08 / TLA service and prioritization delays / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Verify	Ensure that TLA (traffic light assistance) service is computed and delivered with a delay lower than 3 seconds.	NA	Linköping Pilot site is not utilizing any traffic light assistance intelligence

Performance test Scenario PTS08 / TLA service and prioritization delays / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
1	Verify	Ensure that prioritization is computed and granted with a delay lower than 3 seconds.	NA	As above

Table 27: Communication Test Scenario CTS01 - Linköping pilot site

Communication Test Scenario CTS01 / Fleet to cloud data transfer, notifications, tele-operation commands and VoIP transfer / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Perform an exchange of vehicle/trip static data and close real time data / trip data.	PASS	Using OEM cloud API
1	Verify	The exchange of data shall be enabled via data APIs (MQTT or HTTPs) and it achieves a specific latency of completeness.	PASS	Using OEM cloud API

Communication Test Scenario CTS01 / Fleet to cloud data transfer, notifications, tele-operation commands and VoIP transfer / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
2	Verify	Ensure that fleet members are able to receive fleet missions / operational notifications.	PASS	We can communicate with the safety drivers but not with the vehicles themselves
3	Verify	Ensure that fleet members are able to receive data / voice / image (tele-operation commands).	NA	We have not planned tele operation

Table 28: Communication Test Scenario CTS02 - Linköping pilot site

Communication Test Scenario CTS02 / LFMP integration with external data providers / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Perform a data exchange between LFMP and an external data provider (e.g. PT backend, TMC, smart city backend…)	NA	We have no external third party

Communication Test Scenario CTS02 / LFMP integration with external data providers / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
1	Verify	Ensure that the data exchange is supported via standardized APIs and it achieves a specific latency of completeness.	PASS	We support the standards put forward by the SHOW DMP
2	Verify	Ensure that the communication is done via standardized interfaces.	PASS	As above

Table 29: Communication Test Scenario CTS03 - Linköping pilot site

Communication Test Scenario CTS03 / 3r party systems communication / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Establish a connection between the SHOW Dashboard and a 3rd party system residing on test site.	PASS	This is done through the RISE database and data management system. Manage connection to SHOW DMP as well as internal dashboard
1	Verify	Ensure that the connection is done via API interfaces (MQTT and REST)	PASS	MQTT connection to the SDMP has been successfully tested

Communication Test Scenario CTS03 / 3r party systems communication / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
		and it achieves a specific latency of completeness.		

Table 30: Communication Test Scenario CTS04 - Linköping pilot site

Communication Test Scenario CTS04 / V2X standard compliance / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Verify	Each involved partner that operates V2X devices shall report and share in detail all the relative implemented V2X protocols and the corresponding standards versions. For example, "ETSI EN 302 637-2 V1.4.1" for Cooperative Awareness Basic service.	NA	Linköping Pilot site is not utilizing V2X system and its intelligence
1	Action	Devices under testing (OBUs, RSUs) shall be able to trigger the generation of all used V2X messages (CAM, DENM, MAPEM, SPATEM, CPM, …) upon external request.	NA	As above
2	Action	Each device generates, encodes and transmits every message that is responsible for, in a real UC scenario. The tests should be performed with a series of consequent messages of the same kind. For example, generation	NA	As above

Communication Test Scenario CTS04 / V2X standard compliance / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
		and transmission of CAM messages only. This step shall be a repetitive process for each used V2X message ID.		
3	Verify	Every device that is a common receiver of the messages sent in step 2, verifies the reception and correct decoding of the sent messages.	NA	As above

Table 31: Communication Test Scenario CTS05 - Linköping pilot site

Communication test Scenario CTS05 / V2X implemented services / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Each involved partner that implements a V2X based service, shall report the availability of such a service and describe the necessary steps for evaluation.	NA	Linköping Pilot site is not utilizing V2X system and its intelligence
1	Action	Each implemented service shall be tested for correct operation. The actual required steps for each service depend heavily upon the nature of the tested service and the required actors. For example, a traffic light prioritization	NA	As above

Communication test Scenario CTS05 / V2X implemented services / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
		service requires a smart traffic light that implements the service and vehicles that will receive or not traffic prioritization benefits.		
2	Verify	Correct operation of each implemented service should be verified in analytical steps accordingly.	NA	As above

Table 32: Communication Test Scenario CTS06 - Linköping pilot site

Communication test Scenario CTS06 / GNSS and cellular network coverage / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Initially the itinerary of the AVs on the pilot sites shall be identified and planned	PASS	Available in confidential AV OEM site assessment report and Site Acceptance Test from the STA
1	Action	For the evaluation of the GNSS, the enhanced positioning service and the cellular network coverage on site, any device or a combination of devices utilizing these services may be used. Preferably the on-board device that offers the positioning service of the AV and the	PASS	Available in confidential AV OEM site assessment report, site description report. A dry test run is always carried out before our service starts.

Communication test Scenario CTS06 / GNSS and cellular network coverage / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
		one with the higher demands of the cellular network coverage (bandwidth and latency wise) should be used (for example the tele-operation device on the vehicle side). The AV should follow the itinerary route on a test run, while the selected test devices are operating.		
2	Action	In case a positioning enhancement service is being implemented and utilized by some or all positioning devices it should operate normally during testing.	PASS	Available in confidential AV OEM site assessment report, site description report and vehicle manual document. A dry test run is always carried out before our service starts showing the reliance and status of the enhanced positioning quality.
3	Action	The positioning device (plain GNSS and/or utilizing positioning enhancement services) constantly logs and/or transmits the positioning solution obtained throughout the whole selected route.	PASS	Available in confidential AV OEM site description report and vehicle manual document.
4	Verify	The positioning solutions are evaluated against the real position of the vehicle at the time of generation. Possible “blind” or poor positioning performance spots	PASS	Available in confidential AV OEM site assessment report, site description report. A dry test run is always carried out before our service starts. OEMs support service are also available if needed.

Communication test Scenario CTS06 / GNSS and cellular network coverage / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
		during the course of the AV should be identified.		
5	Action	The identified device with the higher cellular network demands (throughput, latency) operates continuously throughout the selected route.	PASS	Available in confidential AV OEM site assessment report and commissioning acceptance report
6	Verify	Successful operation is evaluated with respect to cellular network coverage, offered bandwidth and latency requirements.	PASS	Available in confidential AV OEM site assessment report and commissioning acceptance report. A dry test run is always carried out before our service starts

Table 33: Communication Test Scenario CTS07 - Linköping pilot site

Communication test Scenario CTS07 / TMC connection and standard compliance / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	A vehicle is approaching a signalised intersection.	NA	Linköping Pilot site is not utilizing RSU and TMC units
1	Action	The vehicle sends a CAM message to the RSU to ask the priority to cross the intersection.		
2	Verify	RSU receives the CAM message.		
3	Action	RSU generates a SREM with the priority request, and it forwards the request to the TMC (traffic management center).		
4	Verify	TMC receives the SREM message.		
5	Action	TMC checks the right of the vehicle and decides whether it has the adequate permission to ask priority.		
6	Action	TMC generates SSEM message and sends it to the RSU.		

Communication test Scenario CTS07 / TMC connection and standard compliance / Iteration 1-5				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
7	Verify	RSU receives the SSEM with information about granted priority, within 3 seconds from the generation of the SREM message.		
8	Verify	If priority is granted, vehicle passes with green right at the intersection.		

Table 34: Cybersecurity - Linköping pilot site

Cybersecurity Risk ID	**Mitigation action deployed**	**Comments**
1 Unused Services and Open Ports (Servers)	Only active ports are opened in the firewall	
2 Unpatched Services (Servers)	We monitor patch releases regularly and do security patch updates at least once a month	
3 Inattentive Administration (Servers)	Properly skilled project members are more or less daily working on the servers and monitoring the services	We have automated function that sends out alerts if services are compromised
4 DoS/DdoS CVE exploitation MitM Drive-by	Back-end services are behind a firewall with a white list of authorised computers. Public web services are	

Cybersecurity Risk ID	Mitigation action deployed	Comments
Password attack (Servers)	running in restricted environment on well tested server SW like Windows IIS	
5 Spyware (Servers)	No anti-spyware deployed	Only authorized personnel can install any SW on the servers. Very low risk of accidental installation of spyware
6 Ransomware (Servers)	Daily snap shots are taken on all critical services	Only authorized personnel can install any SW on the servers. Very low risk of accidental installation of spyware
7 Unauthorized access (Servers)	We have a FW and white listing of authorized computers for back-end access	
8 Unauthorized network scanning	We have firewall deployed	We are running the FWs intrusion detection SW that send alerts on intrusion detection
9 Non-invasive Attacks (Vehicle Related Threats)	During the pilot a safety driver is on board. Limited number of people allowed access to vehicle or allowed maintenance	Physical access to the systems is close to impossible without being noticed by safety driver. Parked in locked garage overnight
10 Side Channel Attacks (Vehicle Related Threats)	Use of secure coding standards	No wireless packages transmitted from vehicle to external entities that could harm the operation
11 Code Modification (Vehicle Related Threats)	Use of secure coding standards	OEM report

Cybersecurity Risk ID	Mitigation action deployed	Comments
12 Code Injection (Vehicle Related Threats)	Vehicles operate in a local secure network with limited access	OEM report
13 Packet Sniffing (Vehicle Related Threats)	We use daily new authentication token to retrieve API data from OEMs	No wireless packages transmitted from vehicle to external entities that could harm the operation
14 Packet Fuzzing (Vehicle Related Threats)	Use of secure coding standards	In case of malicious message, the system won't behave as expected and safety driver will take over
15 In vehicle spoofing (Vehicle Related Threats)	Safety driver is always on board. Limited number of people allowed access to vehicle or allowed maintenance	Sanity checks and code changes/upgrades are verified before testing cases are executed. In case the system won't behave as expected and safety driver will take over
16 GPS spoofing (Vehicle Related Threats)	Vehicles utilise GPS only to limited extent	In case of malicious GPS signal, the system won't behave as expected and safety driver will take over
17 Jamming (Vehicle Related Threats)	In case of sensor fail vehicle will perform a safe stop	In case of sensor/communication failure, the vehicle will transition to safe state and safety driver will take over

I.2. Technical verification results of pilot site Sweden – Gothenburg

Table 35: Safety Test Scenario STS01 - Gothenburg pilot site

Test Scenario STS01 / **Lane marking and traffic signs detection /** Iteration 0
Not applicable for NAVYA Shuttle - the technology does not read the lane marking nor detects the traffic signs.

Table 36: Safety Test Scenario STS02 - Gothenburg pilot site

Test Scenario STS02 / **Dynamic and static objects detection**				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0 to 4	Action	Lidar conception and algorithm implementation to make possible for the shuttles to detect dynamic and static objects	PASS	The lidars have been designed and the algorithms have been developed to enable the shuttles to detect dynamic and static objects
4	Verify	The AV is able to detect the dynamic and static objects anticipated to be on the route	PASS	Tests done at each Navya Drive validation
5	Verify	The AV is able to avoid collisions with obstacles that could lead to a dangerous situation	PASS	Test done at each Navya Drive validation

Table 37: Safety Test Scenario STS03 - Gothenburg pilot site

Test Scenario STS03 / Lane keeping and override				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	The AV is driving at constant speed in autonomous mode.	PASS	Tests done at each Navya Drive validation
1	Verify	The AV is not leaving its lane.	PASS	
2	Verify	The driver wishes to perform an override.	PASS	
3	Action	The driver can take back the control of the vehicle.	PASS	
4	Action	The driver activates the autonomous mode again.	PASS	
5	Action	A notification is shown to the driver to take over the control of the vehicle at the end of ODD.	PASS	
6	Action	A notification is shown to the driver to take over the control of the vehicle due to an emergency.	PASS	
7	Verify	The notification is shown with sufficient time for the driver to take the control back.	PASS	

Table 38: Safety Test Scenario STS04 - Gothenburg pilot site

Test Scenario STS04 / Loss of communication from sensors				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	The AV loses communication with its perception sensors.	PASS	Tests done at each Navya Drive validation
1	Verify	The AV performs a safe stop.	PASS	
2	Action	The AV recovers from the loss of communication and continues its route.	PASS	
3	Action	The AV loses communication with the GNSS.	PASS	
4	Verify	The AV performs a safe stop.	PASS	

Table 39: Performance Test Scenario PTS01 - Gothenburg pilot site

Test Scenario STS04 / Loss of communication from sensors				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Perform a stress test in the cloud platform	PASS	Tests done at each Navya Drive validation
1	Verify	Ensure that the data platform supports high volume of traffic with no affect to its performance	PASS	

Table 40: Performance Test Scenario PTS02 - Gothenburg pilot site

Performance test Scenario PTS02 / V2X communication performance
Not applicable: No V2X on the Gothenburg pre-demo site

Table 41: Performance Test Scenario PTS03 - Gothenburg pilot site

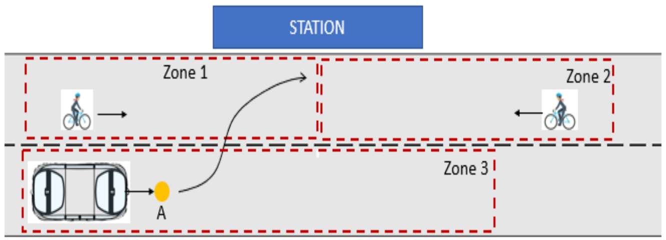
Performance test Scenario PTS03 / GNSS performance				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Every device that incorporates a plain GNSS receiver or enhanced positioning services should be able to store/transmit the obtained positioning solution (including the timestamp with millisecond resolution).	PASS	GNSS positioning is available through API - 1Hz
1	Action	In case a positioning enhancement service is being implemented and utilized by some or all positioning devices it should operate normally during testing.	PASS	Tests done at each Navya Drive validation
3	Verify	The obtained positioning solutions are evaluated against the real position of the device at the time of generation. The mean solution's accuracy should be less than 5 m.	PASS	Tests done at each Navya Drive validation
4	Verify	The obtained positioning solutions are evaluated against the real position of the device at the time of generation. The mean solution's accuracy should be less than 1 m.	PASS	
5	Verify	Check directly on Gothenburg that the GNSS Signal must be "Good" or "Medium"	PASS	

Table 42: Performance Test Scenario PTS04 - Gothenburg pilot site

Performance test Scenario PTS04 / Speed adaptation				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Verify	Verify with the FAV's OEM, integrator, or constructor which technology is chosen for speed adaptation: -Predefined speed zone in path And / or -Adaptive Cruise Control and traffic sign reading -Other...	PASS	Predefined speed zone in path and adaptive speed.
1	Verify	If in the pre-defined speed zone in path, verify that the information is shared with the site authorities during the mapping of the site according to the risk analysis that is done by OEMs (items considered: ODD, traffic density, visibility, localization, etc.).	PASS	Done
2	Verify	Verify that the vehicle can adapt its speed depending on the environment conditions on specific sections on the path, (the ACC shall be tested apart from this requirement).	PASS	Done

Performance test Scenario PTS04 / Speed adaptation				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
3	Action	This will be checked during the deployment on site.	PASS	The shuttle speed was adapted to the driving conditions (road width, priority zone, road users around) of the site.

Table 43: Performance Test Scenario PTS05 - Gothenburg pilot site

Performance test Scenario PTS05 / AV arrival/pick up management				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	The AV is driving to priority node A. There is no obstacle on priority zones 1 and 3. An obstacle moving in the AV's opposite direction (cyclist at V =TBD m/s) enters the priority zone 2 when the AV arrives at node A.	PASS	Test done at each Navya Drive validation 

Performance test Scenario PTS05 / AV arrival/pick up management				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
1	Verify	The AV shall stop.	PASS	Test done at each Navya Drive validation
2	Verify	The AV shall start driving to the station when the bicycle is not on the AV's trajectory anymore.	PASS	Test done at each Navya Drive validation

Table 44: Performance Test Scenario PTS06 - Gothenburg pilot site

Performance test Scenario PTS06 / Service provision				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Two or more OEMs / PTOs involved in the same route.	PASS	This scenario is not applicable for the Gothenburg pre-demo: just one OEM (Navya) was involved
1	Verify	Ensure that the service provision used by the different OEMs / PTOs is the same when the operation transits from the Area of Operator A to the Area of Operator B.	PASS	As above

Table 45: Performance Test Scenario PTS07 - Gothenburg pilot site

Performance test Scenario PTS07 / Data Registry protocol				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Analyze log files produced during a test scenario.	PASS	
1	Verify	Ensure that the data registry protocol principles and mechanisms are applied.	PASS	
2	Verify	Ensure that the actual data transfer to the platform through the given API is successful.	PASS	

Table 46: Performance Test Scenario PTS08 - Gothenburg pilot site

Performance test Scenario PTS08 / TLA service and prioritization delays				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Verify	Ensure that TLA service is computed and delivered with a delay lower than 3 seconds.	PASS	
1	Verify	Ensure that prioritization is computed and granted with a delay lower than 3 seconds.	PASS	

Table 47: Communication Test Scenario CTS01 - Gothenburg pilot site

Communication Test Scenario CTS01 / Fleet to cloud data transfer, notifications, tele-operation commands and VoIP transfer				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Perform an exchange of vehicle/trip static data and close real time data / trip data.	PASS	
1	Verify	The exchange of data shall be enabled via data APIs (MQTT or HTTPs) and it achieves a specific latency of completeness.	PASS	
2	Verify	Ensure that fleet members are able to receive fleet missions / operational notifications.	PASS	

Communication Test Scenario CTS01 / Fleet to cloud data transfer, notifications, tele-operation commands and VoIP transfer				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
3	Verify	Ensure that fleet members are able to receive data / voice / image (tele-operation commands).	PASS	
4	Verify	For Gothenburg: Ensure that data APIs are available and complete for our FMS partner	PASS	

Table 48: Communication Test Scenario CTS02 - Gothenburg pilot site

Communication Test Scenario CTS02 / LFMP integration with external data providers				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Perform a data exchange between LFMP and an external data provider (e.g. PT backend, TMC, smart city backend...)	PASS	
1	Verify	Ensure that the data exchange is supported via standardized APIsand it achieves a specific latency of completeness.	PASS	
2	Verify	Ensure that the communication is done via standardized interfaces.	PASS	

Table 49: Communication Test Scenario CTS03 - Gothenburg pilot site

Communication Test Scenario CTS03 / 3r party systems communication				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Establish a connection between the SHOW Dashboard and a 3rdparty system residing on test site.	PASS	5G antennas installed on the roof of the different shuttles enabled a location in live of the shuttle. However, the shuttle API was not directly connected to the SHOW Dashboard.
1	Verify	Ensure that the connection is done via API interfaces (MQTT and REST)and it achieves a specific latency of completeness.	PASS	

Table 50: Communication Test Scenario CTS04 - Gothenburg pilot site

Communication Test Scenario CTS04 / V2X standard compliance
Not applicable: No V2X on the Gothenburg pre-demo site

Table 51: Communication Test Scenario CTS05 - Gothenburg pilot site

Communication Test Scenario CTS05 / V2X standard compliance
Not applicable: No V2X on the Gothenburg pre-demo site

Table 52: Communication Test Scenario CTS06 - Gothenburg pilot site

Communication test Scenario CTS06 / GNSS and cellular network coverage				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Initially the itinerary of the AVs on the pilot sites shall be identified and planned	PASS	it is prerequisite and normal business for Navya
1	Action	For the evaluation of the GNSS, the enhanced positioning service and the cellular network coverage on site, any device or a combination of devices utilizing these services may be used. Preferably the on-board device that offers the positioning service of the AV and the one with the higher demands of the cellular network coverage (bandwidth and latency wise) should be used (for example the tele-operation device on the vehicle side). The AV should follow the itinerary route on a test run, while the selected test devices are operating. In case a positioning enhancement service is being implemented and utilized by some or all positioning devices it should operate normally during testing.	PASS	it is prerequisite and normal business for Navya during deployment

Communication test Scenario CTS06 / GNSS and cellular network coverage				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
2	Action	The positioning device (plain GNSS and/or utilizing positioning enhancement services) constantly logs and/or transmits the positioning solution obtained throughout the whole selected route.	PASS	
3	Verify	The positioning solutions are evaluated against the real position of the vehicle at the time of generation. Possible “blind” or poor positioning performance spots during the course of the AV should be identified.	PASS	
4	Action	The identified device with the higher cellular network demands (throughput, latency) operates continuously throughout the selected route.	PASS	
5	Verify	Successful operation is evaluated with respect to cellular network coverage, offered bandwidth and latency requirements.	PASS	

Table 53: Communication Test Scenario CTS07 - Gothenburg pilot site

Communication test Scenario CTS07 / TMC connection and standard compliance				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	A vehicle is approaching a signalised intersection		
1	Action	The vehicle sends a CAM message to the RSU to ask the priority to cross the intersection.	PASS	CAM messages are sent by the Navya shuttle to broadcast several information called vehicle ego date such as: vehicle's positioning, heading, type, ID, etc…
2	Verify	RSU receives the CAM message.	NA	Navya shuttle can only read SPAT messages
3	Action	RSU generates a SREM with the priority request, and it forwards the request to the TMC.	NA	Navya shuttle can only read SPAT messages
4	Verify	TMC receives the SREM message	NA	Navya shuttle can only read SPAT messages

Communication test Scenario CTS07 / TMC connection and standard compliance				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
5	Action	TMC checks the right of the vehicle and decides whether it has the adequate permission to ask priority.	NA	Navya shuttle can only read SPAT messages
6	Action	TMC generates SSEM message and sends it to the RSU.	NA	Navya shuttle can only read SPAT messages
7	Verify	RSU receives the SSEM with information about granted priority, within 3 seconds from the generation of the SREM message.	NA	Navya shuttle can only read SPAT messages
8	Verify	If priority is granted, vehicle passes with green light at the intersection	PASS	if SPAT message

Table 54: Cybersecurity reporting - Gothenburg pilot site

Risk Threat Identified		Mitigation actions	
Risk ID	**Description**	**Mitigation action deployed**	**Comments**
1	Unused Services and Open Ports (Servers)	Only active ports are opened in the firewall	Effectively, only active ports are opened in the firewall which is paired to the router.
2	Unpatched Services (Servers)	We monitor patch releases regularly and do security patch updates at least once a month	Depending on the level of criticality we have intelligent supervision. So, we monitor patch releases regularly and do security patch updates at least once a month and after and after each incident.
3	Inattentive Administration (Servers)	Properly skilled project members are more or less daily working on the servers and monitoring the services	We perform real-time log analysis to detect and block the spread of attacks according to ISO 21434 and ANSSI recommendations. We have automated function that sends out alerts logs if services are compromised
4	DoS/DdoS CVE exploitation MitM Drive-by Password attack (Servers)	Back-end services are behind a firewall with a whitelist of authorised computers. Public web services are running in restricted environment on well tested server SW like Windows IIS	We place servers behind a firewall configured to stop inbound SYN packets.

Risk Threat Identified		Mitigation actions	
Risk ID	**Description**	**Mitigation action deployed**	**Comments**
5	Spyware (Servers)	We increase the size of the connection queue and decrease the timeout on open connections.	
6	Ransomware (Servers)	An anti-spyware is deployed	We perform audits regularly and whenever necessary to ensure that our anti-spyware is enabled and configured correctly. In addition, only authorized personnel can install any SW on the servers. Very low risk of accidental installation of spyware.
7	Unauthorized access (Servers)	Daily snap shots are taken on all critical services	We perform audits regularly and whenever necessary to ensure that our backup system is enabled and configured correctly. In addition, only authorized personnel can access and/or manage our backup system on the servers. The risk is therefore very low of losing our data after a possible Ransomware
8	Unauthorized network scanning	We have a FW and white listing of authorized computers for back-end access	We have a robust access process (FW + White & Blacklisting) according to ISO27001 and ISO21434 standards
9	Non-invasive Attacks (Vehicle Related Threats)	We have firewall deployed	We are running the FWs intrusion detection SW that send alerts on intrusion detection

Risk Threat Identified		Mitigation actions	
Risk ID	**Description**	**Mitigation action deployed**	**Comments**
10	Side Channel Attacks (Vehicle Related Threats)	During the pilot a safety driver is on board. Limited number of people allowed access to vehicle or allowed maintenance	Physical access to the systems is close to impossible without being noticed by safety driver. Parked in locked garage overnight
11	Code Modification (Vehicle Related Threats)	Use of secure coding standards	No wireless packages transmitted from vehicle to external entities that could harm the operation
12	Code Injection (Vehicle Related Threats)	Use of secure coding standards	OEM report according to ISO27001 and ISO21434 standards
13	Packet Sniffing (Vehicle Related Threats)	Vehicles operate in a local secure network with limited access	OEM report according to ISO27001 and ISO21434 standards
14	Packet Fuzzing (Vehicle Related Threats)	We use daily new authentication token to retrieve API data from OEMs	We use strong authentication via VPN to retrieve API data from OEMs. In effect, there is no wireless packages transmitted from vehicle to external entities that could harm the operation
15	In vehicle spoofing (Vehicle Related Threats)	Use of secure coding standards	We use a system for detecting misbehaviour of Cyber codes (secure coding standards). So, in case of malicious message, the system won't behave as expected and safety driver will take over

Risk Threat Identified		Mitigation actions	
Risk ID	**Description**	**Mitigation action deployed**	**Comments**
16	GPS spoofing (Vehicle Related Threats)	Safety driver is always on board. Limited number of people allowed access to vehicle or allowed maintenance	Sanity checks and code changes/upgrades are verified before testing cases are executed. In case the system won't behave as expected and safety driver will take over
17	Jamming (Vehicle Related Threats)	Vehicles utilise GPS only to limited extent	We have a sensor synchronization and GPS signal verification system. So, in case of malicious GPS signal, the system won't behave as expected and safety driver will take over

I.3. Technical verification results of pilot site Finland – Tampere

Table 55: Safety Test Scenario STS01 - Tampere pilot site

Safety Test Scenario STS01 / **Lane marking and traffic signs detection /** Iteration 0	Vehicle can operate without lane markings and without additional maintenance of vegetation.

Table 56: Safety Test Scenario STS02 - Tampere pilot site

Safety Test Scenario STS02 / **Dynamic and static objects detection** / Iteration 10				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Ensure that there are no obstacles around the route, including intersections with incoming traffic, that are not part of the test.	PASS	
1	Action	Ensure that there are no static and dynamic obstacles that are not anticipated to be on the route.	PASS	
2	Action	Attend to the vegetation maintenance on the side road and cleaning of the road.	NA	The vehicle operations do not require road markings or vegetation trimming.
3	Action	Ensure that all the parked cars are correctly parked and have pre-defined parking lot zones	PASS	Vehicles in the area have been parked to adequate safety level. The vehicle can safely operate even when vehicles are parked outside of pre-defined parking zones.
4	Verify	The AV is able to detect the dynamic and static objects anticipated to be on the route.	PASS	
5	Verify	The AV is able to avoid collisions with obstacles that could lead to a dangerous situation.	PASS	

Table 57: Safety Test Scenario STS03 - Tampere pilot site

Safety Test Scenario STS03 / **Lane keeping and override** / Iteration 10				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Verify	The AV is driving at constant speed in autonomous mode.	PASS	Vehicles have been in extensive operation in Norway over the year of 2021.
1	Action	The AV is not leaving its lane.	PASS	
2	Action	The driver wishes to perform an override.	PASS	
3	Verify	The driver can take back the control of the vehicle.	PASS	Hand-over verified over daily tests at test track and in operations.
4	Action	The driver activates the autonomous mode again.	PASS	
5	Action	A notification is shown to the driver to take over the control of the vehicle at the end of ODD.	PASS	At the end of route vehicle either continues to repeat route or returns safely the control to driver.
6	Action	A notification is shown to the driver to take over the control of the vehicle due to an emergency.	PASS	Process described in D7.2 [4].

Safety Test Scenario STS03 / **Lane keeping and override** / Iteration 10				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
7	Action	The notification is shown with sufficient time for the driver to take the control back.	PASS	

Table 58: Safety Test Scenario STS04 - Tampere pilot site

Safety Test Scenario STS04 / Loss of communication from sensors / Iteration X				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	The AV loses communication with its perception sensors.	PASS	Vehicle will stop if the autonomous driving software does not get the signals it needs from the sensors for driving.
1	Verify	The AV performs a safe stop.	PASS	
2	Action	The AV recovers from the loss of communication and continues its route.	PASS	Safety driver input is required

Safety Test Scenario STS04 / Loss of communication from sensors / Iteration X				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
3	Action	The AV loses communication with the GNSS.	PASS	GNSS failure does not affect vehicle operation.
4	Verify	The AV performs a safe stop.	PASS	

Table 59: Performance Test Scenario PTS01 - Tampere pilot site

Performance test Scenario PTS01 / Cloud platform storage / Iteration 10				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Perform a stress test in the cloud platform.	PASS	Server load stress tested and verified over fleet operations in Norway as part of ongoing client project.
1	Verify	Ensure that the data platform supports high volume of traffic with no affect to its performance.	PASS	SHOW pilot level traffic can be handled.

Table 60: Performance Test Scenario PTS02 - Tampere pilot site

Performance test Scenario PTS02 / V2X communication performance	No V2X implemented on the pilot site

Table 61: Performance Test Scenario PTS03 - Tampere pilot site

Performance test Scenario PTS03 / GNSS performance / Iteration 10				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Every device that incorporates a plain GNSS receiver or enhanced positioning services should be able to store/transmit the obtained positioning solution (including the timestamp with millisecond resolution). GNSS receiver or enhanced positioning services should be able to store/transmit the obtained positioning solution (including the timestamp with millisecond resolution).	PASS	Infrastructure requirement not tested, vehicle GNSS operating within parameters.
1	Action	In case a positioning enhancement service is being implemented and utilized by some or all positioning devices it should operate normally during testing.	PASS	

Performance test Scenario PTS03 / GNSS performance / Iteration 10				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
2	Verify	The obtained positioning solutions are evaluated against the real position of the device at the time of generation. The mean solution's accuracy should be less than 5 m.	PASS	
3	Verify	The obtained positioning solutions are evaluated against the real position of the device at the time of generation. The mean solution's accuracy should be less than 1 m.	PASS	

Table 62: Performance Test Scenario PTS04 - Tampere pilot site

Performance test Scenario PTS04 / Speed adaptation / Iteration 10				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Verify	Verify with the FAV's OEM, integrator, or constructor which technology is chosen for speed adaptation: - Predefined speed zone in path And / or - Adaptive Cruise Control and traffic sign reading - Other...	PASS	Predefined speed zone in path
1	Verify	If in the pre-defined speed zone in path, verify that the information is shared with the site authorities during the mapping of the site according to the risk analysis that is done by OEMs (items considered: ODD, traffic density, visibility, localization, etc.).	PASS	
2	Verify	Verify that the vehicle can adapt its speed depending on the environment conditions on specific sections on the path, (the ACC shall be tested apart from this requirement).	PASS	
3	Action	This will be checked during the deployment on site.	PASS	Vehicle operates at set speed

Table 63: Performance Test Scenario - Tampere pilot site

Performance test Scenario PTS05 / AV arrival/pick up management / Iteration 10				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	The AV is driving to priority node A. There is no obstacle on priority zones 1 and 3. An obstacle moving in the AV's opposite direction (cyclist at V = TBD m/s) enters the priority zone 2 when the AV arrives at node A.	PASS	
1	Verify	The AV shall stop.	PASS	
2	Verify	The AV shall start driving to the station when the bicycle is not on the AV's trajectory anymore.	PASS	

Table 64: Performance Test Scenario PTS06 - Tampere pilot site

Performance test Scenario PTS06 / Service provision	Tampere site handles one OEM (and PTO) at a time for now.

Table 65: Performance Test Scenario PTS07 - Tampere pilot site

Performance test Scenario PTS07 / Data Registry protocol / Iteration 10				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Analyse log files produced during a test scenario.	PASS	
1	Verify	Ensure that the data registry protocol principles and mechanisms are applied.	PASS	
2	Verify	Ensure that the actual data transfer to the platform through the given API is successful.	PARTLY PASS	Verified in test surrounding. To be verified on location.

Table 66: Performance Test Scenario PTS08 - Tampere pilot site

Performance test Scenario PTS08 / TLA service and prioritization delays	Tampere site will not have TLA implemented.

Table 67: Communication Test Scenario CTS01 - Tampere pilot site

Communication Test Scenario CTS01 / Fleet to cloud data transfer, notifications, tele-operation commands and VoIP transfer / Iteration 10				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Perform an exchange of vehicle/trip static data and close real time data / trip data.	PASS	
1	Verify	The exchange of data shall be enabled via data APIs (MQTT or HTTPs) and it achieves a specific latency of completeness.	PASS	
2	Verify	Ensure that fleet members are able to receive fleet missions / operational notifications.	PASS	Safety operator on board
3	Verify	Ensure that fleet members are able to receive data / voice / image (tele-operation commands).	PASS	Safety operator on board

Table 68: Communication Test Scenario CTS02 - Tampere pilot site

Communication Test Scenario CTS02 / LFMP integration with external data providers / Iteration 10				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Perform a data exchange between LFMP and an external data provider (e.g. PT backend, TMC, smart city backend...)	PASS	
1	Verify	Ensure that the data exchange is supported via standardized APIs and it achieves a specific latency of completeness.	PASS	
2	Verify	Ensure that the communication is done via standardized interfaces.	PASS	

Table 69: Communication Test Scenario CTS03 - Tampere pilot site

Communication Test Scenario CTS03 / 3rd party systems communication / Iteration 10				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Establish a connection between the SHOW Dashboard and a 3rd party system residing on test site.	PASS	
1	Verify	Ensure that the connection is done via API interfaces (MQTT and REST) and it achieves a specific latency of completeness.	PASS	Where applicable, 3rd party connections to SHOW dashboard are handled via LFMP

Table 70: Communication Test Scenario CTS04 - Tampere pilot site

Communication Test Scenario CTS04 / V2X standard compliance / Iteration X ==> No V2X implemented on the pilot site				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**

Table 71: Communication Test Scenario CTS05 - Tampere pilot site

Communication test Scenario CTS05 / V2X implemented services	Tampere site has only OEM-internal V2X communications to LFMP tested above.

Table 72: Communication Test Scenario CTS06 - Tampere pilot site

Communication test Scenario CTS06 / GNSS and cellular network coverage / Iteration 10				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
0	Action	Initially the itinerary of the AVs on the pilot sites shall be identified and planned	PASS	
1	Action	For the evaluation of the GNSS, the enhanced positioning service and the cellular network coverage on site, any device or a combination of devices utilizing these services may be used. Preferably the on-board device that offers the positioning service of the AV and the one with the higher demands of the cellular network coverage (bandwidth and latency wise) should be used (for example the tele-operation device on the vehicle side). The AV should follow the itinerary route on a test run, while the selected test devices are operating.	PASS	

Communication test Scenario CTS06 / GNSS and cellular network coverage / Iteration 10				
Step	**Type**	**Description**	**PASS/ NOT PASS/ PARTLY PASS**	**Comments**
2	Action	In case a positioning enhancement service is being implemented and utilized by some or all positioning devices it should operate normally during testing.	PASS	Sensor fusion of the vehicle operating to parameters.
3	Verify	The positioning device (plain GNSS and/or utilizing positioning enhancement services) constantly logs and/or transmits the positioning solution obtained throughout the whole selected route.	PASS	
4	Action	The positioning solutions are evaluated against the real position of the vehicle at the time of generation. Possible “blind” or poor positioning performance spots during the course of the AV should be identified.	PASS	
5	Action	The identified device with the higher cellular network demands (throughput, latency) operates continuously throughout the selected route.	PASS	
6	Verify	Successful operation is evaluated with respect to cellular network coverage, offered bandwidth and latency requirements.	PASS	

Table 73:. Communication Test Scenario CTS07 - Tampere pilot site

Communication test Scenario CTS07 / TMC connection and standard compliance	TMC operations not utilised in Tampere pilot.

Table 74: Cybersecurity reporting - Tampere pilot site

Risk Threat Identified		**Mitigation actions**	
Risk ID	**Description**	**Mitigation action deployed**	**Comments**
1	Unused Services and Open Ports (Servers)	No unused ports left open. Utilisation of VPN.	
2	Unpatched Services (Servers)	Servers patched and up to date with latest security updates.	
3	Inattentive Administration (Servers)	Automate maintenance. Up to date security. Minimise threat vectors.	
4	DoS/DdoS CVE exploitation MitM Drive-by Password attack (Servers)	Vehicles can operate independently. Safety driver on board, as required by the setup and law.	No mitigation action deployed as no operational service is deployed and safety driver is always present in the TNO-C vehicle.

Risk Threat Identified		Mitigation actions	
Risk ID	**Description**	**Mitigation action deployed**	**Comments**
5	Spyware (Servers)	Regular checks are run against malicious code. Utilisation of safety measures and VPN.	
6	Ransomware (Servers)	Regular checks are run against malicious code. Utilisation of safety measures and VPN.	
7	Unauthorized access (Servers)	Access management and limited access.	
8	Unauthorized network scanning	Utilisation of VPN.	Physical access to the systems is close to impossible without being noticed by safety driver
9	Non-invasive Attacks (Vehicle Related Threats)	During the pilot a safety driver is on board. Limited number of people allowed access to vehicle or allowed maintenance.	Physical access to the systems is close to impossible without being noticed by safety driver
10	Side Channel Attacks (Vehicle Related Threats)	Use of secure coding standards	No wireless packages transmitted from vehicle to external entities that could harm the operation

Risk Threat Identified		Mitigation actions	
Risk ID	**Description**	**Mitigation action deployed**	**Comments**
11	Code Modification (Vehicle Related Threats)	Use of secure coding standards	
12	Code Injection (Vehicle Related Threats)	Vehicles operate in a secure network with limited access.	
13	Packet Sniffing (Vehicle Related Threats)	Use of secure coding standards	No wireless packages transmitted from vehicle to external entities that could harm the operation
14	Packet Fuzzing (Vehicle Related Threats)	Use of secure coding standards	In case of malicious message, the system won't behave as expected and safety driver will take over
15	In vehicle spoofing (Vehicle Related Threats)	During the pilot a safety driver is on board. Limited number of people allowed access to vehicle or allowed maintenance.	Sanity checks and code changes are verified before testing cases are executed. In case the system won't behave as expected and safety driver will take over
16	GPS spoofing (Vehicle Related Threats)	Vehicles utilise GPS only to limited extent.	In case of malicious GPS signal, the system won't behave as expected and safety driver will take over

Risk Threat Identified		Mitigation actions	
Risk ID	**Description**	**Mitigation action deployed**	**Comments**
17	Jamming (Vehicle Related Threats)	In case of sensor fail vehicle will perform a safe stop.	In case of sensor/communication failure, the vehicle will transition to safe state and safety driver will take over

I.4. Technical verification results of pilot site The Netherlands – Brainport

Table 75: Test cases of pilot site The Netherlands – Brainport

Test Case	Repetition	Pass/No Pass/Partly pass	Remark
STS01	6	PASS	Setting up the scenario every test day
STS02	30	PASS	Test case is continuously monitored while driving tests cases in the verification and validation process.
STS03	4	PASS	Performed outside SHOW project in the process of retrofitting the vehicles. Verified and validated by TNO as well as external party.
STS04	2	PASS	Performed outside SHOW project in the process of retrofitting the vehicles. Verified and validated by TNO as well as external party.
CTS04	2	PASS	Vehicle complies by design to ETSI standards
CTS06	6	PASS	Several test days confirmed & tested
PTS07	4	PASS	Several data uploads have been carried out, still ongoing

Table 76: Technical verification reporting of pilot site The Netherlands – Brainport

Scenario_ID	Step	Type	Description	Requirement	Requirement in Selected SubSet	PASS/NOT PASS/ PARTLY PASS	Comment/Justification
STS01	2	Action	Improve longitudinal pavement markings at intersections (if applicable).	SHOW_01_003	SHOW_01_003, SHOW_01_004	All Applicable PASS	
STS01	4	Verify	Ensure that the AV is able to detect properly all the lane and pavement marks.	SHOW_01_001, SHOW_01_002, SHOW_01_003, SHOW_01_004	SHOW_01_003, SHOW_01_004	All Applicable PASS	
STS02	0	Action	Ensure that there are no obstacles around the route, including intersections with incoming traffic, that are not part of the test.	SHOW_01_007	SHOW_01_007, SHOW_01_008, SHOW_01_009	All PASS	

Scenario_ID	Step	Type	Description	Requirement	Requirement in Selected SubSet	PASS/NOT PASS/ PARTLY PASS	Comment/Justification
STS02	1	Action	Ensure that there are no static and dynamic obstacles that are not anticipated to be on the route.	SHOW_01_007	SHOW_01_007, SHOW_01_008, SHOW_01_009	All PASS	
STS02	2	Action	Attend to the vegetation maintenance on the side road and cleaning of the road.	SHOW_01_007	SHOW_01_007, SHOW_01_008, SHOW_01_009	All PASS	
STS02	3	Action	Ensure that all the parked cars are correctly parked and have pre-defined parking lot zones	SHOW_01_008	SHOW_01_007, SHOW_01_008, SHOW_01_009	All PASS	
STS02	4	Verify	The AV is able to detect the dynamic and static objects anticipated to be on the route.	SHOW_01_007, SHOW_01_008	SHOW_01_007, SHOW_01_008, SHOW_01_009	All PASS	

Scenario_ID	Step	Type	Description	Requirement	Requirement in Selected SubSet	PASS/NOT PASS/ PARTLY PASS	Comment/Justification
STS02	5	Verify	The AV is able to avoid collisions with obstacles that could lead to a dangerous situation.	SHOW_01_009	SHOW_01_007, SHOW_01_008, SHOW_01_009	All PASS	
STS03	0	Action	The AV is driving at constant speed in autonomous mode.	SHOW_01_010	SHOW_01_010, SHOW_01_011, SHOW_01_012, SHOW_01_013	All PASS	
STS03	1	Verify	The AV is not leaving its lane.	SHOW_01_010	SHOW_01_010, SHOW_01_011, SHOW_01_012, SHOW_01_013	All PASS	
STS03	2	Action	The driver wishes to perform an override.	SHOW_01_011	SHOW_01_010, SHOW_01_011, SHOW_01_012, SHOW_01_013	All PASS	
STS03	3	Verify	The driver can take back the control of the vehicle.	SHOW_01_011	SHOW_01_010, SHOW_01_011, SHOW_01_012, SHOW_01_013	All PASS	

Scenario_ID	Step	Type	Description	Requirement	Requirement in Selected SubSet	PASS/NOT PASS/ PARTLY PASS	Comment/Justification
STS03	4	Action	The driver activates the autonomous mode again.		SHOW_01_010, SHOW_01_011, SHOW_01_012, SHOW_01_013	All PASS	
STS03	5	Action	A notification is shown to the driver to take over the control of the vehicle at the end of ODD.	SHOW_01_012	SHOW_01_010, SHOW_01_011, SHOW_01_012, SHOW_01_013	All PASS	
STS03	6	Action	A notification is shown to the driver to take over the control of the vehicle due to an emergency.	SHOW_01_013	SHOW_01_010, SHOW_01_011, SHOW_01_012, SHOW_01_013	All PASS	
STS03	7	Verify	The notification is shown with sufficient time for the driver to take the control back.	SHOW_01_012, SHOW_01_013	SHOW_01_010, SHOW_01_011, SHOW_01_012, SHOW_01_013	All PASS	

Scenario_ID	Step	Type	Description	Requirement	Requirement in Selected SubSet	PASS/NOT PASS/ PARTLY PASS	Comment/Justification
STS04	0	Action	The AV loses communication with its perception sensors.	SHOW_01_014	SHOW_01_014, SHOW_01_015	All PASS	
STS04	1	Verify	The AV performs a safe stop.	SHOW_01_014	SHOW_01_014, SHOW_01_015	All PASS	
STS04	2	Action	The AV recovers from the loss of communication and continues its route.		SHOW_01_014, SHOW_01_015	All PASS	
STS04	3	Action	The AV loses communication with the GNSS.	SHOW_01_015	SHOW_01_014, SHOW_01_015	All PASS	
STS04	4	Verify	The AV performs a safe stop.	SHOW_01_015	SHOW_01_014, SHOW_01_015	All PASS	
CTS04	0	Verify	Each involved partner that operates V2X devices shall report and share in detail all the relative	SHOW_03_008 SHOW_03_009	SHOW_03_008	All Applicable PASS	

Scenario_ID	Step	Type	Description	Requirement	Requirement in Selected SubSet	PASS/NOT PASS/ PARTLY PASS	Comment/Justification
			implemented V2X protocols and the corresponding standards versions. For example, “ETSI EN 302 637-2 V1.4.1” for Cooperative Awareness Basic service.				
CTS04	1	Action	Devices under testing (OBUs, RSUs) shall be able to trigger the generation of all used V2X messages (CAM, DENM, MAPEM, SPATEM, CPM, …) upon external request.		SHOW_03_008	All Applicable PASS	

Scenario_ID	Step	Type	Description	Requirement	Requirement in Selected SubSet	PASS/NOT PASS/ PARTLY PASS	Comment/Justification
CTS04	2	Action	Each device generates, encodes and transmits every message that is responsible for, in a real UC scenario. The tests should be performed with a series of consequent messages of the same kind. For example, generation and transmission of CAM messages only. This step shall be a repetitive process for each used V2X message ID.	SHOW_03_008 SHOW_03_009	SHOW_03_008	All Applicable PASS	
CTS04	3	Verify	Every device that is a common receiver of the messages sent in step 2, verifies the	SHOW_03_008 SHOW_03_009	SHOW_03_008	All Applicable PASS	

Scenario_ID	Step	Type	Description	Requirement	Requirement in Selected SubSet	PASS/NOT PASS/ PARTLY PASS	Comment/Justification
			reception and correct decoding of the sent messages.				
CTS06	0	Action	Initially the itinerary of the AVs on the pilot sites shall be identified and planned	SHOW_03_011, SHOW_03_012, SHOW_03_013, SHOW_03_014	SHOW_03_011, SHOW_03_013	All Applicable PASS	
CTS06	1	Action	For the evaluation of the GNSS, the enhanced positioning service and the cellular network coverage on site, any device or a combination of devices utilizing these services may be used. Preferably the on-board device that offers the positioning service	SHOW_03_011, SHOW_03_012, SHOW_03_013, SHOW_03_014	SHOW_03_011, SHOW_03_013	All Applicable PASS	

Scenario_ID	Step	Type	Description	Requirement	Requirement in Selected SubSet	PASS/NOT PASS/ PARTLY PASS	Comment/Justification
			of the AV and the one with the higher demands of the cellular network coverage (bandwidth and latency wise) should be used (for example the tele-operation device on the vehicle side). The AV should follow the itinerary route on a test run, while the selected test devices are operating.				
CTS06	2	Action	The positioning device (plain GNSS and/or utilizing positioning enhancement services) constantly logs and/or transmits the positioning solution obtained throughout	SHOW_03_011, SHOW_03_012	SHOW_03_011, SHOW_03_013	All Applicable PASS	

Scenario_ID	Step	Type	Description	Requirement	Requirement in Selected SubSet	PASS/NOT PASS/ PARTLY PASS	Comment/Justification
			the whole selected route.				
CTS06	3	Verify	The positioning solutions are evaluated against the real position of the vehicle at the time of generation. Possible "blind" or poor positioning performance spots during the course of the AV should be identified.	SHOW_03_011, SHOW_03_012	SHOW_03_011, SHOW_03_013	All Applicable PASS	
PTS07	0	Action	Analyze log files produced during a test scenario.	SHOW_02_009	SHOW_02_009	All PASS	
PTS07	1	Verify	Ensure that the data registry protocol principles and mechanisms are applied.	SHOW_02_009	SHOW_02_009	All PASS	

Scenario_ID	Step	Type	Description	Requirement	Requirement in Selected SubSet	PASS/NOT PASS/ PARTLY PASS	Comment/Justification
PTS07	2	Verify	Ensure that the actual data transfer to the platform through the given API is successful.	SHOW_02_009	SHOW_02_009	All PASS	

Table 77: Cybersecurity reporting of pilot site The Netherlands – Brainport

Risk Threat Identified		Possible Mitigation actions, see D11.1 Section 6.4.1					
Risk ID	**Description**	**Likelihood**	**Impact**	**Exposure Level**	**Impact description**	**Mitigation action deployed**	**Comments**
1	Unused Services and Open Ports (Servers)	Medium	Critical	Medium	An attacker can exploit misconfigured services.	NA	No mitigation action deployed as no operational service is deployed (for now) and safety driver is always present in the TNO-C vehicle.
2	Unpatched Services (Servers)	Medium	Marginal	Medium	An attacker can exploit known or	NA	As above

Risk Threat Identified		Possible Mitigation actions, see D11.1 Section 6.4.1					
Risk ID	**Description**	**Likelihood**	**Impact**	**Exposure Level**	**Impact description**	**Mitigation action deployed**	**Comments**
					undiscovered software vulnerabilities.		
3	Inattentive Administration (Servers)	Medium	Marginal	Medium	Often untrained and inexperienced administrators have the duty to maintain security in the system.	NA	As above
4	DoS/DdoS CVE exploitation MitM Drive-by Password attack (Servers)	High	Uncontrollable	High	An attacker makes a network unavailable by overloading the system with numerous and large requests.	NA	As above
5	Spyware (Servers)	High	Uncontrollable	High	Spyware can steal critical information and sensitive	Access control and authentication	

Risk Threat Identified		Possible Mitigation actions, see D11.1 Section 6.4.1					
Risk ID	**Description**	**Likelihood**	**Impact**	**Exposure Level**	**Impact description**	**Mitigation action deployed**	**Comments**
					data from servers.		
6	Ransomware (Servers)	High	Uncontrollable	High	Ransomware is malicious software that infects servers and personal computers and displays messages demanding a fee to be paid in order for the computer to work again. It has the ability to lock a computer screen or encrypt important, predetermined files with a password.	Access control and authentication	

Risk Threat Identified		Possible Mitigation actions, see D11.1 Section 6.4.1					
Risk ID	**Description**	**Likelihood**	**Impact**	**Exposure Level**	**Impact description**	**Mitigation action deployed**	**Comments**
7	Unauthorized access (Servers)	High	Critical	High	An attacker can gain unauthorized access to host machine.	Access control and authentication	
8	Unauthorized network scanning	Low	Marginal	Low	An attacker performs a network scan to detect which services of the host machine are online.	Controlled access to wireless network only for specific users	Physical access to the systems is close to impossible without being noticed by safety driver
9	Non-invasive Attacks (Vehicle Related Threats)	High	Uncontrollable	High	An attacker can physically access the device.	Access control and authentication	As above
10	Side Channel Attacks (Vehicle Related Threats)	Medium	Critical	Medium	An attacker can gather information from data and	Controlled access to wireless network only for specific users	No wireless packages transmitted from vehicle to external entities that could harm the operation

Risk Threat Identified		Possible Mitigation actions, see D11.1 Section 6.4.1					
Risk ID	**Description**	**Likelihood**	**Impact**	**Exposure Level**	**Impact description**	**Mitigation action deployed**	**Comments**
					packets in transit.		
11	Code Modification (Vehicle Related Threats)	Low	Critical	Medium	An attacker can modify a “Secure” tool that is connected to the system with malicious code.	Access control and authentication	
12	Code Injection (Vehicle Related Threats)	Medium	Critical	Medium	Trojans, Viruses and Spyware.	Access control and authentication	
13	Packet Sniffing (Vehicle Related Threats)	High	Marginal	Medium	An attacker can sniff the packets in transit between two parties.	Controlled access to wireless network only for specific users	No wireless packages transmitted from vehicle to external entities that could harm the operation
14	Packet Fuzzing (Vehicle Related Threats)	Medium	Marginal	Medium	An attacker can send a fake message	Implementation of testing procedures	In case of malicious message, the system won't behave as

Risk Threat Identified		Possible Mitigation actions, see D11.1 Section 6.4.1					
Risk ID	**Description**	**Likelihood**	**Impact**	**Exposure Level**	**Impact description**	**Mitigation action deployed**	**Comments**
					nearly identical to a trusted one. The system believes that the fake message is secure.		expected and safety driver will take over
15	In vehicle spoofing (Vehicle Related Threats)	Low	Critical	Medium	An attacker pretends to be a legitimate user in order to displace a default component and replace it with a modified spoofing component.	Implementation of testing procedures	Sanity checks and code changes are verified before testing cases are executed. In case the system won't behave as expected and safety driver will take over
16	GPS spoofing (Vehicle Related Threats)	Low	Critical	Medium	An attacker transmits fake GPS signals	Implementation of testing procedures	In case of malicious GPS signal, the system won't behave as expected and

Risk Threat Identified		Possible Mitigation actions, see D11.1 Section 6.4.1					
Risk ID	**Description**	**Likelihood**	**Impact**	**Exposure Level**	**Impact description**	**Mitigation action deployed**	**Comments**
					from a device he owns.		safety driver will take over
17	Jamming (Vehicle Related Threats)	Low	Critical	Medium	An attacker can use a device called jammer to interrupt the sensors from receiving data.	Implementation of testing procedures	In case of sensor/communication failure, the vehicle will transition to safe state and safety driver will take over

Table 78: Mitigation and security mechanisms [Options] of pilot site The Netherlands – Brainport

Mitigation and security mechanisms [Options]
Access control and authentication
Password rules for use of secure passwords
Logging and monitoring

Mitigation and security mechanisms [Options]
Security for databases, servers and workstations
Use of encryption solutions for specific files and pseudonymisation techniques
Fixed security settings for workstations
Use of constantly updated antivirus applications
Firewalls which are properly configured and using the latest software
Network and communication security
Use of cryptographic protocols
Controlled access to wireless network only for specific users
Monitoring of traffic inbound and outbound, controlled through Firewalls
Mobile device security
Implementation of rules for proper use of mobile devices and roles and responsibilities for device management
Use of encryption software and theft protection
Application lifecycle security process

Mitigation and security mechanisms [Options]
Early definition of specific security requirements
Use of secure coding standards
Implementation of testing procedures
Rules and strategy for data deletion and disposal
The network administrator must disable all unused services and close all the unused ports.
Regular and effective system maintenance should be required from the administrator.
NA

Appendix II – Results from Technical validation & commissioning on integrated service level

II.1. Technical validation results of demo site Sweden – Linköping

Table 79: Technical validation objectives - Linköping pilot site

Test/Use Case	Technical Validation objectives			
	Safety	**Performance**	**Quality of Service**	**Other (if applicable)**
1.1 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.	No injuries on the way to and from the shuttle.	Detection of all obstacles ahead	No interruptions of the service during the test.	
1.3 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 out boundaries of the area." The work is connected to the PT service.	No injuries either inside or outside the shuttle.	Detection of all obstacles ahead	No interruptions of the service during the test.	

Test/Use Case	Technical Validation objectives			
	Safety	**Performance**	**Quality of Service**	**Other (if applicable)**
1.6 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.	No injuries either inside or outside the shuttle	Detection of all obstacles ahead	No interruptions of the service during the test.	
1.7 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). The work is a connected to the Control tower.	Not relevant	The Linköping site is connected to the SHOW dashboard.	The API data is uploaded to the dashboard and the KPIs are calculated.	
3.4 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. A simple but integrated and connected “stop button” is placed along the route. The stop button (and potentially other sources like an app or Linköping MaaS) will signal the operation centre and create a stop order at the	Not relevant	The Veridict solution is available and the information of the maps accurate.	The Veridict solution is easy to use.	

Test/Use Case	Technical Validation objectives			
	Safety	Performance	Quality of Service	Other (if applicable)
correct bus stop. The work is a connected to a DRT service.				
3.1 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 a connected to a DRT service.	*NOT in the pre-demo*	*NOT in the pre-demo*	*NOT in the pre-demo*	
3.2 information, historical travel data and passenger information 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.	*NOT in the pre-demo*	*NOT in the pre-demo*	*NOT in the pre-demo*	

Table 80: Overview of the testing framework - Linköping pilot site

Test/Use Case [as coded above]	Vehicle demonstrators deployed [as coded above]	Physical & Digital Infra deployed [in summary]	Average Km run (from all iterations)	Operation features				
				Maximum speed reached during the trials (km/h)	Average speed during the trials (km/h)	Weather, sight & road conditions	Any special events triggered (e.g. road works, pedestrians crossing, etc.)	Traffic context and conditions
1.1	1 Navya + 1 EasyMile	Using existing physical infra. Bus stops at place.	4-8 October 2021; 4 km/lap; 16 laps/shuttle/day=160 laps in total	19km/h	5-6 km/h	Good.	2 hard brakings due to leave and hard wind.	1 occasions with misplaced parking of cycles.
1.3	1 Navya + 1 EasyMile	Using existing physical infra. Bus stops at place.	4-8 October 2021; 4 km/lap; 16 laps/shuttle/day=160 laps in total	19km/h	5-6 km/h	Good.	3 hard brakings due to leave and hard wind.	2 occasions with misplaced parking of cycles.
1.6	1 Navya + 1 EasyMile	Using existing physical infra.	4-8 October 2021; 4 km/lap; 16 laps/shuttle/d	19km/h	5-6 km/h	Good.	4 hard brakings due to leave and hard wind.	3 occasions with misplaced

Test/Use Case [as coded above]	Vehicle demonstrators deployed [as coded above]	Physical & Digital Infra deployed [in summary]	Average Km run (from all iterations)	Operation features				
				Maximum speed reached during the trials (km/h)	Average speed during the trials (km/h)	Weather, sight & road conditions	Any special events triggered (e.g. road works, pedestrians crossing, etc.)	Traffic context and conditions
		Bus stops at place.	ay=160 laps in total					parking of cycles.
1.7	1 Navya + 1 EasyMile	GPS position from Tablet, real time data from vehicle API and tablet solution.	4-8 October 2021; 4 km/lap; 16 laps/shuttle/day=160 laps in total	19km/h	5-6 km/h	Good.	5 hard brakings due to leave and hard wind.	4 occasions with misplaced parking of cycles.
3.4	1 Navya + 1 EasyMile	GNSS mast, NRTK subscription, lidare panels, mobile internet connection.	4-8 October 2021; 4 km/lap; 16 laps/shuttle/day=160 laps in total	19km/h	5-6 km/h	Good.	6 hard brakings due to leave and hard wind.	5 occasions with misplaced parking of cycles.
3.1	*NOT in the pre-demo*							

Test/Use Case [as coded above]	Vehicle demonstrators deployed [as coded above]	Physical & Digital Infra deployed [in summary]	Average Km run (from all iterations)	Operation features				
				Maximum speed reached during the trials (km/h)	Average speed during the trials (km/h)	Weather, sight & road conditions	Any special events triggered (e.g. road works, pedestrians crossing, etc.)	Traffic context and conditions
3.2	*NOT in the pre-demo*							

II.2. Technical validation results of pilot site Sweden – Gothenburg

Table 81: Technical validation objectives - Gothenburg pilot site

Test/Use Case	Technical Validation objectives			
	Safety	**Performance**	**Quality of Service**	**Other (if applicable)**
Quality of Localization: Level of position Check (Test_01)		The Level of Position (called Hit Ratio) must be stable and higher than 80%		
Quality of Localization: GNSS Signal (Test_02)			The GNSS Signal must be "Good" or "Medium"	
Road width (Test_03)		The shuttle position must be consistent with the road configuration and the real environment state (vehicles parked, road users around...)		
Shuttle speed (Test_04)		The shuttle speed must be adapted to the driving conditions and be consistent with the feasibility study (road width, priority zone, road users around)		
Respecting priorities (Test_05)	The shuttle must respect each priority on cars and			

Test/Use Case	**Technical Validation objectives**			
	Safety	**Performance**	**Quality of Service**	**Other (if applicable)**
	each signage (stops, yields, pedestrians' crossings…)			
Automated stop at station (Test_06)	The shuttle must stop in autonomous mode at each station (blinkers, approach phase, stop phase, departure phase)			
Blinkers (Test_07)	The shuttle must illuminate blinkers if necessary			

Table 82: Overview of the testing framework - Gothenburg pilot site

Test/Use Case	Vehicle demonstrators deployed [as coded above]	Physical & Digital Infra deployed [in summary]	Average Km run (from all iterations)	Operation features				
				Maximum speed reached during the trials (km/h)	Average speed during the trials (km/h)	Weather, sight & road conditions	Any special events triggered (e.g. road works, pedestrians crossing, etc.)	Traffic context and conditions
Quality of Localization: Hit Ratio Check (Test_01)	2 Arma Navya Shuttles : P94 & P95 (VG9A2CB2CJV019094 & VG9A2CB2CJV019095)	Lidar Markers placed in some points on the path	130 km	18 km/h	5,0 km/h	Good visibility		Open road Free-Flowing Traffic
Quality of Localization: GNSS Signal (Test_02)	2 Arma Navya Shuttles : P94 & P95 (VG9A2CB2CJV019094 & VG9A2CB	The GNSS base was installed on top of a building (see "GNSS base" on the picture below)	130 km	18 km/h	5,0 km/h	Good visibility		Open road Free-Flowing Traffic

Test/Use Case	Vehicle demonstrators deployed [as coded above]	Physical & Digital Infra deployed [in summary]	Average Km run (from all iterations)	Operation features				
				Maximum speed reached during the trials (km/h)	Average speed during the trials (km/h)	Weather, sight & road conditions	Any special events triggered (e.g. road works, pedestrians crossing, etc.)	Traffic context and conditions
	2CJV019095)	 Exclusion zones can be defined when the GNSS is too low. Then, the shuttle navigates with the Lidar sensors only						

Test/Use Case	**Vehicle demonstrators deployed [as coded above]**	**Physical & Digital Infra deployed [in summary]**	**Average Km run (from all iterations)**	**Operation features**				
				Maximum speed reached during the trials (km/h)	**Average speed during the trials (km/h)**	**Weather, sight & road conditions**	**Any special events triggered (e.g. road works, pedestrians crossing, etc.)**	**Traffic context and conditions**
								
Road width (Test_03)	Shuttle : P94 & P95 (VG9A2CB2CJV019094 & VG9A2CB2CJV019095)	If the road width is to tiny, we can shift the trajectory of the shuttle if necessary and reduce speed	130 km	18 km/h	5,0 km/h	Good visibility		Open road Free-Flowing Traffic

Test/Use Case	Vehicle demonstrators deployed [as coded above]	Physical & Digital Infra deployed [in summary]	Average Km run (from all iterations)	Operation features				
				Maximum speed reached during the trials (km/h)	Average speed during the trials (km/h)	Weather, sight & road conditions	Any special events triggered (e.g. road works, pedestrians crossing, etc.)	Traffic context and conditions
Shuttle speed (Test_04)	2 Arma Navya Shuttles : P94 & P95 (VG9A2CB2CJV019094 & VG9A2CB2CJV019095)		130 km	18 km/h	5,0 km/h	Good visibility		Open road Free-Flowing Traffic
Respecting priorities (Test_05)	2 Arma Navya Shuttles : P94 & P95 (VG9A2CB2CJV019094 & VG9A2CB2CJV019095)	Some STOP&GO (the shuttle stops and waits until the operator pushes « Go » on the screen after checking if the way is clear) have been implemented on the path (see "GO" on the picture below)	130 km	18 km/h	5,0 km/h	Good visibility		Open road Free-Flowing Traffic

Test/Use Case	Vehicle demonstrators deployed [as coded above]	Physical & Digital Infra deployed [in summary]	Average Km run (from all iterations)	Operation features				
				Maximum speed reached during the trials (km/h)	**Average speed during the trials (km/h)**	**Weather, sight & road conditions**	**Any special events triggered (e.g. road works, pedestrians crossing, etc.)**	**Traffic context and conditions**
		 If necessary, the priorities implemented in the code can be reconfigured						
Automated stop at station (Test_06)	2 Arma Navya Shuttles : P94 & P95 (VG9A2CB 2CJV0190 94 & VG9A2CB		130 km	18 km/h	5,0 km/h	Good visibility		Open road Free-Flowing Traffic

Test/Use Case	Vehicle demonstrators deployed [as coded above]	Physical & Digital Infra deployed [in summary]	Average Km run (from all iterations)	Operation features				
				Maximum speed reached during the trials (km/h)	Average speed during the trials (km/h)	Weather, sight & road conditions	Any special events triggered (e.g. road works, pedestrians crossing, etc.)	Traffic context and conditions
	2CJV0190 95)							
Blinkers (Test_07)	2 Arma Navya Shuttles : P94 & P95 (VG9A2CB 2CJV0190 94 & VG9A2CB 2CJV0190 95)		130 km	18 km/h	5,0 km/h	Good visibility		Open road Free-Flowing Traffic

II.3. Technical validation results of pilot site Finland – Tampere

Table 83: Technical validation objectives - Tampere pilot site

Test/Use Case [as coded above]	**Technical Validation objectives**			
	Safety	**Performance**	**Quality of Service**	**Other (if applicable)**
UC1.1 Automated passengers/cargo mobility in Cities under normal traffic & environmental conditions.	The AVs have 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 during the validation.	The vehicles are 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.	The demo route works well for the transporting passengers to the Hervanta tram stop. When the two AVs are operating continuously, the maximum waiting time for the passengers at any bus stop is 7 minutes.	
UC1.2 Automated passengers/cargo mobility in Cities under complex traffic & environmental conditions.	Validation of the deployment was also done during rush time and no additional safety concerns were found	The AVs have difficulties in entering the roundabout on the route when the amount of traffic is significantly higher than normal. In some of the cases the safety operator had to take manual control	Vehicles are driving on one predefined route. The amount of traffic on the route does not affect the quality of service. Abnormal environmental conditions were not tested during the	

Test/Use Case [as coded above]	Technical Validation objectives			
	Safety	Performance	Quality of Service	Other (if applicable)
		and drive through the roundabout.	validation but they should not affect the quality of service from user perspective. Vehicles will drive in manual mode if extreme weather conditions prevent autonomous driving	
UC1.4 Energy sustainable automated passengers/cargo mobility in Cities.	Not Applicable with Sensible 4 vehicles			
UC1.7 Connection to Operation Centre for tele-operation and remote supervision.	Not Applicable with Sensible 4 vehicles at this stage.	The operation centre for monitoring and remote operations, while does exist, does not have the functionality at present to do those actions. Data from vehicles does flow to a remote monitoring centre normally.	Functions normally with no service disruptions.	
UC3.1 Self-learning Demand Response Passengers/Cargo mobility	Not Applicable with Sensible 4 vehicles			

Table 84: Overview of the testing framework - Tampere pilot site

Test/Use Case [as coded above]	Vehicle demonstrators deployed [as coded above]	Physical & Digital Infra deployed [in summary]	Average Km run (from all iterations)	Operation features				
				Maximum speed reached during the trials (km/h)	Average speed during the trials (km/h)	Weather, sight & road conditions	Any special events triggered (e.g. road works, pedestrians crossing, etc.)	Traffic context and conditions
All above	Two Sensible 4 Toyota Proace (diesel) vehicles	-	70 km	30 km/h	14 km/h	Road covered with snow	Open road conditions	Normal to heavy amount of traffic

II.4. Technical validation results of pilot site The Netherlands – Brainport

Table 85: Technical validation objectives - Brainport pilot site

Test/Use Case [as coded on cover page]	**Safety**	**Performance**	**Quality of Service**	**Other (if applicable)**
UC1.1	The response to the C-ITS information from the traffic light yields the vehicle to brake when applicable	The response to the C-ITS information from the traffic light is consistent and predictable	NA	NA
UC1.3	The response to the C-ITS information from the road side unit yields the vehicle to brake when applicable	The response to the C-ITS information from the road side unit is consistent and predictable	NA	NA
UC1.8	The time gap is maintained. End to end communication delay between vehicles should not exceed 100ms.	Vehicle platoon has overdamped characteristics at the set following distance in order to allow for smooth platooning.	NA	NA

Table 86: Testing framework - Brainport pilot site

				Operation features				
Test/Use Case [as coded on cover page]	**Vehicle demonstrators deployed [as coded above]**	**Physical & Digital Infra deployed [in summary]**	**Average Km run (from all iterations)**	**Maximum speed reached during the trials (km/h)**	**Average speed during the trials (km/h)**	**Weather, sight & road conditions**	**Any special events triggered (e.g. road works, pedestrians crossing, etc.)**	**Traffic context and conditions**
UC1.1	TNO-C	Physical: Test site is equipped with remote operated traffic light Digital: Scenario generator mocking C-ITS SPAT/MAP/GLOSA/DENM messages	600	80	40	Clear, Dry, Any time of day	Traffic light phase transition	None
UC1.3	TNO-C	Physical: Test site is equipped with remote operated traffic light Digital: Scenario generator mocking C-ITS	400	80	40	Clear, Dry, Any time of day	Traffic light phase transition, VRU reg light violation	None

				Operation features				
Test/Use Case [as coded on cover page]	**Vehicle demonstrators deployed [as coded above]**	**Physical & Digital Infra deployed [in summary]**	**Average Km run (from all iterations)**	**Maximum speed reached during the trials (km/h)**	**Average speed during the trials (km/h)**	**Weather, sight & road conditions**	**Any special events triggered (e.g. road works, pedestrians crossing, etc.)**	**Traffic context and conditions**
		SPAT/MAP/GLOSA/DENM messages						
UC1.8	TNO-C	No Digital infra, vehicle functionality is solely running on V2V communication	50	80	40	Clear, Dry, Any time of day	None	None