ENSEMBLE

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ENSEMBLE

ENabling **S**af**E** **M**ulti-**B**rand p**L**atooning for **E**urope

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Written By	Jordi Pont, Marc Perez , Jose Javier Anaya, Armand Voskoboynikov, Sergio Silva, IDIADA	05-10-2021
Checked by	Pablo Rodríguez, Eva Álvarez, IDIADA	01-02-2022
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FIGURES

TABLES

1 EXECUTIVE SUMMARY

1.1 Context and need of a multi brand platooning project

Context

Platooning technology has made significant advances in the last decade, but to achieve the next step towards deployment of truck platooning, an integral multi-brand approach is required. Aiming for Europe-wide deployment of platooning, 'multi-brand' solutions are paramount. It is the ambition of ENSEMBLE to realise pre-standards for interoperability between trucks, platoons and logistics solution providers, to speed up actual market pick-up of (sub)system development and implementation and to enable harmonisation of legal frameworks in the member states.

Project scope

The main goal of the ENSEMBLE project is to pave the way for the adoption of multi-brand truck platooning in Europe to improve fuel economy, traffic safety and throughput. This will be demonstrated by driving up to seven differently branded trucks in one (or more) platoon(s) under real world traffic conditions across national borders. During the years, the project goals are:

- Year 1: setting the specifications and developing a reference design;
- Year 2 and 3: implementing this reference design on the OEM own trucks, as well as performing impact assessments with several criteria;
- Year 4 (due to COVID-19): focus on testing the multi-brand platoons on test tracks and public road.

The technical results will be evaluated against the initial requirements. Also, the impact on fuel consumption, drivers and other road users will be established. In the end, all activities within the project aim to accelerate the deployment of multi-brand truck platooning in Europe.

Abstract of this Deliverable

The present deliverable aims to show the results of the scenarios reproduced at IDIADA Proving Grounds (Spain) in September 2021 for the platooning support function (PSF) as specified in D2.5 [1]. The scenarios were defined in D5.7 in order to cover all the aspects that need to be identified and validated in the project. Scenarios including manoeuvres like join, disengage or cut-in among others were executed in a controlled environment at IDIADA Proving Ground before going to public roads. The technical team from ENSEMBLE and all the OEMs travelled to Spain in order to execute and supervise the execution of the tests. As a result of the execution of these scenarios, log data was generated in order to be analysed.

This deliverable contains the analysis done for the static and dynamic tests, the previously defined test plan and the dataflow process. All the test planned to be deployed in IDIADA Proving Grounds were successfully (or at least partially) executed during the test weeks, so we can claim that the main objectives of the testing activities have been achieved. In the chapters below, a deeper analysis can be found for each of the scenarios reproduced.

A large number of scenarios was executed successfully at the IDIADA Proving Grounds, and the logging data was sufficient to validate the results. In D5.7, five groups of scenarios were defined, to be tested in the validation phase: Platoon join, Steady state, I2V interaction, Cut-in and disengage. Each one of these groups included a list of sub scenarios to be executed, to ensure the correct functionality. It can be confirmed, that all these 5 scenario groups have been validated successfully at the IDIADA Proving Grounds. A representative sample dataset is added to section 6 of the deliverable, in order to demonstrate the correct execution of each scenario

2 INTRODUCTION

2.1 Background

This document refers to the tests performed during September 2021 at IDIADA Test track. For two weeks, the scenarios defined in deliverable D5.7 [2] were executed at the IDIADA facilities, in order to validate the platooning support function as specified in D2.5 ([1]). The information of other deliverables was also taken into account in order to correctly deploy all the scenarios. For the Use Cases, the information can be found in D2.3 [3], for the V2X communication protocol details, the information can be found in D2.8 [4] and for the security details the information can be found in D2.9 [5].

Before performing these final tests, mono-brand testing was performed as a first step to ensure the correct functionality of the communication protocol. After testing successfully mono-brand, the planning was to start validating the 3-brand tests. However, this was interrupted and impacted by the COVID pandemic. In the end, a number of 3-brand tests was performed on German test tracks with a delay in timing. Due to this, September 2021 was the first time that all 7 brands came together in Spain, to test the implementations of the Platooning Support Function. And thus, it was also the first time, that certain differences in implementation were discovered (see D2.5 [1]). This also meant that some time had to be spend on aligning and could thus not be spent on testing.

2.2 Aim

This deliverable aims to show the results of the scenarios executed at the test track, to prove the correct functionality of the platooning support function. The scenarios were executed at the IDIADA test track, and all the OEMs participated in the execution. The scenarios performed include static and dynamic demonstrations, to cover all the technical aspects of the validation. The main objective of the deliverable, is to show that the main objectives of the project were achieved successfully, by means of the data generated during the test sessions, and analysis of these afterwards.

2.3 Positioning within ENSEMBLE WP5 Context

The objective of WP5 is testing, validation and demonstration of the results achieved in the ENSEMBLE project. In this work package all testing is comprised, from integration testing until the final demonstration.

More precisely, the objective of the task that concludes with this deliverable together with D5.4 (which contains the validation results for Open Road), is to validate the acceptance criteria of all the scenarios defined in the previous task of the WP, through analysis of the data gathered during test track testing. Thanks to the scenarios ([2]) and data guidelines (Appendix 2. Data Logging guidelines) defined previously in this WP, this deliverable will prove that the multi-brand platooning was executed correctly during the test sessions to achieve the main objective of the WP5.

2.4 Structure of this report

This report is divided in the following chapters:

- **Chapter 2: Introduction**. The introductory chapter's main objective, is to provide context to the reader, by explaining the background and the main content of the deliverable, which will be described in the following chapters.

- **Chapter 3: Test plan and scenarios**. In this chapter, the executed scenarios are explained. The chapter contains a summary of the scenarios specifically defined in D5.7 [2], and explains which scenarios were executed and which were not. It also contains information about the defined test plan.

- **Chapter 4: Data analysis**. This chapter contains information about the data analysis process. It covers all the data sources from which data was extracted to obtain the results. Additionally, it describes the post-processing performed, to be able to analyse all the different data in a homogenous way.

- **Chapter 5: Static Test Results**. This is the first main chapter of the deliverable regarding test results. It contains the results for the static scenarios executed. For every test done, a detailed explanation, including data analysis and results, is provided.

- **Chapter 6: Dynamic Test Results**. This is the second main chapter of the deliverable, containing the results for the dynamic scenarios executed. For each test performed, a detailed explanation, including data analysis and results, is provided.

- **Chapter 7: Summary and conclusions**. This is the final chapter of the deliverable, where a summary of the results of each executed scenario can be found.

The final chapters of the deliverable include an appendix with extra information, for a better comprehension of the content, and a second appendix with the data logging guidelines.

3 TEST PLAN AND SCENARIOS

3.1 Scenario descriptions

Below is a summary of the scenarios defined in D5.7 [2], which were planned to be executed during the test sessions.

3.1.1 Platoon join

Table 1 Platoon join scenarios

Scenario ID	Scenario Name	Scenario description
SC0101	Joining form behind by a single vehicle	An ego vehicle behind sends a joining request to an existing platoon in front. The ego vehicle is accepted and joins the platoon.
SC0102	Joining from behind by an existing platoon	An existing platoon behind sends a joining request to an existing platoon in front. The platoon behind is accepted and joins the platoon in front.
SC0103	Merge in between by single vehicle	A joinable external vehicle merges into an established, steady state driving platoon in front.
SC0104	Verification of the maximum number of trucks in a platoon	An ego vehicle from behind proceeds to join to the platoon. When the ego vehicle would join the platoon, the platoon acquires the maximum number of trucks allowed.
SC0105	Refuse joining due to maximum number of trucks	An existing platoon behind tries to join a platoon in front, but then the maximum number of trucks in a platoon would be exceeded. The platoon that is being joined, should refuse the joining.

3.1.2 Steady State platooning

Table 2 Steady State platooning scenarios

Scenario ID	Scenario Name	Scenario description
SC0201	Steady state following a constant speed	An existing platoon in steady state maintains a constant speed.
SC0202	Steady state acceleration	An existing platoon in steady state maintains a constant acceleration.
SC0203	Steady state deceleration	An existing platoon in steady state maintains a constant deceleration.
SC0204	Steady state gap variation	An existing platoon in steady state maintains a stable gap distance.
SC0205	Follow a braking target	An existing platoon in steady state reduces the speed until less than 30 km/h and even stops.
SC0206	Platoon in two adjacent lanes	An existing platoon in steady state overtakes another platoon in steady state.

3.1.3 Emergency braking

Table 3 Emergency braking scenarios

Scenario ID	Scenario Name	Scenario description
SC0301	Lead vehicle doing an emergency braking	The leading vehicle performs an emergency braking and communicates it to the platoon via V2V. The platoon reacts as well as required.

SC0302	Following vehicle doing an emergency braking	One of the following vehicles performs an emergency braking and communicates it to the platoon via V2V.
SC0303	Two instances of emergency braking in the platoon	The leader vehicle and an ego vehicle far from the leader vehicle perform two different emergency braking and communicate it to the platoon.
SC0304	Aborting emergency braking after TBD seconds	An ego vehicle of an existing platoon performs an emergency braking. Before being validated by the vehicles in the back, the emergency braking is aborted.

3.1.4 I2V interaction

Table 4 I2V interaction scenarios

Scenario ID	Scenario Name	Scenario description
SC0401	New minimum distance policy	A platoon gap adaptation received through I2V interaction.
SC0402	New maximum speed policy	A platoon speed adaptation received through I2V interaction.

3.1.5 Cut-in

Table 5 Cut-in scenarios

Scenario ID	Scenario Name	Scenario description
SC0501	Cut-in	An external vehicle cuts in into a working platoon and remains within it.
SC0502	Cut-through	An external vehicle cuts through a working platoon.

SC0503	Cut-out	An external vehicle cuts out from working platoon.
SC0504	Steady state multiple vehicles cut-in	An external vehicle cuts in into a working platoon and remains within it.

3.1.6 System status

Table 6 System status scenarios

Scenario ID	Scenario Name	Scenario description
SC0601	GPS failure	A platoon vehicle detects that the platooning system is not performing as expected (GPS failure).
SC0602	Communication failure	A platoon vehicle detects that the platooning system is not performing as expected (internal communication).
SC0603	Package loss	A platoon vehicle detects that the platooning system is not performing as expected (V2V communication).
SC0604	Steady state multiple vehicles cut-in	A platoon vehicle detects that the platooning system is not performing as expected (forward range sensor failure).

3.1.7 Disengage platoon

Table 7 Disengage platoon scenarios

Scenario ID	Scenario Name	Scenario description
SC0701	Leave by trailing truck	The ego vehicle sends a leave message to its existing platoon. The leaving procedure is performed, and the ego vehicle leaves the platoon.

SC0702	Leave by following truck	One of the following vehicles (not the leader nor the trailing vehicle) sends a leave request to the platoon it is part of. The leave procedure is performed, and the following vehicle leaves the platoon.
SC0703	Leave by leading truck	The leading vehicle sends a leave request to the platoon it is leading. The leave procedure is performed, and the leading vehicle leaves the platoon.
SC0704	Split platoon	During stable platooning, one of the follower vehicles (not the leader nor the trailer vehicle) starts the split procedure.
SC0705	Leave by steering-out as following truck	During table platooning, one of the follower trucks decides to leave and steers out and takes an exit.
SC0706	Leave by steering-out by leading truck	During stable platooning, the leader trucks decide to leave and steers out by changing lane.

3.1.8 Platoon cohesion

Table 8 Platoon cohesion scenarios

Scenario ID	Scenario Name	Scenario description
SC0801	Closing gap at maximum set speed	During stable platooning, one of the following vehicles or the trailing vehicle sends a maximum attainable speed, that is lower than the platoon speed.
SC0802	Closing gap at maximum acceleration and speed performance	During stable platooning, one of the following vehicles or the trailing vehicle sends a maximum attainable speed and acceleration.

3.2 Scenarios executed

The purpose of the testing on the proving ground was to validate the system with up to 7 trucks connected during simultaneous operation. The test scenarios involved the I2V infrastructure of the proving ground, target vehicles for cut-in, -out and -through scenarios. The execution of the test scenarios was carried out on the high-speed track of Applus+ IDIADA Proving Ground.

The following scenarios were executed at the IDIADA Proving Ground:

Table 9 Scenarios executed at IDIADA Proving Ground

Scenario ID	Scenario Name	Number of trucks involved
SC0101	Join from behind	2-7 trucks
SC0102	Joining from behind by an existing platoon	*2-7 trucks*
SC0201	Steady state following a constant speed	*2-7 trucks*
SC0202	Steady state acceleration	*2-7 trucks*
SC0204	Steady State Gap variation	*2-7 trucks*
SC0401	New minimum distance policy	*2-7 trucks*
SC0402	New maximum speed policy	*2-7 trucks*
SC0501	Cut-in	*2-7 trucks*
SC0502	Cut-through	*2-7 trucks*
SC0503	Cut-out	*2-7 trucks*
SC0701	Leave by trailing truck	*2-7 trucks*
SC0702	Leave by following truck	*2-7 trucks*
SC0703	Leave by leading truck	*2-7 trucks*
SC0704	Split platoon	*2-7 trucks*

3.3 Test plan

According to the initial test plan all test scenarios were divided into 6 test runs, comprising a combination of default scenarios (engage, steady state and disengage) and specific scenarios such as fuel measuring, gap closing, complete stop, components/communication failures etc. The following test runs (TR) have been planned for Proving Ground testing:

TR1: "Acceleration and deceleration"

TR.FC: "Acceleration, FC (Fuel consumption measurement) run and deceleration"

TR2: "Platoon #1 approaching Platoon #2; refuse 8 trucks platooning"

TR3: "one platoon overtakes another one"

TR4: "complete stop"

TR6: "GPS/Communication/V2x failures"

				Monday - 13.09											Tuesday - 14.09										
			day	Monday - 13.09											Tuesday - 14.09										
			daily summury	TR1						TR1 + TR.FC					TR3						TR6				
TR#	Short description	Approx duration	Short test run description	Session 1: 7-10			10-13			Session 2: 13-17					Session 1: 7-10			10-13			Session 2: 13-17				
	Briefings			Initial briefing (6:30)					follow-up	Safety briefing (13:00 / 14:30)				follow-up	drivers' briefing					follow-up					follow-up
TR1	Acceleration and deceleration	0:44:00	Engage 7 Acceleration 7 Decelerion 7 Disengage		TR1.1	TR1.2																			
TR.FC	Acceleration, FC run and deceleration	1:24:00	Engage 7 Acceleration 7 Steady state (FC check) Decelerion 7 Disengage							TR.FC.1															
TR2	PI1+PI2 refuse 8 trucks	1:13:00	Engage 4 and 4 Refuse 4+4 Acceleration to MAX 7 Decelerion 7 Disengage																		TR2.1	TR2.2	TR2.3	TR2.4	
TR3	one overtake another one	0:42:00	Engage 4 and 3 4 overtake 3 3 overtake 4 Engage 7 Cut in/out/through 7 Disengage												TR3.1	TR3.2	TR3.3								
TR4	complete stop	0:36:00	Engage 7 Complete stop Engage 7 Split 2+3+3 Engage 7 Disengage																						
TR6	GPS/Communication/V2x failures	0:42:00	Engage 7 failures																						
Fuel	Trucks refuel	0:30:00																							

Office task
PG task
PG non-driving hours
optional test iteration
Refuel

Figure 1 Proving Ground activities Test plan, part 1

			day	Wednesday - 15.09											Thursday - 16.09										
			daily summury	TR1			TR1 + TR.FC								TR1			TR1 + TR.FC							
TR#	Short description	Approx duration	Short test run description	Session 1: 7-10			10-13			Session 2: 13-17					Session 1: 7-10			10-13			Session 2: 13-17				
	Briefings			drivers' briefing	**Safety briefing** (13:00 / 14:30)				follow-up					follow-up	drivers' briefing					follow-up	follow-up				follow-up
TR1	**Acceleration and deceleration**	0:44:00	Engage 7 Acceleration 7 Decelerarion 7 Disengage																						
TR.FC	**Acceleration, FC run and deceleration**	1:24:00	Engage 7 Acceleration 7 Steady state (FC check) Decelerarion 7 Disengage																		TR.FC.2				
TR2	**Pl1+Pl2 refuse 8 trucks**	1:13:00	Engage 4 and 4 Refuse 4+4 Acceleration to MAX 7 Decelerarion 7 Disengage																						
TR3	**one overtake another one**	0:42:00	Engage 4 and 3 4 overtake 3 3 overtake 4 Engage 7 Cut in/out/through 7 Disengage																						
TR4	**complete stop**	0:36:00	Engage 7 Complete stop Engage 7 Split 2+3+3 Engage 7 Disengage	TR4.1	TR4.2	*TR4.3*																			
TR6	**GPS/Communication/V2x failures**	0:42:00	Engage 7 failures							TR6.1	TR6.2	TR6.3	*TR6.4*												
Fuel	**Trucks refuel**	0:30:00																							

Office task
PG task
PG non-driving hours
optional test iteration
Refuel

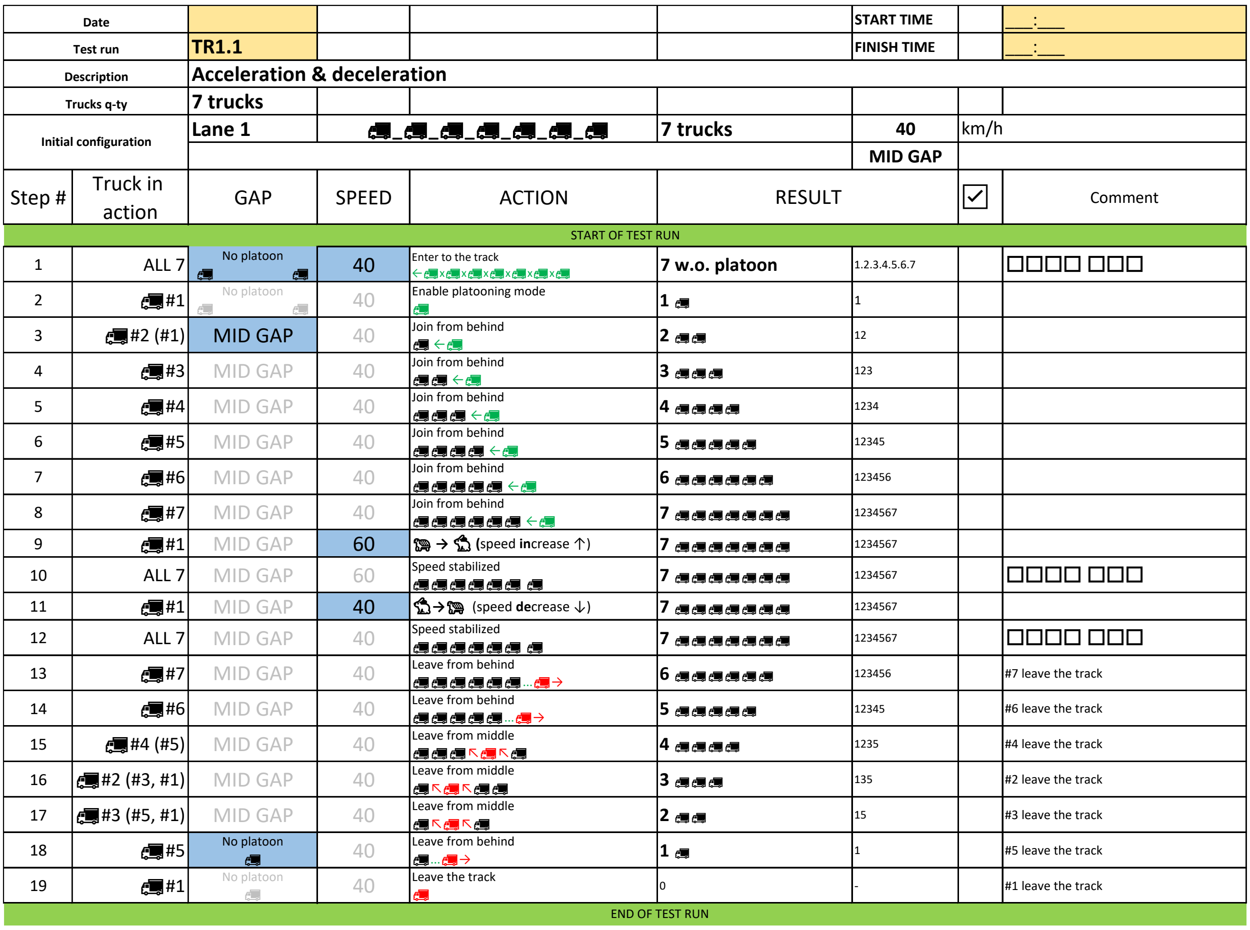
Figure 2 Proving Ground activities Test plan, part 2

The sequence of the trucks was defined randomly for every test run and test iteration (order change within the same test run) to ensure that every truck brand has a chance to be validated in different positions (leading, following, trailing).

Table 10 Example of trucks' sequence randomization

	TR1.1	TR2.1	TR3.1	TR4.1	TR.FC.1	TR6.1
TRUCK 1	**MAN**	**VOLVO**	**IVECO**	**SCANIA**	**MAN**	**DAF**
TRUCK 2	**SCANIA**	**SCANIA**	**DAIMLER**	**IVECO**	**SCANIA**	**RENAULT**
TRUCK 3	**VOLVO**	**IVECO**	**DAF**	**VOLVO**	**DAF**	**MAN**
TRUCK 4	**DAIMLER**	**DAIMLER**	**SCANIA**	**RENAULT**	**IVECO**	**IVECO**
TRUCK 5	**IVECO**	**RENAULT**	**RENAULT**	**MAN**	**DAIMLER**	**VOLVO**
TRUCK 6	**RENAULT**	**DAF**	**MAN**	**DAF**	**RENAULT**	**DAIMLER**
TRUCK 7	**DAF**	**MAN**	**VOLVO**	**DAIMLER**	**VOLVO**	**SCANIA**
		IVECO				

Every test run was executed in accordance with Test plan script distributed to the drivers and test coordinator. These documents contained a detailed plan for test execution, communication and test execution confirmation.



Date					START TIME		___:___	
Test run	TR1.1				FINISH TIME		___:___	
Description	Acceleration & deceleration							
Trucks q-ty	7 trucks							
Initial configuration	Lane 1			7 trucks	40	km/h		
					MID GAP			
Step #	Truck in action	GAP	SPEED	ACTION	RESULT		✓	Comment
START OF TEST RUN								
1	ALL 7	No platoon	40	Enter to the track	7 w.o. platoon	1.2.3.4.5.6.7		□□□□ □□□
2	#1	No platoon	40	Enable platooning mode	1	1		
3	#2 (#1)	MID GAP	40	Join from behind	2	12		
4	#3	MID GAP	40	Join from behind	3	123		
5	#4	MID GAP	40	Join from behind	4	1234		
6	#5	MID GAP	40	Join from behind	5	12345		
7	#6	MID GAP	40	Join from behind	6	123456		
8	#7	MID GAP	40	Join from behind	7	1234567		
9	#1	MID GAP	60	→ (speed increase ↑)	7	1234567		
10	ALL 7	MID GAP	60	Speed stabilized	7	1234567		□□□□ □□□
11	#1	MID GAP	40	→ (speed decrease ↓)	7	1234567		
12	ALL 7	MID GAP	40	Speed stabilized	7	1234567		□□□□ □□□
13	#7	MID GAP	40	Leave from behind	6	123456		#7 leave the track
14	#6	MID GAP	40	Leave from behind	5	12345		#6 leave the track
15	#4 (#5)	MID GAP	40	Leave from middle	4	1235		#4 leave the track
16	#2 (#3, #1)	MID GAP	40	Leave from middle	3	135		#2 leave the track
17	#3 (#5, #1)	MID GAP	40	Leave from middle	2	15		#3 leave the track
18	#5	No platoon	40	Leave from behind	1	1		#5 leave the track
19	#1	No platoon	40	Leave the track	0	-		#1 leave the track
END OF TEST RUN								

Figure 3 Test plan script example

4 DATA ANALYSIS

4.1 Data process flow

To ensure a correct data analysis, a Data Management Plan was needed. This document was initially defined in D5.7 [2] and it was finalized during the last months before the testing sessions.

The main objective of this Data Management plan is to provide a document containing logging guidelines to ensure that all the devices were logging in the same format and structure. This is important to facilitate the data analysis process but at the same time it has also been a challenge to define it; due to several data providers involved in ENSEMBLE project.

The complete document including the logging guidelines can be found in Appendix 2 of this deliverable. In this chapter the main ideas are summarised.

The data process flow of ENSEMBLE project starts when the data is logged in the data provider device and ends when it is stored in IDIADA's Data Management Platform, called iDrive. Below the main points of this process followed by an explanation of each of them, is displayed.

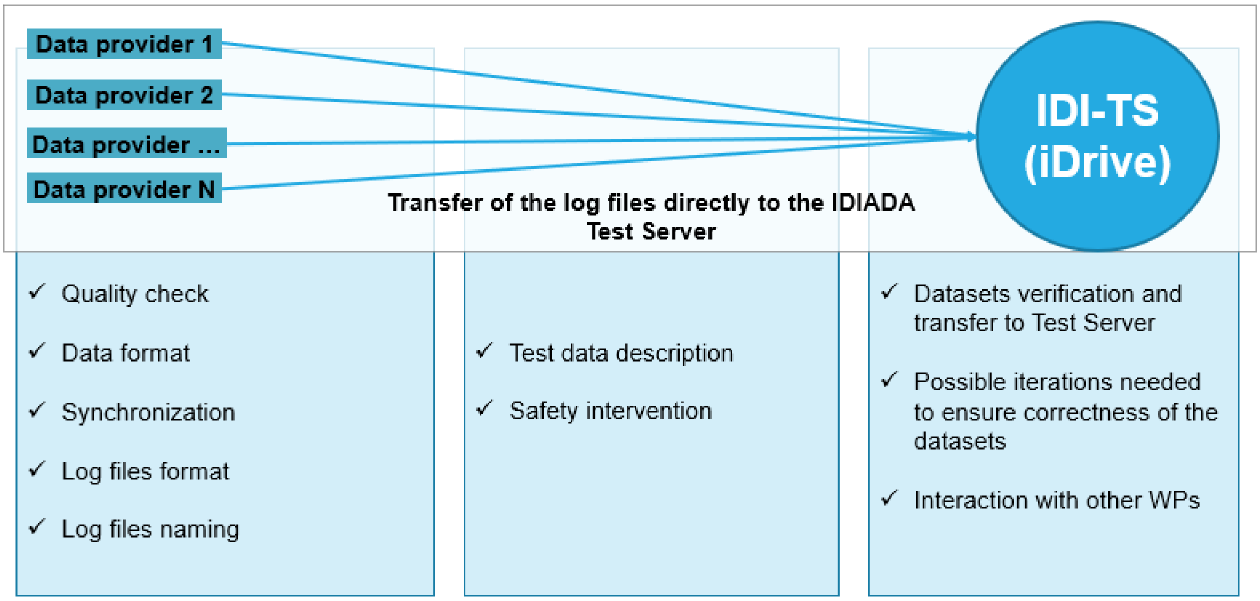


Figure 4 ENSEMBLE Data Management

Once the data providers were identified and the logging was performed, big datasets have been obtained. These datasets would be used to analyze all the executed scenarios. However, before the analysis, the datasets would need to pass a quality check to ensure a minimum level of homogeneity and correctness.

The main objective of the quality check is to ensure in near-real-time that the log files generated after a test session, were valid for the later analysis. This has been done by checking the following items:

1. Assess and quantify **missing data**. Check the null and zero values to ensure that all the signals are logged correctly.
2. Control **data values** and **units of the signal**. Check that the signal values are within the range defined and that the units are the correct ones.
3. Ensure that all the data is **timestamped** and **synchronized**. Check that every signal is logged with its timestamp and that all the signals are synchronized among them.
4. Check the **file format** and the **file naming**. Check that the format and the name of the file follow the data logging guidelines.

Once this quality check was executed and the homogeneity of the datasets was ensured, the next step was to put together the complementary data with the logged data. The complementary data includes basically two documents:

1. Test data description. It contains basic information regarding the dataset such as the road status, traffic status, weather among other information that will help to a better understanding of the content of the log files.
2. Safety intervention report. This is an optional report to make sure that all safety incidents that may happen, are reported. This will include information regarding the safety intervention, the main cause, and the severity.

Finally, the validation of the datasets is done. A post-process of the datasets is performed to guarantee that useful results can be extracted from the datasets. This may require several iterations with the data provider until the dataset can be analyzed and compared to other datasets from other data providers. After these iterations, the datasets will be uploaded to the IDIADA Data Platform, iDrive.

From iDrive, every WP will have access to this valid postprocessed datasets to be used for their own analysis. The data will be anonymized to certify the anonymity and the impartiality of the results.

4.2 Data sources and volume

As mentioned in the previous section, different data providers were involved in ENSEMBLE project. To guarantee the correct deployment of the Data Management Platform and to identify the expected outputs of the testing sessions, all the data providers were categorized.

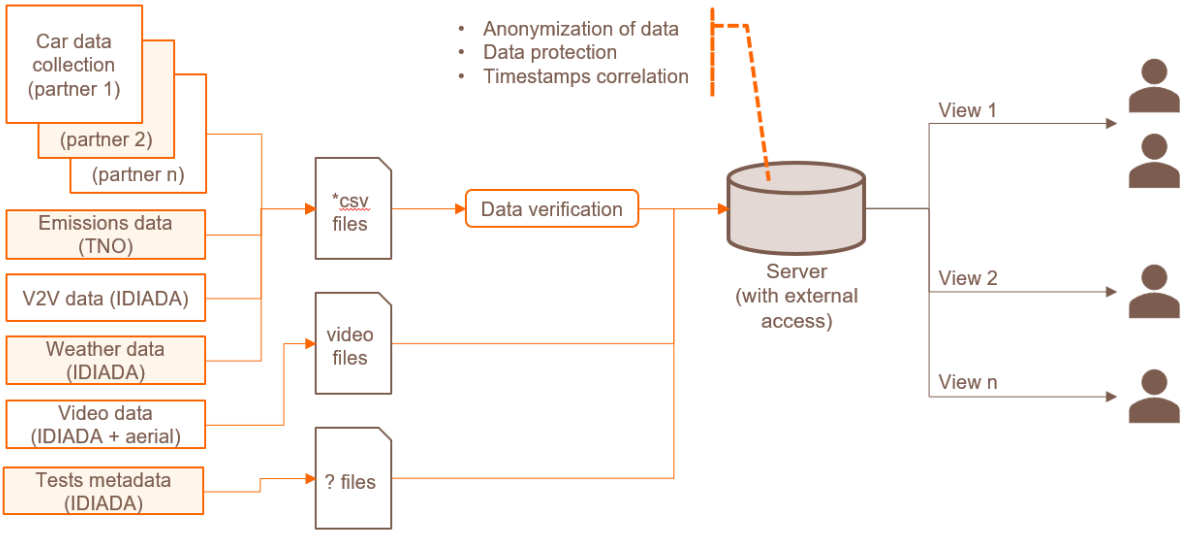


Figure 5 Data types and data sources

As shown in the image above, the data from ENSEMBLE project has been divided into 6 categories:

1. **Car data collection**. This are the datasets generated by the trucks from each OEM in the agreed specific format. These datasets include vehicle data (speed, acceleration…), GPS data (heading, latitude, longitude…) and V2V message exchanged between the trucks. The dataset is recommended to be logged in a .csv file but .mat files are also accepted.
2. **Emissions data**. The datasets include all the information related to the emissions and fuel consumption. TNO was the responsible to install the equipment to perform the logging. The datasets generated were first stored in a TNO internal database and after post-processing, data was sent to the project data platform. The data was also logged in .csv format.
3. **V2V data**. This category includes the V2X data that was captured by the Roadside Units installed on the perimeter of the High-Speed Track, the test track where the scenarios were performed. This was done to avoid losing performance of the V2V devices in the truck by the logging process. The truck V2V devices were only logging the main messages without overloading the system. The rest of logging was done in the RSUs capturing the messages in the air. The data was also logged in .csv format.
4. **Weather data**. The data was generated by the IDIADA Weather Station. The certain information needed by ENSEMBLE project was selected and a dataset was generated each day with the information needed (asphalt temperature, humidity, temperature…). The information was logged in .csv format.
5. **Video data**. Several different cameras were installed during the tests to log either the traffic, the HMI status, or the other trucks.
    a. HMI cameras. A video file containing the HMI recording was generated for each truck during the Proving Ground tests.
    b. Lateral cameras. A video file containing images from the traffic surrounding and the other trucks was generated during the Open Road Tests.

   c. Aerial camera. A video file containing images from a helicopter point of view was generated during the Open Road Tests.
6. **Test metadata**. This is the data that provides information and the other datasets in order to be easily shared when the project ends.

In the image below, an estimation for the data volume was made to know the capacity that our Data Management platform would need to have.

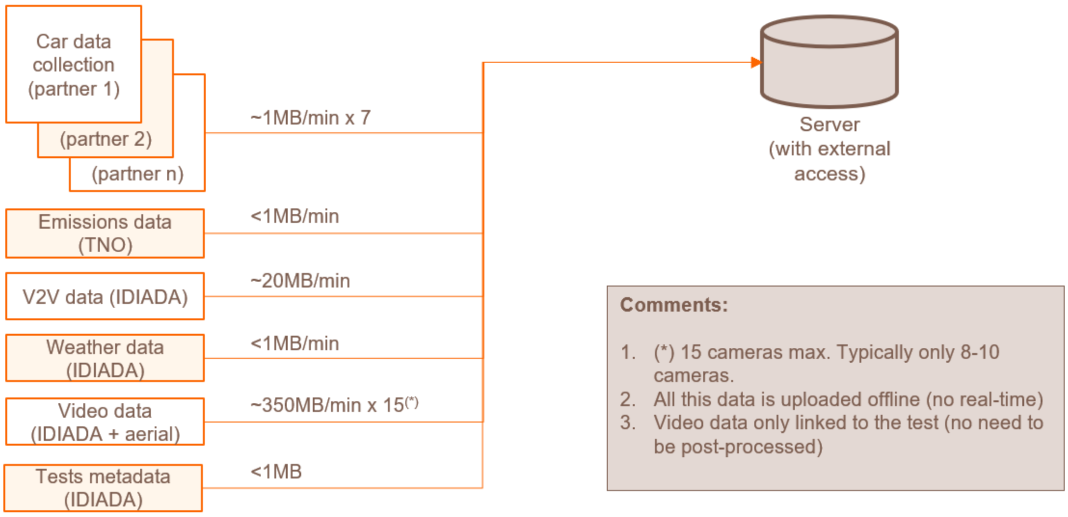


Figure 6 Data volume

4.3 Data post-processing

During three weeks of testing (two of them at IDIADA Proving Grounds and one of them at Open Roads) the datasets mentioned in the sections above were generated. After a first quality check, they were uploaded to IDIADA Data Management Platform ready for a post-processing to make them as more homogeneous as possible to facilitate the analysis. The data post-processing procedure followed by IDIADA team had the next steps:

1. Download the datasets from each OEM from the Data Management Platform. The post-processing procedure was done separately for each data provider.
2. Data verification process to detect errors and unexpected values. Despite a first iteration to detect errors in the datasets was performed during the quality check, a more deeply process was executed in this phase. In this step, several logging errors (e.g., values out of range) were detected. Depending on the criticality of the error, the OEM was contacted to solve the problem when IDIADA team was not able to do so.
3. Creation of a common database. The main objective of this step was to unify all the data from the different OEMs in the same database. Thanks to the logging guidelines defined prior to the testing, the process to create this common database was simplified. However,

due to several unexpected factors such as logging and tool compatibility issues this process lasted more time than expected.

4. Scenario algorithms definition. Several algorithms were defined to identify the different scenarios in the database, according to the requirements defined within ENSEMBLE context. The first intention was to develop only a common algorithm to be able to extract all the information from the different datasets. However, after finding some difficulties in the data extraction due to not being as homogeneous as expected, different algorithms needed to be created to extract the information.
5. Thanks to the algorithms, the interesting events from the datasets were extracted and evaluated. This data can be found in Chapter 6 of this deliverable.

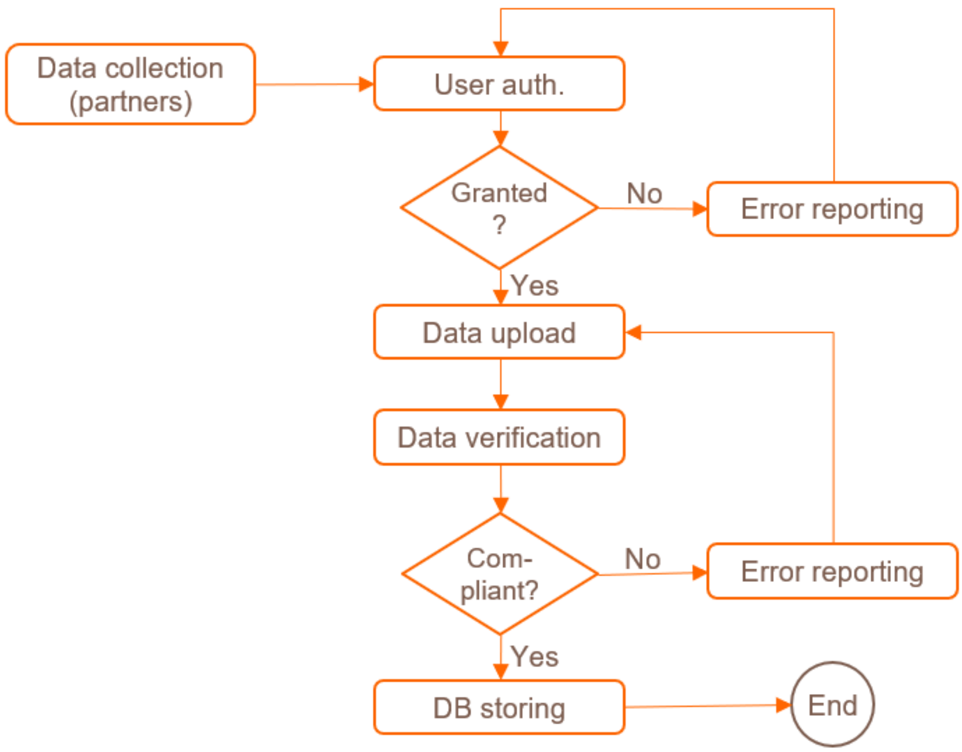


Figure 7 Data processing

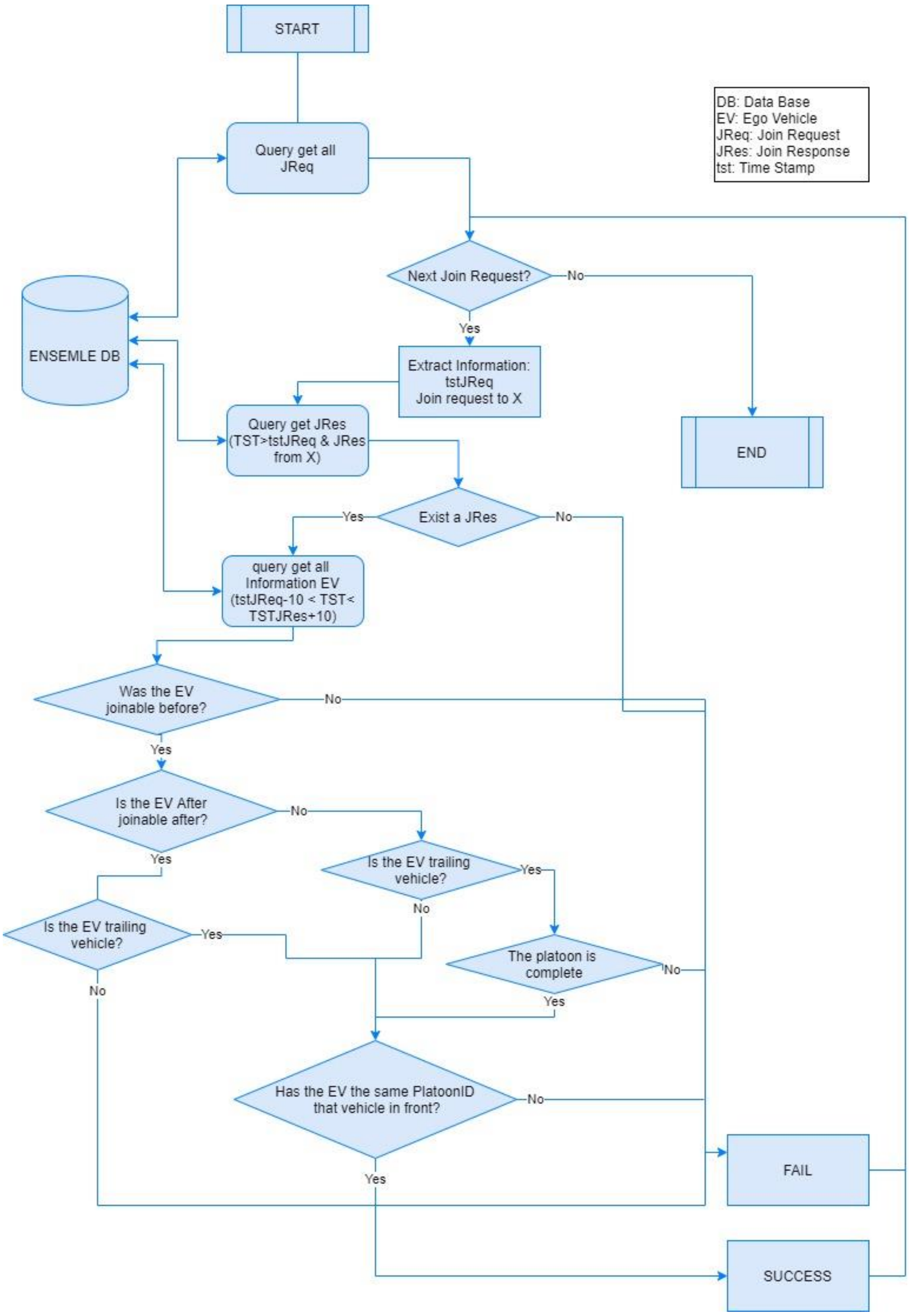


Figure 8 Sample generic join algorithm to SC_0101 & SC_0102 (chapter 6.1)

5 STATIC TESTS RESULTS

5.1 ENSEMBLE V2X and GPS quality checks

During the first week of testing, V2X and GPS validation tests have been performed to check if the trucks are in line with the project requirements. The V2X communication and the positioning of the trucks turned out to be the main challenges of the testing in the ENSEMBLE project, so before starting with the dynamic scenarios, the main objective was to ensure that these two systems were working as expected.

5.1.1 GPS tests methodology

For the GPS tests, a SETTOP M1 device has been used. The SETTOP M1 is a communication device designed to work independently and autonomously in topographic monitoring projects. The device can be connected via Wi-Fi, Bluetooth, Radio, Ethernet, or GSM with exclusive IST Connect cloud service. The SETTOP M1 allows to directly connect several sensors and record complete and precise measurements.

Figure 9 SETTOP M1 device

The GPS static tests have been performed following the next procedure:

1. Place the SETTOP M1 in a strategic location (several positions in the truck were tested to obtain the most valuable results) and record GPS logs for 5 minutes.
2. Place the truck in the same location as the SETTOP M1 was before and record the truck's GPS logs for 5 minutes.
3. Perform a GPS data analysis to check the concordance between SETTOP M1 logs and truck GPS logs.

Once the static GPS test was succeeded, a GPS dynamic test was also done to ensure the correct functionality while moving. To perform these tests a V2X unit was needed. For this a Cohda Wireless MK5 On-Board-Unit was used. The MK5 exchanges data at high speeds over extended distances, making it suitable for this test.

Figure 10 MK5 OBU Cohda Wireless device

The next procedure was followed:

1. Install the SETTOP M1 device in the truck.
2. Use the MK5 OBU in an external vehicle to capture the CAMs from the truck.
3. Record the GPS SETTOP M1 logs and V2X logs while the truck is driving at constant speed for 5 minutes.
4. Perform a GPS data analysis to check the concordance between SETTOP M1 logs and the V2X logs.

5.1.2 V2X tests methodology

The V2X tests were performed using the MK5 unit described in the previous subchapter. The procedure followed was:

1. Record the V2X messages (CAM, PMM and PCM) using the MK5 OBU for 5 minutes.
2. Analyse the V2X logs to check if logs are in line with the project requirements described in the following subchapter.

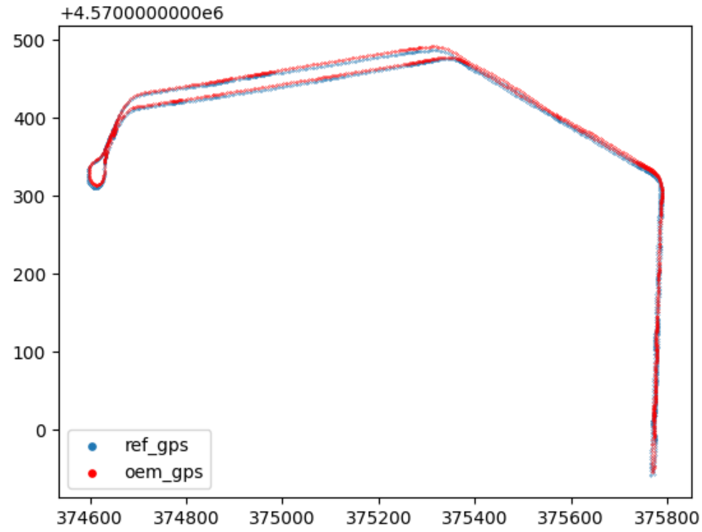


Figure 11 Sample of dynamic GNSS capture and check

5.2 V2X and GPS analysis results

Once the V2X and GPS tests were performed, the log data was analysed according to the requirements defined in D5.7. The results of the test can be found below:

Table 11 V2X and GPS Static Test Results (General View)

Test scenario	Name	Result	Comments
SC_0001	Device power emission	PASS	All trucks are in line with REQ_V2V_003 requirement.
SC_0002	Channel Emission	PASS	All trucks are in line with REQ_V2V_006 requirement.
SC_0003	MAC	PASS	All trucks are in line with REQ_V2V_020 requirement.
SC_0004	LL/SNAP	PASS	All trucks are in line with REQ_V2V_017, REQ_V2V_018 & REQ_V2V_019 requirement.
SC_0005	CAMs	PASS	All trucks are in line with REQ_V2V_007, REQ_V2V_008 & REQ_V2V_009 requirements.
SC_0006	PMMs	PARTIAL PASS	All trucks are in line with REQ_V2V_010 & REQ_V2V_011. Some of the PMM messages have been sent using a different lifetime parameter, for this reason some of the trucks tested are not in line with the project requirements. The V2X functionality was not affected despite the value was not aligned with the project requirements. (Table 2 from document D2.8 v1.1)

SC_0007	PCMs	PARTIAL PASS	All trucks are in line with REQ_V2V_010 & REQ_V2V_012. Some of the PCM messages have been sent using a different lifetime parameter, for this reason some of the trucks tested are not in line with the project requirements. The V2X functionality was not affected despite the value was not aligned with the project requirements. (Table 2 from document D2.8 v1.1)
SC_0008	GNSS cold start and static accuracy	PASS	All trucks are in line with requirement.
SC_0009	GNSS dynamic accuracy	PASS	All trucks are in line with requirement.

Table 12 V2X & GPS Static Test results per OEM

	SC_0001	SC_0002	SC_0003	SC_0004	SC_0005	SC_0006	SC_0007	SC_0008	SC_0009
OEM 1	PASS	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS
OEM 2	PASS	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS
OEM 3	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
OEM 4	PASS	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS
OEM 5	PASS	PASS	PASS	PASS	PASS	PASS	FAIL	PASS	PASS
OEM 6	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS	PASS
OEM 7	PASS	PASS	PASS	PASS	PASS	FAIL	FAIL	PASS	PASS

The failed tests for some OEMs are because the lifetime parameter of the PCM and PMM messages differs from the requirements defined by the project. After an analysis of the values and ensuring that all vehicles were able to communicate with each other, it was decided to not make any modifications to the systems and continue with the original testing plan. For this reason, in general view the test appears as a PARTIAL PASS but in the table above it appears as FAIL due to the misalignment with the project requirements.

5.3 Emergency Braking Warning check

After the validation of the GPS and the V2X communications were succeed, the following tests were related to Emergency Braking. These tests were redefined to check that the trucks were receiving the Emergency Braking message and display it to the driver. An actual execution of a following brake action was not within the scope of the testing as the added value of the PSF lies in the earlier warning of the driver of the emergency braking in the truck in front.

The test procedure followed was:

1. Generate a platoon of at least two trucks.
2. Place the truck which is going to perform the emergency braking test (i.e. the vehicle under test) in the second position of the platoon. This step was repeated for each of the trucks.
3. The leading truck performs an emergency braking with an acceleration lower than -4.5 m/s^2.
4. The driver of the truck under test shall receive a message indicating that (s)he may have to perform an emergency braking.

Acceptance criteria: The Emergency Braking warning message is activated on the HMI.

- The leader vehicle shall send the deceleration and predicted acceleration values properly in the V2X messages to the other trucks in the platoon.
- The vehicle under test shall receive the acceleration information in the PCM and inform to the driver through the HMI.

Results

This was successfully tested by all OEMs.

Table 13 Scenario result (SC_0011, SC_0012 & SC_0013)

Test ID	Test Name	Result	Comment
SC_0011	Send information of deacceleration	PASS	All vehicles were able to send the information of the acceleration during the emergency brake.
SC_0012 **SC_0013**	Receive and process an emergency braking (dynamic)	PASS	All vehicles were able to receive the information from the vehicle in front during the emergency brake and displayed a warning on the HMI.

6 DYNAMIC TEST RESULTS

6.1 Platoon Join

SC_0101 & SC_0102: Joining from behind

An ego vehicle behind sends a joining request to an existing platoon in front. The ego vehicle is accepted and joins the platoon.

Data analysis on SC_0101 & SC_0102

First the initial conditions are checked:

- The ego vehicle is driving behind an existing platoon in the same lane.
- The existing platoon in front is formed and in steady state condition with a specific number of trucks.
- The platoon is joinable (only the trailing vehicle).

V2X acceptance criteria

Check that the ego vehicle is joined to the platoon and if the V2X parameters are according to the specifications as described in D2.5 and D2.8 ([4] [1]) (principal parameters):

- A join request was sent.
- A join response was received.
- The ego vehicle is Joinable if it is the last truck in the platoon.
- The platoon ID is the same.

Acceptance criteria Acceleration lower than –4.5 m/s2

The acceleration shall not have values lower than –4.5 m/s^2 during the scenario. As seen in the plots below, this was successfully achieved.

Acceptance criteria GAP bigger than 1.4 s

The time gap shall not have values lower than 1.4 s during the scenario. As seen in the plots below, this was successfully achieved.

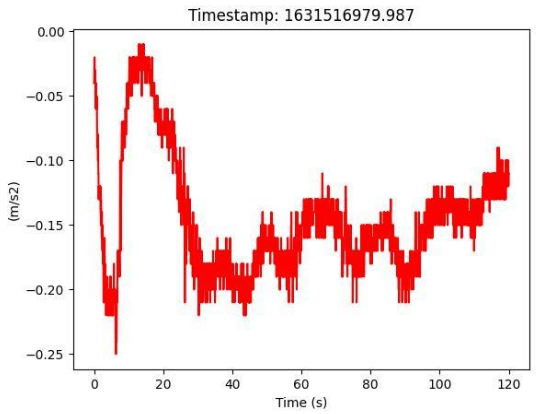


Figure 12 Acceleration Join Sample 1

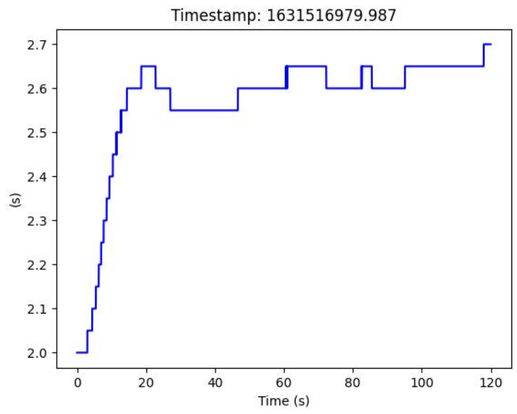


Figure 13 GAP Join Sample 1

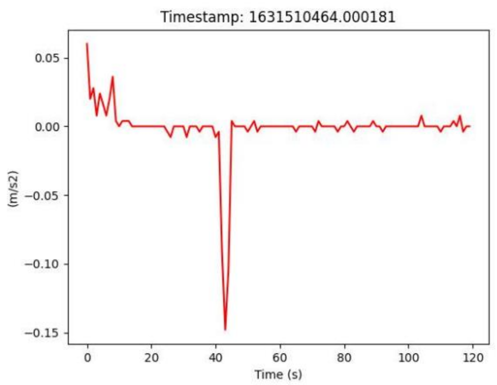


Figure 14 Acceleration Join sample 2 (1)

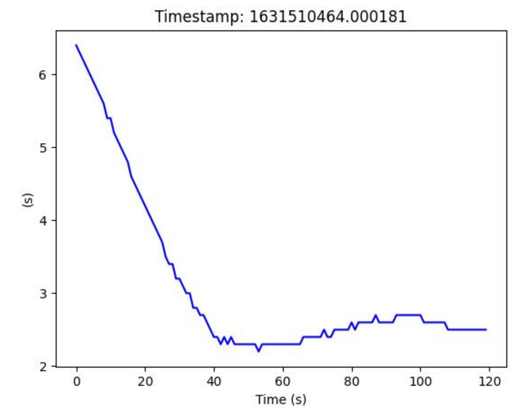


Figure 15 GAP Join Sample 2

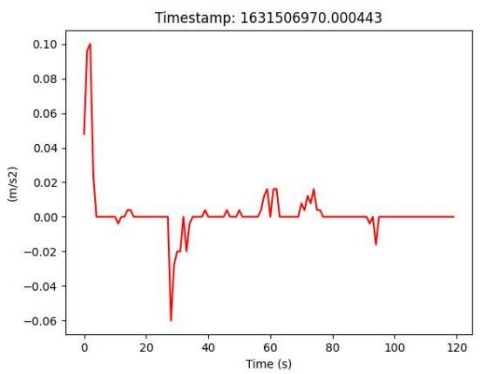


Figure 16 Acceleration Join Sample 3

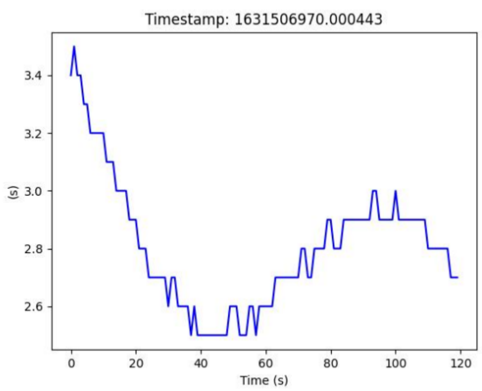


Figure 17 GAP Join Sample 3

[1]Peaks are caused by missing parts on the data log file.

Result for SC_0101 & SC_0102

Table 14 Scenario result (SC_0201 & SC_0202)

Test ID	Test Name	Result	Comment
SC_0101	Join from behind by a single vehicle.	PASS	According to the results obtained the result is pass because all vehicles are able to join to a platoon, but could partially pass as there are several unsuccessful attempts.. In addition, the complexity of the processing and analysis of the data collected during the tests must be taken into account.
SC_0102	Join from behind by a platoon.	PASS	

Table 15 Iterations scenario SC_0101 & SC_0102

Date	Success	Fail	Success ratio
13th September 2021	99	152	39
14th September 2021	136	148	48
15th September 2021	65	122	34
16th September 2021	103	266	26
17th September 2021	168	213	44

The V2V communication between the trucks shall occur as described in the previous deliverables.

6.2 Steady State

SC_0201, SC_0202 & SC_0204: Steady state

This test validates that the platoon can be kept for long periods and the message sharing is working for maintaining the distance between trucks in all conditions.

Data Analysis on test SC_0201, SC_0202 & SC_0204

Details for the platoon data selection:

- Trucks are in platoon
- Number of trucks is bigger than 3

[1] Peaks are caused by missing parts on the data log file.

- No trucks leave the platoon
- No trucks join the platoon
- Platoon duration should be greater than 70s to be able to check that key update is working as expected

Acceptance criteria:

- PCM sending rate per truck is 20Hz
- Gap distance is bigger than 1.4 seconds
- Truck's speed must be the same after transitions state (joining, platoon accelerations...)
- Truck's acceleration must be higher than -4.5 m/s^2
- Key update is done every 60 seconds

Following these requirements and after manually analysing multiple platoons that met the requirements, a detailed analysis has been done to a platoon in which all OEM were involved with a duration of 1575 seconds.
For better understanding of the results, we have selected only the most representative data to be shown in order to focus only on the interesting part of the analysis.

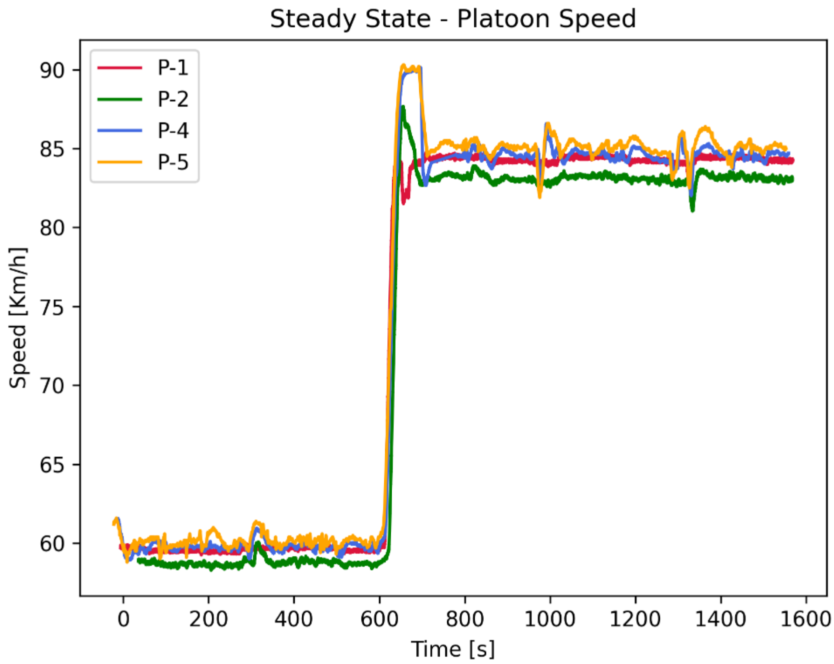


Figure 18 Speed Steady State sample

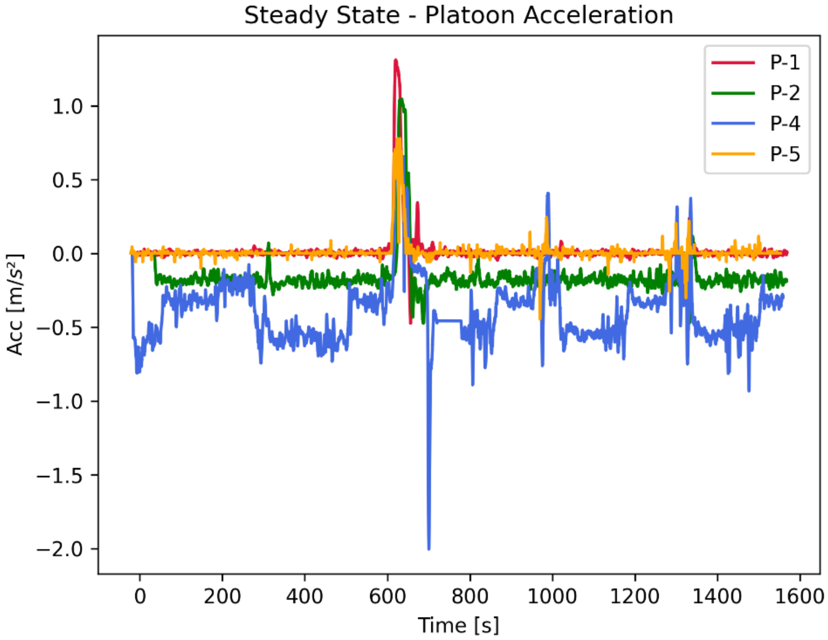


Figure 19 Acceleration Steady State sample

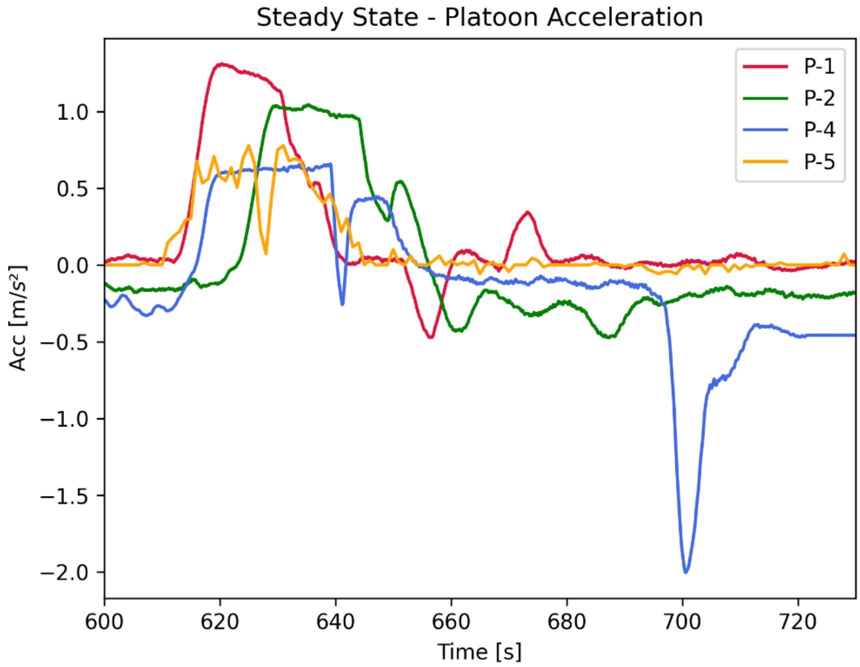


Figure 20 Acceleration graph during platoon speed up transition

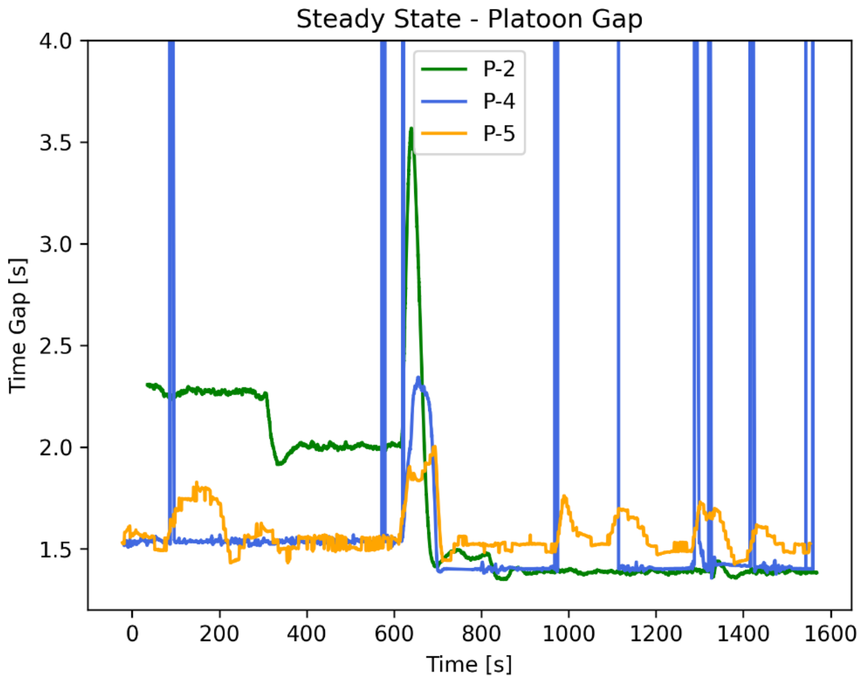


Figure 21 GAP Steady State sample ([2])

This image shows all vehicles keeping the same speed before and after the platoon acceleration. Please note that during acceleration a transition state is created, where the platoon leader does a smooth acceleration from 60km/h to 85km/h.

When the platoon leader accelerates, acceleration delay from vehicle to vehicle increases over the platoon, resulting in time gap increase on this situation. When the trucks arrive at the target speed of 85kmh, the time gap between trucks has increased to almost 4 seconds, and the following vehicles accelerate to eliminate that gap. We can see on those figures that after speeding to reach the target gap trucks needs to adjust to front truck speed. On one case, this speed adjustment is done by applying a 2m/s^2 deceleration when it approaches the target gap of 1.4 seconds.

Result for Test SC_0201, SC_0202 & SC_0204

Table 16 Scenario result (SC_0201, SC_0202 & SC_0204)

Test ID	Test Name	Result	Comment
SC0201	Steady State	PASS	
SC0202	Steady State Acceleration	PASS	
SC0204	Steady State Gap variation	PASS	

[2] OEM-2 peaks are caused by missing parts on the data log file.

6.3 I2V interaction

The ego vehicle is able to receive the I2V message, display it to the driver, who in turn is able to adapt the speed and/or GAP by interaction with platooning system (adjustment of set speed or preferred gap size).

SC_0401 & SC_0402: I2V interaction

SC_0401: Validate the correct platoon reception in terms of I2V communication; new distance policy.

SC_0402: Validate the correct platoon reception in terms of I2V communication; new speed policy.

Data analysis on SC_0401 & SC_0402

First the initial condition should be checked:

- An existing platoon formed with a specified gap and speed in steady state platooning.

V2X acceptance criteria

Check that the ego vehicle is not able to join to the platoon and whether the V2X parameters are according to the specifications as described in D2.5 and D2.8 ([1] [4]) (principal parameters):

- The ego vehicle is able to receive, process and inform the driver of the new policy.

Result for SC_0401 & SC_0402

Table 17 Scenario result (SC_0401 & SC_0402)

Test ID	Test Name	Result	Comment
SC_0401	New distance policy	PARTIALLY PASS	3 OEM PASS 4 OEM NO DATA
SC_0402	New distance speed	PARTIALLY PASS	3 OEM PASS 4 OEM NO DATA

6.4 Cut-in

SC_0501: Cut-in

An external vehicle cuts in into a steady state platoon and remains within it.

Data analysis on SC_0501

First the initial condition should be checked:

- An existing platoon formed with a specified gap and speed in steady state platooning.

V2X acceptance criteria

The V2X parameters are according to the specifications as described in D2.5 and D2.8 ([1] [4]) (principal parameters):

- The intruder is detected, and the rest of the platoon is informed of its presence by PCM message.
- The platoon continues with desired speed and distance in steady state platooning.

Acceptance criteria Acceleration higher than –4.5 m/s2

The acceleration shall not have values lower than –4.5 m/s^2 during the scenario. As seen in the plot below, this was successfully achieved.

Acceptance criteria GAP bigger than 1.4 s

The limit distance gap between trucks is respected during overall the procedure. The time gap shall not have values lower than 1.4 s during the scenario. This was successfully achieved. The plot below gives an example from the logged data.

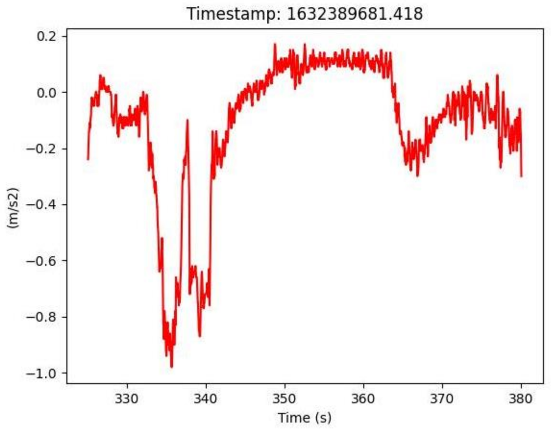


Figure 22 Acceleration Cut-in sample

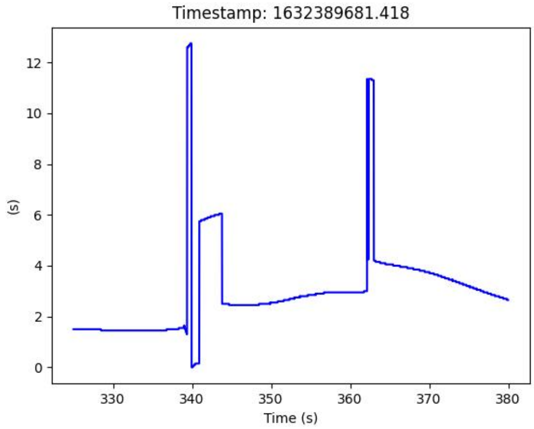


Figure 23 GAP Cut-in sample ([3])

Result for SC_0501

Table 18 Scenario result (SC_0501)

Test ID	Test Name	Result	Comment
SC_0501	Cut-In	PASS	

[3] Peaks are caused by missing parts on the data log file.

Table 19 Iterations scenario SC_0501

Date	Success	Fail	Success ratio
13th September 2021	1	4	20
14th September 2021	5	2	71
15th September 2021	9	0	100
16th September 2021	5	0	100
17th September 2021	1	0	100

SC_0502: Cut-through

An external vehicle cut-through in a steady state platoon.

Data analysis on SC_0502

First the initial condition should be checked:

- An existing platoon formed with a specified gap and speed in steady state platooning.

V2X acceptance criteria

Check that the ego vehicle is able to join to the platoon and whether the V2X parameters are according to the specifications as described in D2.5 and D2.8 ([1] [4]) (principal parameters):

- The intruder is detected, and the rest of the platoon is informed of its presence by PCM message.
- The platoon continues with desired speed and distance in steady state platooning.

Acceptance criteria Acceleration higher than –4.5 m/s2

The acceleration shall not have values lower than –4.5 m/s^2 during the scenario. This was successfully achieved. The plot below gives an example from the logged data.

Acceptance criteria GAP bigger than 1.4 s

The limit distance gap between trucks is respected during overall the procedure. The time gap shall not have values lower than 1.4 s during the scenario This was successfully achieved. The plot below gives an example from the logged data.

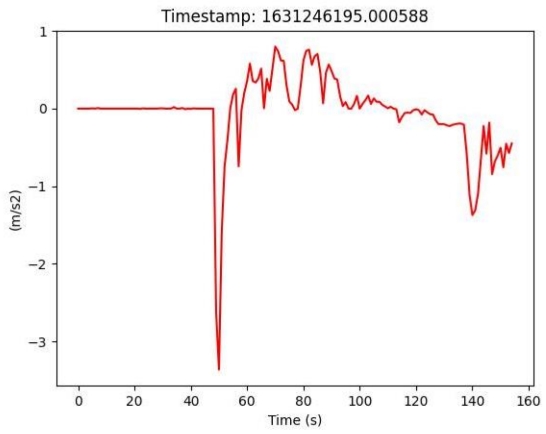


Figure 24 Acceleration Cut-Through sample

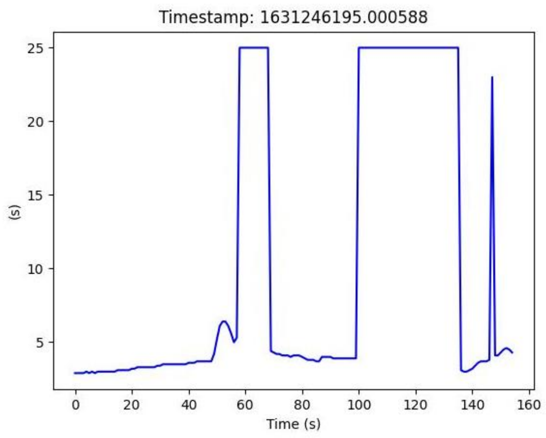


Figure 25 GAP Cut-Through sample ([4])

Result for SC_0502

Table 20 Scenario result (SC_0502)

Test ID	Test Name	Result	Comment
SC_0502	Cut-Through	PASS	

Table 21 Iterations scenario SC_0502

Date	Success	Fail	Success ratio
13th September 2021	27	1	96
14th September 2021	46	1	98
15th September 2021	68	4	94
16th September 2021	33	3	92
17th September 2021	3	3	50

SC_0503: Cut-out

An external vehicle that previously had cut in into a steady state platoon and remained within it, cuts out from the formation.

Data analysis on SC_0503

First the initial condition should be checked:

- An existing platoon formed with a specified gap and speed in steady state platooning.
- An external vehicle is between the trucks.

[4] Peaks are caused by missing parts on the data log file.

V2X acceptance criteria

Check that the ego vehicle informs of the presence of the intruder to the platoon and if the V2X parameters are according to the specifications as described in D2.5 and D2.8 ([1] [4]) (principal parameters):

- The platoon is informed of the presence of the intruder and when they leave the formation by PCM messages.
- The platoon continues with desired speed and distance in steady state platooning.

Acceptance criteria Acceleration higher than –4.5 m/s2

The acceleration shall not have values lower than –4.5 m/s^2 during the scenario. This was successfully achieved. The plot below gives an example from the logged data.

Acceptance criteria GAP bigger than 1.4 s

The limit distance gap between trucks is respected during overall the procedure. The time gap shall not have values lower than 1.4 s during the scenario This was successfully achieved. The plot below gives an example from the logged data.

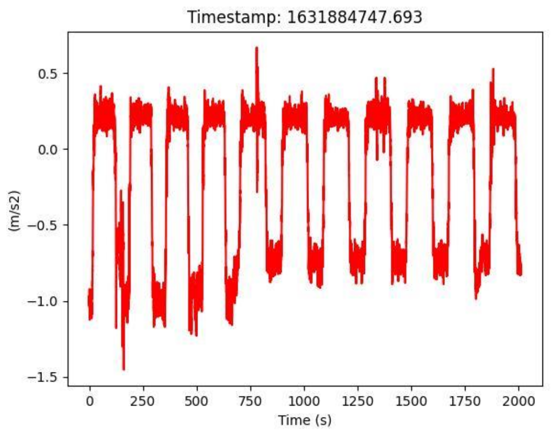


Figure 26 Acceleration Cut-out sample

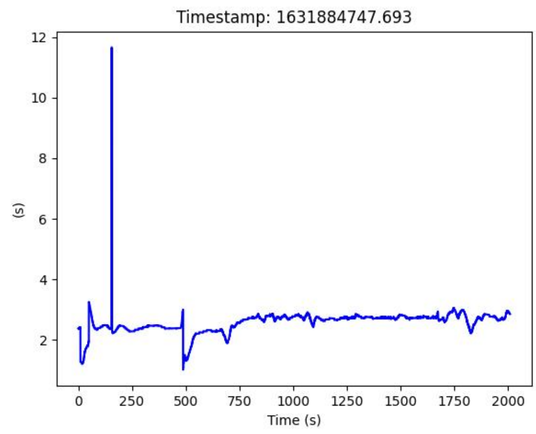


Figure 27 GAP Cut-out sample ([5])

Result for SC_0503

Table 22 Scenario result (SC_0503)

Test ID	Test Name	Result	Comment
SC_0503	Cut-out	PASS	

[5] Peaks are caused by missing parts on the data log file.

Table 23 Iterations scenario SC_0503

Date	Success	Fail	Success ratio
13th September 2021	5	0	100
14th September 2021	5	0	100
15th September 2021	9	0	100
16th September 2021	5	0	100
17th September 2021	1	0	100

6.5 Disengage platoon

SC_0701, SC_0702 & SC_0704: Front split

A vehicle or several vehicles (split platoon) leave the platoon using split in front by the ego vehicle (SC_0701: Leave by trailing truck, SC_0702: Leave by following truck and SC_0704: Split platoon).

Data analysis on SC_0701, SC_0702 & SC_0704

First the initial condition should be checked:

- An existing platoon formed with a specified gap and speed in steady state platooning.

V2X acceptance criteria

Check that the ego vehicle leaves the platoon and if the V2X parameters are according to the specifications as described in D2.5 and D2.8 ([1] [4])(principal parameters):

- The ego vehicle sends a PCM message with “front split” to the vehicle in front, first with “preparing for front split”, and later with “front split prepared”.
- The platoon continues with desired speed and distance in steady state platooning.
- The ego vehicle must be outside of the original platoon.

Acceptance criteria Acceleration higher than –4.5 m/s2

The acceleration shall not have values lower than –4.5 m/s2 during the scenario. This was successfully achieved. The plot below gives an example from the logged data. Acceptance criteria GAP bigger than 1.4 s

The limit distance gap between trucks is respected during overall the procedure. The time gap shall not have values lower than 1.4 s during the scenario This was successfully achieved. The plot below gives an example from the logged data.

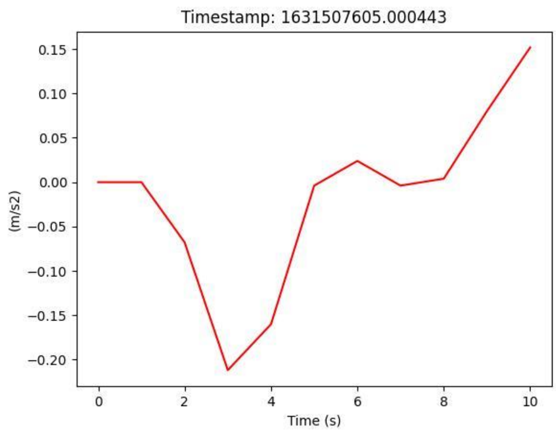


Figure 28 Acceleration Front split sample

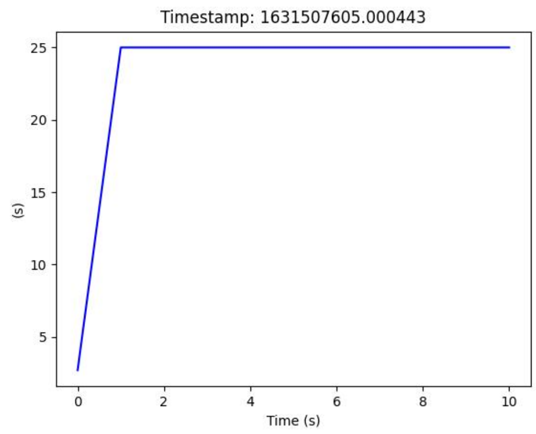


Figure 29 GAP Front split sample

Result for SC_0701, SC_0702 & SC_0704

Table 24 Scenario result (SC_0701, SC_0702 & SC_0704)

Test ID	Test Name	Result	Comment
SC_0701	Leave by trailing truck	PASS	
SC_0702	Leave by following truck	PASS	
SC_0704	Split platoon	PASS	

Table 25 Iterations scenario SC_0701, SC_0702 & SC_0704

Date	Success	Fail	Success ratio
13th September 2021	86	289	23
14th September 2021	44	74	37
15th September 2021	108	171	39
16th September 2021	121	405	23
17th September 2021	12	92	12

SC_0702, SC_0703 & SC_0704: Back split

A request for back split is performed by the ego vehicle to the truck in the back, this petition can affect to a vehicle or several vehicles (SC_0702: Leave by following truck SC_0703: Leave by leader truck and SC_0704: Split platoon).

Data analysis on SC_0702, SC_0703 & SC_0704

First the initial condition should be checked:

- An existing platoon formed with a specified gap and speed in steady state platooning.

V2X acceptance criteria

Check that the vehicle behind ego vehicle leaves the platoon and if the V2X parameters are according to the specifications as described in D2.5 and D2.8 ([1] [4]) (principal parameters):

- The ego vehicle sends a pcm message with “back split” to the vehicle in back
- The truck in back shall respond with a “front split” first with “preparing front split”, and later with “front split prepared”.
- The platoon continues with desired speed and distance in steady state platooning.
- The ego vehicle must be outside of the original platoon.

Acceptance criteria Acceleration higher than –4.5 m/s2

The acceleration shall not have values lower than –4.5 m/s^2 during the scenario. This was successfully achieved. The plot below gives an example from the logged data.

Acceptance criteria GAP bigger than 1.4 s

The limit distance gap between trucks is respected during overall the procedure. The time gap shall not have values lower than 1.4 s during the scenario This was successfully achieved. The plot below gives an example from the logged data.

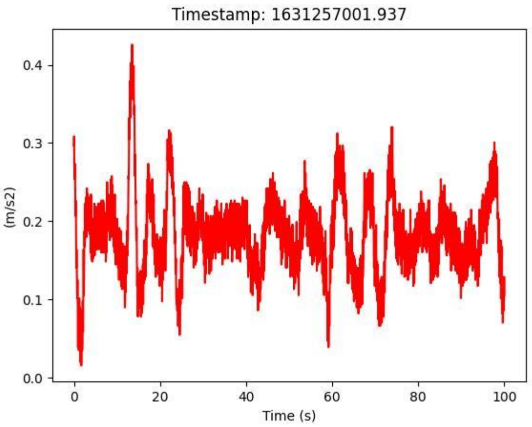


Figure 30 Acceleration Back split sample

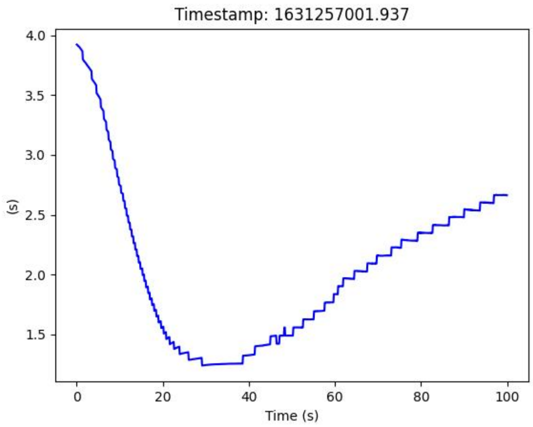


Figure 31 GAP Back split sample

Result for SC_0702, SC_0703 & SC_0704

Table 26 Scenario result (SC_0702, SC_0703 & SC_0704)

Test ID	Test Name	Result	Comment
SC_0702	Leave by following truck	PASS	

SC_0703	Leave by leading truck	PASS	
SC_0704	Split platoon	PASS	

Table 27 Iterations scenario SC_0702, SC_0703 & SC_0704

Date	Success	Fail	Success ratio
13th September 2021	72	296	20
14th September 2021	85	147	37
15th September 2021	54	81	40
16th September 2021	79	107	42
17th September 2021	46	30	61

7 SUMMARY OF TEST RESULTS AND CONCLUSIONS

In general, most of the tests that have been executed at the IDIADA premises were successful. A few of them are considered as partially passed but there is not any critically fail within all the executed tests (see D5.5 Technical Evaluation for further explanations). The main expectation is that the behaviour is consistent, despite not matching the requirements at some cases. This would be useful in the future in order to reduce the number of partially pass and increase the success ratio of each scenario.

It was found that, when executing some platoon functionalities, the logging process was affecting the functionality of the system. This means that the functionality could have been affected if the logging was performed according the project requirements. This led to a challenging situation: for some of the scenarios, the execution was done successfully but there was not enough data evidence to perform a validation of it. Improving the logging system, would solve these issues for future evaluations of the platooning systems. Another point that could be improved is that the log data formats need to have a more homogenous logging format among all the trucks.

Nevertheless, a large number of scenarios was executed successfully at the IDIADA Proving Grounds, and the logging data was sufficient to validate the results. In D5.7, five groups of scenarios were defined, to be tested in the validation phase: Platoon join, Steady state, I2V interaction, Cut-in and disengage. Each one of these groups included a list of sub scenarios to be executed, to ensure the correct functionality. It can be confirmed, that all these 5 scenario groups have been validated successfully at the IDIADA Proving Grounds. A representative sample dataset is added to section 6 of the deliverable, in order to demonstrate the correct execution of each scenario.

Finally, as it is usual for Innovation Projects, we have learned several lessons for the next time we face similar challenges:

- System requirements must be defined to be able to perform data quality tests. The use cases alone are not enough.
- The platooning system shall be defined in parallel with the signals for analysis.
- The signals shall be well defined, both in naming, range and in units.
- The measurement and logging systems must be well synchronized in time.

Table 28 Summary of the Proving Ground Test Results

Scenario ID	Scenario Name	Result
SC_0001	Device power emission	PASS
SC_0002	Channel Emission	PASS
SC_0003	MAC	PASS
SC_0004	LL/SNAP	PASS
SC_0005	CAMs	PASS
SC_0006	PMMs	PARTIALLY PASS
SC_0007	PCMs	PARTIALLY PASS
SC_0008	GNSS cold start and static accuracy	PASS
SC_0009	GNSS dynamic accuracy	PASS
SC_0011	Send information of deacceleration	PASS
SC_0012	Receive and process a short emergency braking (dynamic)	PASS
SC_0013	Receive and process a medium emergency braking (dynamic)	PASS

SC0101	Join from behind	PASS
SC0102	Joining from behind by an existing platoon	PASS
SC0201	Steady state following a constant speed	PARTIALLY PASS
SC0202	Steady state acceleration	PASS
SC0204	Steady State Gap variation	PASS
SC0401	New minimum distance policy	PARTIALLY PASS
SC0402	New maximum speed policy	PARTIALLY PASS
SC0501	Cut-in	PASS
SC0502	Cut-through	PASS
SC0503	Cut-out	PASS
SC0701	Leave by trailing truck	PASS
SC0702	Leave by following truck	PASS
SC0703	Leave by leading truck	PASS
SC0704	Split platoon	PASS

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9 APPENDIX 1. DEFINITIONS & ACRONYMS

9.1.1 Definitions

Term	Definition
Convoy	A truck platoon may be defined as trucks that travel together in convoy formation at a fixed gap distance typically less than 1 second apart up to 0.3 seconds. The vehicles closely follow each other using wireless vehicle-to-vehicle (V2V) communication and advanced driver assistance systems
Cut-in	A lane change manoeuvre performed by vehicles from the adjacent lane to the ego vehicle's lane, at a distance close enough (i.e., shorter than desired inter vehicle distance) relative to the ego vehicle.
Cut-out	A lane change manoeuvre performed by vehicles from the ego lane to the adjacent lane.
Cut-through	A lane change manoeuvre performed by vehicles from the adjacent lane (e.g. left lane) to ego vehicle's lane, followed by a lane change manoeuvre to the other adjacent lane (e.g. right lane).
Ego Vehicle	The vehicle from which the perspective is considered.
Emergency brake	Brake action with an acceleration of <-4 m/s2
Event	An event marks the time instant at which a transition of a state occurs, such that before and after an event, the system is in a different mode.
Following truck	Each truck that is following behind a member of the platoon, being every truck except the leading and the trailing truck, when the system is in platoon mode.
Leading truck	The first truck of a truck platoon
Legal Safe Gap	Minimum allowed elapsed time/distance to be maintained by a standalone truck while driving according to Member States regulation (it could be 2 seconds, 50 meters or not present)
Manoeuvre ("activity")	A particular (dynamic) behaviour which a system can perform (from a driver or other road user perspective) and that is different from standing still, is being considered a manoeuvre.
ODD (operational	The ODD should describe the specific conditions under which a given automation function is intended to function. The ODD is the definition of where (such as what roadway types and speeds) and when (under what conditions,

Term	Definition
design domain)	such as day/night, weather limits, etc.) an automation function is designed to operate.
Operational layer	The operational layer involves the vehicle actuator control (e.g. accelerating/braking, steering), the execution of the aforementioned manoeuvres, and the control of the individual vehicles in the platoon to automatically perform the platooning task. Here, the main control task is to regulate the inter-vehicle distance or velocity and, depending on the Platooning Level, the lateral position relative to the lane or to the preceding vehicle. Key performance requirements for this layer are vehicle following behaviour and (longitudinal and lateral) string stability of the platoon, where the latter is a necessary requirement to achieve a stable traffic flow and to achieve scalability with respect to platoon length, and the short-range wireless inter-vehicle communication is the key enabling technology.
Platoon	A group of two or more automated cooperative vehicles in line, maintaining a close distance, typically such a distance to reduce fuel consumption by air drag, to increase traffic safety by use of additional ADAS-technology, and to improve traffic throughput because vehicles are driving closer together and take up less space on the road.
Platoon Automation Levels	In analogy with the SAE automation levels subsequent platoon automation levels will incorporate an increasing set of automation functionalities, up to and including full vehicle automation in a multi-brand platoon in real traffic for the highest Platooning Automation Level. The definition of “platooning levels of automation” will comprise elements like e.g. the minimum time gap between the vehicles, whether there is lateral automation available, driving speed range, operational areas like motorways, etc. Three different levels are anticipated; called A, B and C.
Platoon candidate	A truck who intends to engage the platoon either from the front or the back of the platoon.
Platoon cohesion	Platoon cohesion refers to how well the members of the platoon remain within steady state conditions in various scenario conditions (e.g. slopes, speed changes).
Platoon disengaging	The ego-vehicle decides to disengage from the platoon itself or is requested by another member of the platoon to do so. When conditions are met the ego-vehicle starts to increase the gap between the trucks to a safe non-platooning gap. The disengaging is completed when the gap is large enough (e.g. time gap of 1.5 seconds, which is depends on the operational safety based on vehicle dynamics and human reaction times is given). A.k.a. leave platoon

Term	Definition
Platoon dissolve	All trucks are disengaging the platoon at the same time. A.k.a. decoupling, a.k.a. disassemble.
Platoon engaging	Using wireless communication (V2V), the Platoon Candidate sends an engaging request. When conditions are met the system starts to decrease the time gap between the trucks to the platooning time gap. A.k.a. join platoon
Platoon formation	Platoon formation is the process before platoon engaging in which it is determined if and in what format (e.g. composition) trucks can/should become part of a new / existing platoon. Platoon formation can be done on the fly, scheduled or a mixture of both. Platoon candidates may receive instructions during platoon formation (e.g. to adapt their velocity, to park at a certain location) to allow the start of the engaging procedure of the platoon.
Platoon split	The platoon is split in 2 new platoons who themselves continue as standalone entities.
Requirements	Description of system properties. Details of how the requirements shall be implemented at system level
Scenario	A scenario is a quantitative description of the ego vehicle, its activities and/or goals, its static environment, and its dynamic environment. From the perspective of the ego vehicle, a scenario contains all relevant events. Scenario is a combination of a manoeuvre ("activity"), ODD and events
Service layer	The service layer represents the platform on which logistical operations and new initiatives can operate.
Specifications	A group of two or more vehicles driving together in the same direction, not necessarily at short inter-vehicle distances and not necessarily using advanced driver assistance systems
Steady state	In systems theory, a system or a process is in a steady state if the variables (called state variables) which define the behaviour of the system or the process are unchanging in time. In the context of platooning this means that the relative velocity and gap between trucks is unchanging within tolerances from the system parameters.
Strategic layer	The strategic layer is responsible for the high-level decision-making regarding the scheduling of platoons based on vehicle compatibility and Platooning Level, optimisation with respect to fuel consumption, travel times, destination, and impact on highway traffic flow and infrastructure, employing cooperative ITS cloud-based solutions. In addition, the routing of vehicles to allow for platoon forming is included in this layer. The strategic layer is implemented in a

Term	Definition
	centralised fashion in so-called traffic control centres. Long-range wireless communication by existing cellular technology is used between a traffic control centre and vehicles/platoons and their drivers.
Tactical layer	The tactical layer coordinates the actual platoon forming (both from the tail of the platoon and through merging in the platoon) and platoon dissolution. In addition, this layer ensures platoon cohesion on hilly roads, and sets the desired platoon velocity, inter-vehicle distances (e.g. to prevent damaging bridges) and lateral offsets to mitigate road wear. This is implemented through the execution of an interaction protocol using the short-range wireless inter-vehicle communication (i.e. V2X). In fact, the interaction protocol is implemented by message sequences, initiating the manoeuvres that are necessary to form a platoon, to merge into it, or to dissolve it, also taking into account scheduling requirements due to vehicle compatibility.
Target Time Gap	Elapsed time to cover the inter vehicle distance by a truck indicated in seconds, agreed by all the Platoon members; it represents the minimum distance in seconds allowed inside the Platoon.
Time gap	Elapsed time to cover the inter vehicle distance by a truck indicated in seconds.
Trailing truck	The last truck of a truck platoon
Truck Platoon	Description of system properties. Details of how the requirements shall be implemented at system level
Use case	Use-cases describe how a system shall respond under various conditions to interactions from the user of the system or surroundings, e.g. other traffic participants or road conditions. The user is called actor on the system and is often but not always a human being. In addition, the use-case describes the response of the system towards other traffic participants or environmental conditions. The use-cases are described as a sequence of actions, and the system shall behave according to the specified use-cases. The use-case often represents a desired behaviour or outcome. In the ensemble context a use case is an extension of scenario which add more information regarding specific internal system interactions, specific interactions with the actors (e.g. driver, I2V) and will add different flows (normal & alternative e.g. successful and failed in relation to activation of the system / system elements).

9.1.2 Acronyms and abbreviations

Acronym / Abbreviation	Meaning
ACC	Adaptive Cruise Control
ADAS	Advanced driver assistance system
AEB	Autonomous Emergency Braking (System, AEBS)
ASIL	Automotive Safety Integrity Level
ASN.1	Abstract Syntax Notation One
BTP	Basic Transport Protocol
C-ACC	Cooperative Adaptive Cruise Control
C-ITS	Cooperative ITS
CA	Cooperative Awareness
CAD	Connected Automated Driving
CAM	Cooperative Awareness Message
CCH	Control Channel
DEN	Decentralized Environmental Notification
DENM	Decentralized Environmental Notification Message
DITL	Driver-In-the-Loop
DOOTL	Driver-Out-Of-the Loop
DSRC	Dedicated Short-Range Communications
ETSI	European Telecommunications Standards Institute
EU	European Union
FCW	Forward Collision Warning
FLC	Forward Looking Camera
FSC	Functional Safety Concept
GN	GeoNetworking
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GUI	Graphical User Interface

Acronym / Abbreviation	Meaning
HARA	Hazard Analysis and Risk Assessment
HIL	Hardware-in-the-Loop
HMI	Human Machine Interface
HW	Hardware
I/O	Input/Output
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
ITL	In-The_Loop
ITS	Intelligent Transport System
IVI	Infrastructure to Vehicle Information message
LDWS	Lane Departure Warning System
LKA	Lane Keeping Assist
LCA	Lane Centring Assist
LRR	Long Range Radar
LSG	Legal Safe Gap
MAP	MapData message
MIO	Most Important Object
MRR	Mid Range Radar
OS	Operating system
ODD	Operational Design Domain
OEM	Original Equipment Manufacturer
OOTL	Out-Of The-Loop
PAEB	Platooning Autonomous Emergency Braking
PMC	Platooning Mode Control
QM	Quality Management
RSU	Road Side Unit
SA	Situation Awareness

Acronym / Abbreviation	Meaning
SAE	SAE International, formerly the Society of Automotive Engineers
SCH	Service Channel
SDO	Standard Developing Organisations
SIL	Software-in-the-Loop
SPAT	Signal Phase and Timing message
SRR	Short Range Radar
SW	Software
TC	Technical Committee
TOR	Take-Over Request
TOT	Take-Over Time
TTG	Target Time Gap
V2I	Vehicle to Infrastructure
V2V	Vehicle to Vehicle
V2X	Vehicle to any (where x equals either vehicle or infrastructure)
VDA	Verband der Automobilindustrie (German Association of the Automotive Industry)
WIFI	Wireless Fidelity
WLAN	Wireless Local Area Network
WP	Work Package

10 APPENDIX 2. DATA LOGGING GUIDELINES

10.1 Log data documentation

Documentation of log data consists of 3 parts; requirements, terminology used in the documentation and the approach or rational for structured logging, specifications and examples.

10.1.1 Requirements

Requirements for collecting log data are defined from the evaluation perspective. From these requirements, several scenarios have been defined and collected in a document “**20200708_ENSEMBLE_ScenariosDescription.docx**”.

The main objective for which log data is collected is to evaluate the correct performance of the manoeuvres and the data communication performance between vehicles.

Safety intervention reports will be also collected during the test runs.

Basic data quality requirements for data logging and provisioning are also considered:

- Time synchronization
- Single and common formats
- Communication, message identification and tracing

Most notably, evaluation assumes that all applications logging data are time synchronized and that all log data is time synchronized. It is also assumed that time synchronization of applications has been verified and validated. Log data does not request redundant parameters to verify time synchronization or detect synchronization issues during piloting and evaluation.

The evaluation also assumes that the trucks and the communications have been previous verified and validated and the correct functionality is expected.

The data quality requirements are elaborated in data log specifications in the next sections.

10.1.2 Terminology

Terminology	
Log station	Station or logical entity with one or more applications that provide logging. A station can be for example an ITS-Station, a vehicle, device, platform or server. A station has a globally unique identifier; the **log_stationId**.

Log application *(optional)*	Application or logical component on a log station that generates logging. An application can be a hardware unit, software component, communication unit, sensor, or HMI device for example. Multiple applications in a single station may provide the same or similar logging formats and generate the same or similar log data items. All log data from all applications of a single station is considered to belong together, e.g. following the same trajectory. A station assigns an identifier to each application; the **log_applicationId**. The log_applicationId is unique within the station; i.e., the tuple <log_stationId, log_applicationId> is globally unique.
Log item	Single set of log parameters logged simultaneously from the same log_application as a single line or record in a log file.
Log timestamp	Timestamp when the log item is logged to storage. The timestamp is stamped by the log application or log station at the time of logging. The timestamps are assumed to be time synchronized with the other log_applications in the same station and between stations.
Event	Instance of period during which an event-full situation occurs. An event is defined from the perspective of a logging station. A driver or vehicle may define an event when starting join manoeuvre.
Event Type (Optional)	Type of events that occur in different form in different types of stations. An event type is defined for a specific service or function, and collectively defines sub events for the related communication, detection, control and actuation. The road works service is a type of event with different appearances in roadside units and in vehicles. A type of events is defined by a set of one or more event models.
Test run	Tests and pilots are logically organized in test runs and test sessions. Important for logging and data analysis is that all logging of all stations that cooperate (e.g., exchange messages) in a test run are collected in the same log data set and are not mixed or duplicated in other experiments.

Table 29 Terminology

10.1.3 Rationale and approach

The rationale and approach to data logging is extended from the approach to structured logging in the InterCor project. The InterCor deliverables are open and publicly available from http://intercor-project.eu/ , and intended to be re-used and refined for example for the evaluation of data communication and platooning functions.

The rationale for specifying logging is to enable automatic processing from decentralized generation and (remote) collection into a central repository, to analysis and reporting for evaluation and assessments. To realize this level of automation, structured log data must be provided in standard formats that can be processed using off-the-shelf tools.

To provide the flexibility to tune logging and analyses per project, services, technology and per project life-cycle step, log data is specified in successive steps for organizing and formatting.

1. Organization is specified in two steps:
2. Logical structure for generating logging
3. Parameters to define log data items.

Formatting of log data is also specified in two steps:

1. Encoding of the log data
2. File type for storing data.

10.2 Logical structure

10.2.1 Unique identifier for log applications

Systems under testing have a physical and logical structure for decomposition that is also implied in the generation and collection of logging. Every physical entity generating logging, such as a vehicle, station, device, server or platform, is globally identified as a *log_station* with a globally unique stationid. A *log_station* is composed of one or more applications that log data, such as sensors, communication units, service applications and human machine interface devices, each of which is uniquely identified as a *log_application* within the *log_station*.

A registry of all *log_stationids* and their *log_applicatioids* is maintained in the spreadsheet "**ENSEMBLE_Registration_StationIds_v0.1.xlsx**".

A convention should be defined for *log_stationids* in ENSEMBLE. For instance, the following coding could be applied for the RSU:

<log_stationid> = *Country Code* (2 digits) + *ITS G5 station id* (2 digits)

For example, IDIADA OBUs numbering can be: 3401, 3402, etc.

10.2.2 Types or layers of logging

This structure is the basis for specifying and organizing log data. Every *log_application* is considered as a black or grey box that generates log data independently of the others. *Log_applications* are organized into several types or layers within a *log_station*. A layer characterizes the type of interactions a *log_application* with external *log_stations* and internally with other layers. Figure shows the layers of a station.

HMI: *Log_applications* that present warnings and other information to drivers. It logs when it receives information from applications and when the information is triggered or revoked for presentation to the user, for example on an HMI display.

Application: In a narrower sense of the ETSI architecture, an application receives information from facilities, takes decisions, that are either sent to the HMI or other applications such as vehicle controls and automated driving applications. An application logs when it receives input, e.g., from communication, and when it takes decisions or actions.

Communication: A communication unit, stack or layer is considered as a separate *log_application* that logs when it receives messages from an external ITS-Station, or when it receives a request to send a message, and when it sends a message via the communication medium.

Vehicle Data: A *log_station* like a Vehicle ITS-Station has its own set of on-board sub systems that provide host and environmental data in parallel with communication. A sensor logs when a host position or speed is measured, when an object in its environment is detected, or when data fusion component detects an object from one or more sensor inputs.

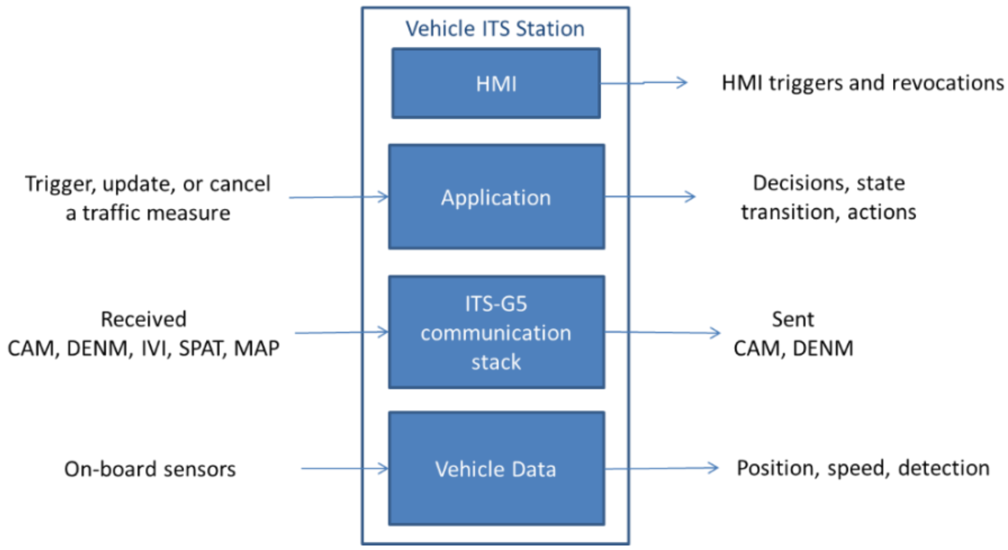

Figure 32 Logging Layers

For each layer, one or more *log_items* are defined. A *log_item* is a specified set of parameters that must be logged simultaneously by a *log_application* as a single item, record or line in a log file. Simultaneously implies that all parameters have the same *log_timestamp*. *Log_items* are specified in the following sections for example for a specific sensor type, message set, or application event model.

A *log_application* manages its own logging, time synchronization and time stamping. A *log_application* cannot mix its log data with another *log_application* because that would violate the integrity of time stamping. If for example a vehicle has two GPS sensors and a positioning and time unit, then each of the three 'sensors' log their own detections of time, position and speed at their own frequency and confidences.

If a *log_application* aggregates data from subcomponents that are also other *log_applications*, then the aggregated data is considered as a new 'sensor' and logged separately from the logging of the subcomponents. A data fusion *log_application* logs the fused detections, independently of the logging of the vehicle camera and radar. A Vehicle Data Provider is a *log_application* that aggregates CAN data signals and logs a single measurement by interpolating all CAN signals at a single timestamp.

The structure of layers and hierarchies of *log_applications* may seem redundant for a single log purpose. However, this structure enables to switch logging on or off for specific *log_applications* or subcomponents, without affecting the integrity of log specifications and component implementations. During verification for example, detailed logging can be collected for sensors, data fusion and communication. Redundancy in the logging is purposeful and needed for verification of dependent components. Once verified and validated to correctly trigger the applications and the HMI, these log levels can be switched of reduced to only HMI logging for evaluation purposes.

10.3 Log item and log parameter

A comprehensive list of *log_parameters* (signals) is defined for logging in spreadsheets that will be identified in the sub sections.

A *log_parameter* is defined with a unique and global name, unit, data type and precision, possibly with a range of allowed values, and other quality criteria. Parameters are logged in SI units.

A *log_item* is a specified set of parameters that must be logged simultaneously by a single *log_application* as a single item, record or line in a log file:

- A parameter is mandatory in a *log_item* if it is essential for analysis.
- Optional parameters can be logged for more detailed analyses.
- New parameters can be added for one-off analysis or debugging and could be ignored in automated data analyses.

The rational for a comprehensive list of parameters is that the single parameter is logged and processed in the same manner by all *log_applications* and in all *log_items*, while data processing remains unambiguous as no ad-hoc or device specific scaling or transformations are necessary.

Parameter names are also defined globally without including references to a specific sensor, component or application. For example:

- Timestamp is in a single time format, time zone and time unit: as UNIX epoch time in msec since 01-01-1970 in UTC.
- Position in WGS'84 coordinates (latitude, longitude, elevation, heading)
- Speed is defined in SI units in [m/s].

A speed can be logged from alternative physical and virtual sensors, nevertheless the parameter is 'speed' in m/s. The log_applicationid is enough to distinguish the sensor generating the speed measurement. No need to use specialized names and analysis scripts for GPS_speed, gpsspeed, GpsSpeed, RTK_GPS_speed, OXTS_RTK_GPS_speed ...

10.3.1 Vehicle data

Vehicle data is data collected from in-vehicle systems such as sensors, vehicle state estimators, vehicle kinematics, position and timing. Vehicle log data is specified in the "WP4-Measurements+Tests_v1.xlsx" spreadsheet with the objective to specify a format that is 'common' and 'natural' for logging each of the sources of vehicle data.

Vehicle data contains different types of data sources:

- Generic vehicle data (e.g., from the CAN bus)
- Data from positioning systems
- Data of vehicle controls to distinguish driver activity, automated controls and driver interventions.
- Data from vehicle sensors about detections of objects in the vehicle's environment. It contains detections with locations in absolute WGS'84 coordinates, and detections with locations (x, y) relative to the vehicle coordinate system; i.e. in longitudinal and lateral distances from a vehicle-based origin. Detections needs only be logged once in either absolute or relative coordinates.

10.3.2 Communication data

Communication logging is collected mainly for the purpose of evaluation communication performance, such as communication delays, reliability and effective communication range.

The approach and formats for communication logging are specified in **ENSEMBLE**_CommonCommunicationLogFormat_<version>.xlsx.

The approach to communication logging is based on a few simple principles:

- Meta information is logged about communication:
  - Communication action identifying whether a message is 'SENT' or 'RECEIVED'
  - Timestamp of the action when the message is sent or received
  - Message type, e.g. the type of ITS-G5 message
  - Message identifier, which is either a:
    - UUID[1], or
    - tuple of data elements for the message type.
- Location of the log_station where the message is sent or received.
- The contents of the message are not relevant and need not be logged for evaluating communication performance.
  - If the contents or payload of a message should be logged, then it shall be logged exactly as defined by the standard for the message type, and
    - Either using the standard encoding, or
    - Using the fully decoded data elements and structure.
    - This avoids any proprietary interpretations and decoding scripts for logging and analysis.
    - ITS-G5 messages (CAM, PCM (Platoon Control Message), PMM (Platoon Management Message)) are specified for normalized and decoded message contents **ENSEMBLE**_CommonCommunicationLogFormat_<version>.xlsx.

10.3.3 Application data

Events, actions and decisions of AD functions and services that are affected by V2X communications should be logged. In the logging terminology, these events, actions and decisions are considered application logging.

10.3.4 HMI data

HMI data should be also logged to ensure that the driver is correctly informed according the data received.

10.4 Encoding

Log_applications natively use a variety of encodings for processing and exchanging information. The objective is to also use the native and common encoding in log_items to minimize processing load on the logging devices. For example:

- C-ITS messages are typically UPER encoded when communicated via ITS-G5, while XER encoding when the same messages are exchanged between roadside and central units
- DATEX-2 messages can be encoded in XML messages. (Open road)
- GPS or GNSS sensors typically provide measurements in NMEA.
- Numerical data or text strings are provided in UTF-8 (ASCII, Unicode)

The rational for logging data is to avoid any unnecessary encoding by log_applications, and instead allow logging data in native encodings. Decoding of any standard can also be executed as part of the post processing.

10.5 File type

Log_applications store *log_items* in files of standard file type or database type. The choice is made in ENSEMBLE to provide all log data (except for communications logging) in **comma-separated values (.csv)** files for numerical and string values. The communications logging will be provided in **JavaScript Object Notation (.JSON)** format.

The delimiter in a .csv file is a **comma**, not a semi-colon, other character or tab.

Note that encoded data is represented in a single string value in the csv file (see next section for file examples).

String values in a .csv file are by default without quotes, for example as:

```
..,string,..
```

in which case double (or single) quotes may not appear in the string value.

Alternatively, the string value may be enclosed with single quotes to make life easier for Excel users and for using JSON string values (see next section for file examples):

```
..,’str”i”ng’,..
```

10.6 Log files

A *log_application* generates a *log_item* by collecting parameters from a ‘raw’ measurement or data interface, uses a standard encoding, and stores the *log_item* in a standard file format. All log files from all stations and applications from a single test run are collected for analysis. Therefore, some strict guidelines need to be followed for generating and organizing data for automated analyses:

- All log files from a test run are collected in a separate file structure or data base.
- Log-items of the same type may be collected in the same file from multiple log_applications or log-stations.
- The first line in a log file is the header line defining all parameter names contained in the file. The parameter names should be the same as defined in the log_item tab of the corresponding spreadsheet.

10.6.1 File name

All log data must follow the file naming convention before. File naming identifies the structure, encoding and format of a log_item:

```
<log_item>_<log_stationid>_<utc_time_iso8601>[_<encoding>].<filetype>
```

The <log_item> is the name of the device in the spreadsheet defining the log_item. For communication logging, the <log_item> is the <message_type> such as “CAM”. For vehicle data logging, the <log_item> is for example “vehicle” or “positioningsystem”. For application logging, the <log_item> is for example “platooningevent” and “platooningaction”.

The <log_stationid> is the log_stationid generating the logging.

The <utc_time_iso8601> is the timestamp of the first log_item in UTC time and in ISO 8601 format:

```
YYYYMMDD'T'HHmmss
```

The <encoding> is mandatory if the data is provided as a single encoded value.

File Name	Content
Vehicle_3901_20190124T103235.csv	Vehicle data from Station ID 3901 logged in the 24/01/2019 at 10:32:35.
PositioningSystem_3101_20190124T103235.csv	GPS data from Station ID 3101 logged in the 24/01/2019 at 10:32:35.

EnvironmentSensorsAbsolute_3301_20190124T103235.csv	Vehicle sensors data from Station ID 3301 logged in the 24/01/2019 at 10:32:35.

Table 30 File name examples

10.7 Test descriptions

All log data of single test run must be uploaded to the IDIADA Test Server and to the Central Test Server (CTS). Additional test description fields need to be provided when uploading the log data.

To harmonize the usage of the test data descriptions for evaluation and validation purposes and searching test runs on the CTS, a test plan and specific usage of the test description fields are specified in following sub sections.

10.7.1 Text context

The context of a test run is the environment set up for testing vehicles, devices and users in the test scenario and session.

Parameter Name	Description and value enumeration
Number_Of_Vehicles	Integer of the number of test vehicles used in the test session
Traffic	Classifies the state of traffic in the test environment. The value can be selected from the enumeration: • Normal • Congested The value 'Normal' is the default and can also be used if the traffic state is irrelevant for the test.
Road	Classifies the state of the road surface in the test environment. The value can be selected from the enumeration: • Normal • Slippery • Precipitation • Snow • Ice The value 'Normal' is the default and can also be used if the road condition has no influence on the test.
Weather	Classifies the state of the weather condition during the test. The value can be selected from the enumeration: • Normal • Fog

	• Heavy rain • Snow • Ice The value 'Normal' is the default and can also be used if the weather condition has no influence on the test.
Safety_Limitations	Free text field describing any limitations on vehicles or V2V service and their use of automated driving modes, such as: - required or expected actions (interventions) of drivers in automated driving modes such as steering or braking to enable or disable automated driving modes - usage of V2V data sources in combination with automated driving modes, or vice versa (dis)abling of automated driving modes in combination with the usage of IoT data sources and services.

Table 31 Text Context

10.7.2 Safety intervention report

Any human intervention by a user to disengage an automated driving mode, function or (safety-relevant) service in real-traffic conditions or during a pilot test run is considered a safety incident or intervention that should be reported.

Parameter Name	Description and value enumeration
Timestamp	Approximate timestamp of the intervention. This is necessary to align the log data and retrieve the IoT data for the intervention.
Intervention_Type	Type of intervention is determined by the who or what intervened during automated driving.
Intervention_Cause	Assumed cause of the unsafe situation that required the intervention. The value can be selected from the enumeration: • Weather condition • Inattentive road user • Unwanted vehicle manoeuvre • Perception discrepancy • Hardware discrepancy • Software discrepancy • Road works • Emergency vehicle • Road surface condition • Obstacle on the road

	• Other	
Intervention_Description	Free text to describe the period or step in the test plan of the intervention, environmental conditions, the intervention (and who or what intervened and how) and assumed cause.	
Severity_Perception	Assess the severity of the safety risk and the required intervention. The value can be selected from the enumeration:	
	• Dangerous	An accident could have happened if the subject would not have intervened, e.g. a system failure that can cause an accident and only the reaction of the driver could avoid it.
	• Moderate	An accident could have happened, but the intervention to avoid it was trivial or automatic, e.g. a system failure could have caused an accident, but there are means that act automatically or the driver is warned in time to avoid the accident.
	• No risk	Even if the subject wouldn't have intervened, there was no risk, e.g. the driver has intervened in response to a system fault, but if he hadn't then an accident was unlikely to happen anyway.
AD_Vehicle_Situation	Free text to describe the activated AD functions and systems, their modes/states, and observed behavior or malfunctioning.	
V2V_Situation	Free text to describe the usage of V2V data sources, and clearly indicate whether and how V2V data is used for automated driving during the unsafe situation and intervention.	
Traffic_Situation	Free text to describe or sketch the traffic situation, traffic control and road users.	

Table 32 Safety Intervention report

10.8 Data storage

The amount of data to be recorded will be approximately 1MB/min for the V2X messages, 20MB/min for each camera, and 968MB/min for the raw lidar data.

Each V2X message is expected to be around 200B, assuming a frequency of 10Hz this would be 2KB/s and 120KB/min. Considering multiple trucks the data load should be less than 1MB/min.

For each camera, the amount of data recorded will depend on the resolution and frame rate along with the encoding of the video. Approximately 5-20MB for HD or full HD.

The lidar packets have 12608 bytes each. And the maximum output rate is 1280 packets/sec. So 968MB/min. This depends on the resolution and frequency and could also be 484MB/min or 242MB/min.

10.9 Data quality check

In order to ensure the quality of the data in the Storage platform, a quality check will be performed before uploading it to the Test Server. This quality check should be done automatically through scripts and this will be only possible if the logging has been done following the guidelines described in the chapters before.

The quality check will consist on:

1. Assessing and quantifying **missing data**. The set of data needs to be complete in order to ensure a correct validation and evaluation.

2. Controlling **data values** and **units of measure**. The data values shall be inside the range agreed in the Data Requirements spreadsheet. The units of measure shall also be aligned with the Data spreadsheet.

3. Checking that all the data are **synchronized**. One device (usually the GPS) should be used to synchronize all the logs from different devices to make the validation easier.

4. Checking that the data are **timestamped**. Timestamp is a mandatory field from each log file.

5. Checking that the data are compliant to the predefined **data format**. Ensure that the logging has been done following the log documentation guidelines provided in this document.

6. Checking that the **data is clearly identified** by station id and application id. The spreadsheet where all the devices are listed and identified with a unique ID should be aligned with the logging files in order to track and identify correctly all the messages.

10.10 Data Sharing

The text in this section is derived from the work done in the FOT-Net Data project (fot-net.eu) for sharing data from field operational tests. The results of this work are described in the Data Sharing Framework (http://fot-net.eu/Documents/data-sharing-framework/)

ENSEMBLE is a test project which will generate raw data like those from the previous FOT/NDS projects. Therefore, as far as data sharing is concerned, it should refer to the guidelines developed in the projects as a start point and take into consideration the regulation for sharing data generated.

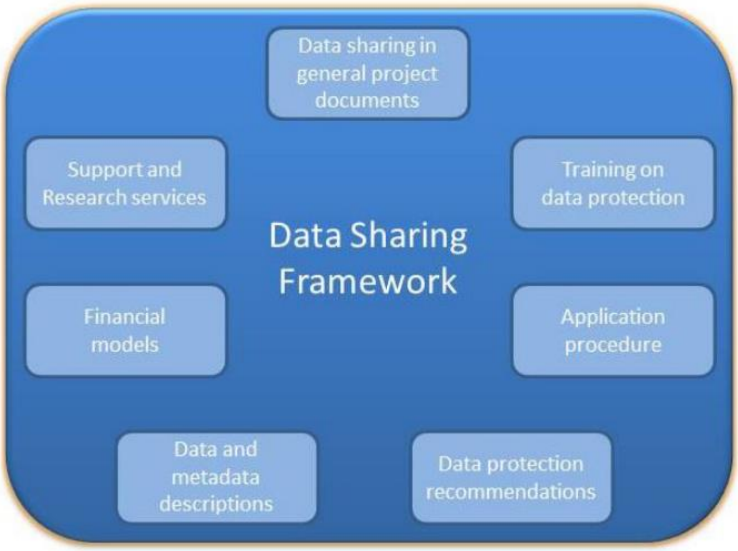

Figure 33 Data Sharing Framework

As a summary, the FOT Data Sharing Framework (FOT-DSF) consists of seven elements as briefly described as follows:

- Project agreement content, including guidelines and checklists to incorporate the prerequisites for data sharing in the agreements, which together with legal and ethical constraints form the conditions for data sharing. The project agreements include the grant agreement (together with the description of the work), the consortium agreement, the participant agreement and external data provider agreements
- To facilitate the understanding of the context in which the data was collected and the validity of the data. These include a suggested standard for the documentation of the data and metadata, divided into 5 categories: ENSEMBLE study design and execution documentation, descriptive metadata (e.g., how the data is calculated), data (e.g., sampling frequency), structural metadata (e.g., how the data is organised) and administrative metadata (e.g.,

access procedures).

- This element consists of security procedures and requirements at both the data provider and analysis sites, including detailed implementation guidelines, to ensure that the personal and confidential data issues in ENSEMBLE are adequately considered and appropriate actions are taken.
- This element is concerned with security and human subject protection training for all involved personnel. Issues include who should be trained and when, what content should be part of the training (including detailed suggestions), how to do the training, and how to document it.
- To identify and select tools for data processing, analysis and interpretation and facilitate the performance of research tasks.
- To provide funding for the data to be maintained and available, and data access services.
- To provide detailed content lists to address when developing application procedures and data application forms.

In the FOT-Net Data Sharing Framework ((http://fot-net.eu/Documents/d3-1-data-sharing-framework/) the following recommendations are given for working with participants from the general public and with external data providers.

For the following questions, it is beneficial for the project partners to develop common answers as early as the application phase:

- Who will own the data?
  - ENSEMBLE consortium?
- May third parties have access to the data? To what extent? Under which conditions?
- Where will the data be stored during and after the project? Who is responsible for maintaining the data?
  - During the project will be stored in IDIADA servers and IDIADA will be responsible of it.
  - After the project, (need feedback from TNO)
- How will the data be accessed? Who will be the Data Administrator?

- Are there legal and ethical or post-project funding constraints to be considered?

From a data-sharing standpoint, it is especially important to describe:

- Where the data will be stored and who is responsible for the data.
- Who (project partners/third parties) will have access to what data and on what conditions, during and potentially after the project?
  - Project partners (and third parties?) will have access to the data during the project. Need feedback from TNO.
- An overview of the access procedures.
  - User and password provided by IDIADA.
- How anonymity will be ensured.
  - Proposal: Remove IDs from the datasets.
- Agreements and consents from the participants, directly related to data sharing.
  - Need a document for the consent?

For external data provider agreements:

External data providers could be companies providing sensor systems, map data, weather data or other services that the project needs to enhance the dataset. Contracts and NDAs should be signed. It is important to be aware of topics that can affect future research due to possible restrictions in data use. Attention from a data-sharing perspective should be given to answering the following questions:

- What is regarded as confidential information and what can be shared?
- Can confidential data be anonymised/changed/aggregated, to allow for more open access?
- Can the data be accessed by another project partner/third party?
- Can the data be transferred to another project partner/third party?
- Are there restrictions on what the data can be used for?
- Are there special conditions for sharing and re-using the data after the project?
- What happens if the external data provider is bought by another company?

For more detailed information and recommendations we refer to the Data Sharing Framework (http://fot-net.eu/Documents/d3-1-data-sharing-framework/).