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ENabling SafE Multi-Brand pLatooning for Europe

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1. EXECUTIVE SUMMARY

1.1. CONTEXT AND NEED FOR 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 take-up of (sub)system development and implementation and to enable harmonization 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 in order 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 with acceptance criteria.
- Year 2: implementing this reference design on the OEM's trucks as well as performing impact assessments with several criteria.
- Year 3: focus on testing the multi-brand platoons on test tracks and international public roads.

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

This deliverable starts with an update of the regulatory framework in which ENSEMBLE project is working on. This update consists of two parts:

- Analysis of the updates in regulatory framework since the publication of the Deliverable 6.10, such as: R (EU) 2019/2144: New General Safety Regulation, WP29-177-19: Framework document on automated/autonomous vehicles or GRVA new structure
- Exemption procedure for the EU approval of automated vehicles

The deliverable continues with a review of the exemption procedures from past experiences and other projects in which some partners such as IVECO, MAN, IFSTTAR and DAIMLER have

participated. A specific questionnaire was created and filled out by the task partners in order to analyse their answers and get an overall idea of exemption procedures in various countries.

In addition, this deliverable describes the existing exemption procedures in some of the Member States involved in this project, including its requirements in order to grant these exemptions. In particular, the exemption procedure in Spain is detailed taking into account that the open road tests will be carried out on Spanish roads.

The last part of the deliverable is an assessment of the tests required before performing open road testing. These tests are defined considering and assuring the safety of the systems and the vehicle.



2. INTRODUCTION

2.1. Background

This document corresponds to the first version of the results obtained for subtask 6.3.2 “Exemption procedure for multi-brand platoon testing across borders in multiple Member States”, which is the second part of the main task 6.3 “Regulatory framework evolution for platooning”, led by IDIADA Automotive Technology.

2.2. Aim

The aim of this Deliverable can be divided into two main blocs. The first one is to collect all the information available on the different exemption processes available from the different Member States and previous experiences from the members of the project. Special attention will be paid to the information available in the countries where the final event will take place, as well as Spain, where it is anticipated that the open road tests will take place.

The second one is to pave the way to propose a mutual recognition of exemption procedures between involved Member States to expedite the testing phase of multi-brand platoons. This deliverable will not define this mutual recognition exemption procedure but will analyse the common requirements in the different Member States and will propose a harmonized set of requirements, considering a future scenario where truck platooning is a reality.

2.3. Structure of this report

The core body of this report can be divided into six parts:

1. Review of the current regulatory framework related to truck platooning. Some months have passed since D6.10 was submitted and the status of the work performed in UNECE and Brussels since then has evolved substantially. An explanation of the latest regulatory changes and discussions are described.
2. Description of the past experiences related to platooning from the various partners involved in the project.
3. Description of the state of the art of existing exemption procedures in the Member States where there is an existing framework.
4. Exemption tests in Spain. Special focus on the procedures defined in Spain to apply for the exemptions to test on open road.

5. Definition and justification of the selected tests. A clear differentiation between which prior tests are strictly required for the open road tests and which ones are intended to further understand the platooning function.
6. Conclusions.



3. PLATOONING AND UPCOMING REGULATIONS

An increasing number of activities have been carried out in the different working groups from Geneva (UNECE) and the European Commission since Deliverable 6.10 was submitted. In this section to better contextualize the present Deliverable, the regulatory framework will be analysed and updated so as to understand better the framework in which the ENSEMBLE project is working.

Note that, in this section only the Type-Approval concerns will be discussed. This section will not include considerations for permissions for each Road Authority at national level. For more information about driving permission at a national level, please refer to Sections 5, 6 and 7.

3.1. Introduction to the main updates related to regulatory framework

Up to now, requirements for platooning are not covered by any regulation or standard. On the one hand, and with the purpose of improving road safety, in December 2019 the European Union introduced the new General Safety Regulation (EU) 2019/2144, which introduces advanced safety requirements that will be regulated as of 2022 [1].

The European Commission decided that, due to its potential, platooning can bring safer, cleaner and more efficient transport in the future. As a consequence, relevant standards and regulatory framework would be needed in order to encourage such technology in a safe manner.

On the other hand, within UNECE and the World Forum for Harmonization of Vehicle Regulations (WP.29), GRVA (Group of Experts on Automated Driving) is the group that discusses all the aspects related to autonomous driving and proposes recommendations or guidelines that may become new UN Regulations.

During 2019, a framework document on automated/autonomous driving (WP29-177-19) [2] was presented as the basis for further development of a series of vehicle safety topics (always looking for a higher level of safety). The list included:

- System Safety
- Failsafe Response
- Human Machine interface (HMI)
- Object Event Detection and Response (OEDR)
- Operational Design Domain (ODD/OD)
- Validation for System Safety

- Cybersecurity
- Software Updates
- Event Data Recorder (EDR)

These priorities are dealt with or discussed in specific working groups directly dependent on GRVA.

3.1.1. GRVA new structure

United Nations Regulations are standards that have been accepted and recognized by all the signatories of the 1958 agreement. Moreover, most of these regulations become mandatory under European laws.

As a result of the growing importance of autonomous and connected vehicles, in 2018 WP.29 started to develop a dedicated subsidiary working party called GRVA. Taking into account the main objectives reflected in the framework document for automated vehicles, different informal groups were established in order to address the different topics. The current structure can be seen in Figure 1.

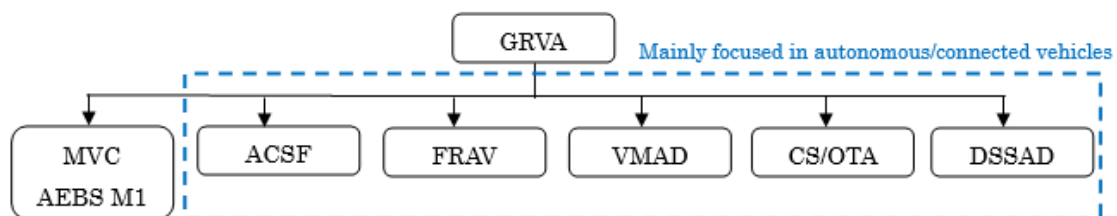


Figure 1. GRVA Informal Working Groups structure

FRAV (Functional Requirements for Automated and Autonomous Vehicles)

This informal working group is developing the functional requirements for automated/autonomous vehicles. In particular, the combination of different driving functions: longitudinal control, lateral control, environment monitoring, minimum risk manoeuvre, transition demand, human machine interface and driver monitoring. FRAV also takes into account the failsafe response in order to validate the system safety, that in so many cases is evaluated by the manufacturer during the development phase by implementing ISO 26262 for Functional Safety.

VMAD (Validation Method for Automated Driving)

VMAD's objective is to develop an assessment method capable of validating the safety of automated systems based on a multi-pillar approach. This new certification approach includes audits, simulations, virtual testing, test track and real-world testing. As for conventional test methods, it is not possible to evaluate all the challenges raised for automated driving. The new assessment and test method does not replace the current testing, but complements it.



The group is developing a new certification approach based on the following pillars as described in Figure 2.

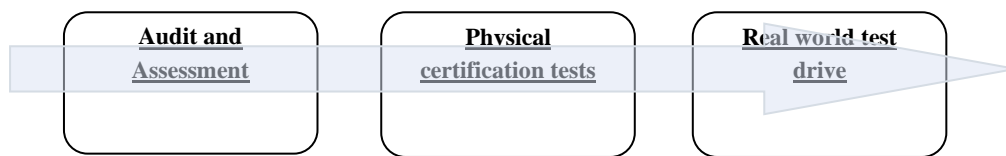


Figure 2. Multi-Pillar Approach

The first step of the certification starts with the audit of the development process. Analysis of the safety concept and functional safety must be performed on complex electronic systems within the classical certifications. Currently this evaluation is growing in importance, so it is necessary to standardize it.

This first pillar is not limited to an audit, as some simulations can be used as validation of the system during the development process.

Once the initial assessment has been done, the next stage is to match the results obtained with proving ground tests. On proving ground, special cases can be reproduced in order to evaluate the real behaviour of the vehicle, focusing on scenarios and conditions considered as “*edge conditions*”.

Finally, the behaviour of the system on public roads is evaluated trying to achieve a given set of scenarios to cover all the possible common situations.

3.1.2. New General Safety Regulation (EU) 2019/2144

In December 2019, a new version of the General Safety Regulation was published in the Official Journal of the European Union. This Regulation applies to vehicles of categories M, N and O, as defined in Article 4 of Regulation (EU) 2018/858 [3], and to systems, components and separate technical units designed and constructed for such vehicles.

Over the past decades the developments introduced in vehicle safety have contributed to the reduction in the number of road fatalities and injuries. Following this path, the European Union’s main objective is to reduce these numbers even more, through new safety measures for both vehicle occupants and vulnerable road users. It will gradually introduce advanced safety systems offering new possibilities to reduce casualties. Starting from 2022, new motor vehicles must be equipped, among others, with the following systems:

- Intelligent speed assistance: system to aid the driver in maintaining the appropriate speed for the road environment by providing dedicated and appropriate feedback.
- Alcohol interlock installation facilitation: standardized interface that facilitates the fitting of aftermarket alcohol interlock devices in motor vehicles.

- Driver drowsiness and attention warning: system that assesses the driver's alertness through vehicle systems analysis and warns the driver if needed.
- Advanced driver distraction warning: system that helps the driver to continue to pay attention to the traffic situation and that warns the driver when he or she is distracted.
- Emergency stop signal: light-signalling function to indicate to other road users to the rear of the vehicle that a high retardation force is being applied to the vehicle relative to the prevailing road conditions.
- Reversing detection: system to make the driver aware of people and objects at the rear of the vehicle with the primary aim of avoiding collisions when reversing.
- Event data recorder: system with the sole purpose of recording and storing critical crash-related parameters and information shortly before, during and immediately after a collision.

Thanks to the technological progress of advanced vehicle safety systems, these new safety measures are already available.

According to clause 25 of the New General Safety Regulation, one of the functions that shall be regulated in upcoming years is platooning:

“(25) Vehicle platooning has the potential to bring about safer, cleaner and more efficient transport in the future. In anticipation of the introduction of platooning technology and the relevant standards, a regulatory framework with harmonized rules and procedures will be needed.”

Additionally, in Article 3 regarding definitions, the Regulation is updated with “*vehicle platooning*” is introduced, among others:

(24) ‘vehicle platooning’ means the linking of two or more vehicles in a convoy using connectivity technology and automated driving support systems which allow the vehicles to maintain automatically a set, close distance between each other when connected for certain parts of a journey and to adapt to changes in the movement of the lead vehicle with little to no action from the drivers;

Table 1 summarizes the application dates for systems regarding trucks.

System	New Types	New Registrations
Pedestrian and cyclist collision warning	July 2022	July 2024
Blind Spot Information System	July 2022	July 2024
Reversing Detection	July 2022	July 2024
Protection against Cyberattacks	July 2022	July 2024
Intelligent speed assistance	July 2022	July 2024
Emergency Stop Signal	July 2022	July 2024
Alcohol Interlock installation facilitation	July 2022	July 2024
Driver drowsiness and attention warning	July 2022	July 2024
Advanced driver distraction warning	July 2024	July 2026
Event Data Recorder	Jan 2026	Jan 2029
System to replace driver's control	July 2022	July 2024
Platooning	July 2022	July 2024
Reversing motion	July 2022	July 2024

Table 1. Systems application dates for trucks according to Annex II of General Safety Regulation (EU)2019/2144

For automated vehicles and fully automated vehicles, the Regulation also adds a set of technical specifications that these vehicles shall comply with in order to add safety to the functions. So, in the case of platooning systems of SAE level 3, more technical requirements would be considered at the time of implementation. The list of technical requirements includes:

- Systems to replace the driver's control of the vehicle, including signalling, steering, accelerating and braking.
- Systems to provide the vehicle with real-time information on the state of the vehicle and the surrounding area.
- Driver availability monitoring systems.

- Event data recorders for automated vehicles.
- Harmonized format for the exchange of data for instance **for multi-brand vehicle platooning**.
- System to provide safety information to road users.

Technical requirements for automated vehicles

From all the technical requirements described above, only a few of them are currently developed by the WP.29 or the European Commission. These requirements will have to evolve in parallel to the Regulations of the systems specified in Table 1 of this section, in order to ensure the full deployment of autonomous vehicles and systems.

One of the system requirements that is being developed from 2019, and which is intended to be presented to GRVA by the end of 2020, is the Event Data Recorder.

Requirements for event data recorders

The event data recorders must be capable of recording and storing a period shortly before, during and after a collision. The regulation defines a minimum range of variables that should be collected, such as vehicle speed, braking, position of the vehicle on the road, state and activation of the safety systems, among others.

These systems will be permanently activated and will protect the data against misuse or threats. One of the main objectives of the implementation of the system is to create a standardized accident database, made available for all the National Authorities, for analysis and research.

Currently, two new regulations establishing the requirements and testing for Data Storage System for Automated Driving (DSSAD) and Event Data Recorder (EDR), are being discussed in an informal group of GRVA, subsidiary group of the World Forum of Harmonization (WP.29).

The purpose of the EDR is to collect data valuable for effective crash investigations and analysis of safety equipment performance. This data will help the Authorities in the understanding of crashes, so this will be mandatory both for vehicles fitted with automated systems and conventional vehicles. On the other hand, DSSAD are intended for determining who is responsible for the driving actions in a wide-time window. In this direction, a first draft of this regulation is already published introducing requirements for Automated Lane Keeping Systems (ALKS), that is anticipated as the first SAE level 3 system that will be regulated (only for passenger cars in the initial stage).



Target Vehicle	Data relevant to	
	Accident Configuration	Who was driving
Vehicles	EDR	-
Automated/ Autonomous Vehicle		DSSAD

Table 2. EDR and DSSAD vehicles coverage [4]

3.2. Exemption Procedure for the EU approval of automated vehicles

While there is not yet a new regulation establishing the platooning requirements, there are other procedures that allow an exemption for new technologies or new concepts. Any Member State may grant a provisional approval to these technologies for its territory.

In 2018, the European Commission presented a guideline for an exemption procedure for the EU approval of automated vehicles [5].

The main purpose of the document is to harmonize the approach of the Member States when approving unforeseen technologies under EU rules. These new concepts that are not compatible with existing rules, may obtain an exemption through Article 20 of Directive 2007/46/EC [6], which will be replaced by Article 39 of Regulation (EU) No 858/2018 [7] on vehicle approval and market surveillance. With the guideline, this exception is standardized ensuring the safety of the vehicle, transparency between Member States and mutual recognition.

“ 1. Member States may, on application by the manufacturer, grant an EC type-approval in respect of a type of system, component or separate technical unit that incorporates technologies or concepts which are incompatible with one or more regulatory acts listed in Part I of Annex IV, subject to authorization being granted by the Commission in accordance with the procedure referred to in Article 40(3)”

The approval of the system may be granted by the European Commission by means of an implementing act based on the guidelines, giving validity to the approval that can be limited to 36 months or by number of units.

In May 2018, the European Commission adopted an EU strategy on automated and connected mobility, and part of the strategy was the creation of a guideline to ensure a harmonized approach for the exemption procedure for EU approval of automated vehicles.

The focus of the guidelines is automated vehicles that can drive themselves in a limited number of driving situations which are already being tested and are expected on a commercial basis from 2020, such as platooning.

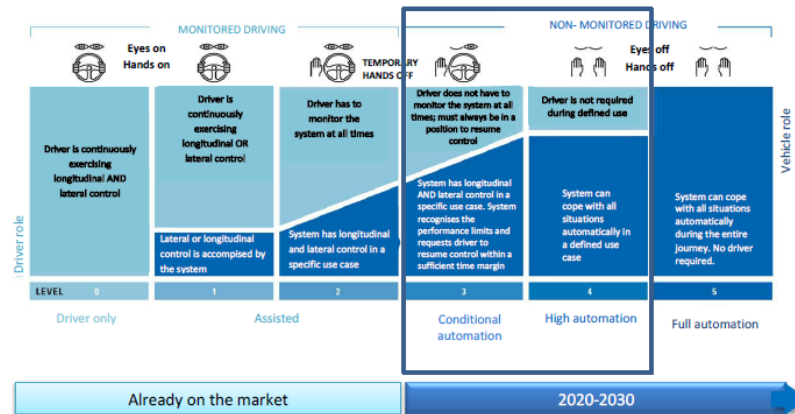


Figure 3. Levels where Article 20 of Directive 2007/46/EC / Article 39 of Regulation (EU) No 858/2018 could be applied

The design and validation process must be agreed by the Technical Service and confirmed by the Approval Authority with the following requirements:

- Safety Requirements: it shall be checked that the automated vehicle mode can replace the driver action in the entire Operation Domain (OD) defined by the manufacturer. In automated driving mode, the vehicle shall not cause any traffic accident that is preventable and shall also follow the driving rules of the country.

It is also important to evaluate if the vehicle or the automated system has been designed according to any “safe-by-design” method. This means that during the development of the system, a safety concept has been used to cover the different steps of the process.

- Driver/passenger interaction: this includes various kinds of interactions. First of all, the driver shall recognize the status of the autonomous system and it shall only be activated when all the conditions of the operational domain are met. Secondly, if the system can require the driver to take control of the vehicle in certain conditions or environments, other systems have to be available, such as driver monitoring systems and specific warnings.
- Transition of the driving tasks: if the vehicle may request the intervention of the driver, this shall also be tested and validated in order to ensure that the system warns the driver in enough time.
- Minimum risk manoeuvre: when the system detects a situation out of the OD that could lead to a danger for the driver, it shall be able to transfer from a minimal risk condition with a minimal risk manoeuvre. When this happens, the other road users shall be informed about the vehicle status in accordance with applicable traffic rules.

- Event data recorders: as explained before, data recorders are needed in order to obtain data about the operational status of the system. In this case it is also required to collect data about who is responsible at a given moment.
- Cybersecurity: while the new Regulation on cybersecurity is not yet published and in force, the guideline describes requirements for protecting the vehicle against hacking and threats. A risk assessment shall be performed by the manufacturer and the relevant mitigations presented.
- Safety assessment and tests: systems shall be designed to cope with the risks that could impact safety functionality and failures. This can be achieved demonstrating that the system has been designed according to ISO 26262, on Functional Safety or an equivalent method. The functional safety analysis is carried out by a Technical Service or Approval Authority, by means of manufacturer's documentation analysis as well as testing verification.
- Information provision to automated vehicle users: lays down the minimum documentation that the manufacturer must provide to vehicle users informing about all the relevant points of the vehicle.

4. PREVIOUS PROJECTS AND PAST EXPERIENCES

As described in Section 3 of deliverable D6.10, there have been previous projects and experiences related to platooning such as COMPANION, CARTRE or ETPC. In order to collect all the information available, not only from the projects mentioned, but also from the experiences that the partners of the project might have, a questionnaire was shared within the consortium.

The questionnaire was divided into four groups:

- Administrative Procedure: questions prepared in order to gather all the information regarding platooning legal procedure.
- Vehicle Control: questions prepared in order to find out the requirements of the vehicles and what tests the vehicles should perform before being allowed to test on the open road.
- Test Control: questions prepared in order to get the information related to test conditions, weather, test tracks or in which situations platooning is allowed.
- Other: questions prepared in order to get other relevant information such as what information OEMs take into account to do a platoon.

In Table 3 below the questions included in the Questionnaire are described.

Administrative Procedure	Is there already, an applicable law/legal procedure to get the license exemption to drive in platoon mode or similar?
	What is the expected duration of the administrative process?
	What is the required information from the driver?
	Is it mandatory to have a specific insurance?
	Is it needed to specify the route in the application for a permission?
	Is there any defined way to report an incident during testing?
	Who is the responsible for the procedure?
	How is the technical information presented to the road authority?
Vehicle Control	Is there any vehicle-type regulation to be exempted?
	Shall the vehicles be type-approved?
	How to declare the number of vehicles involved?
	How are those vehicles identified?
	Is there any way to register the on-board results?
Test Control	Is there a specific technology mandatory to test?
	Are third party witnesses required during testing?
	Which is the gap between truck limitation?



	Are extra visibility elements required?
	Is there any restriction due to climate conditions?
	Is there any actuation procedure in case of unexpected events?
	In which situations should the platoon break?
	Shall the technology be previously tested in test tracks?
Other	Is there any extra requirement not taken into account yet?
	Could previous tests with others road authorities be recognized?

Table 3. Questionnaire classification

4.1. Questionnaire results

The questionnaire was launched during the first half of 2019 and was shared mainly with WP6 partners. The main objective was to get information from the different Member States through the past experiences from the partners.

The following feedback was received from the following partners:

- IVECO (Italy), Ministero delle Infrastrutture e dei Trasporti – MIT
- MAN Truck & Bus SE (Germany, Bavarian), Bayerisches Staatsministerium des Innern, fuer Bau und Verkehr (Bavarian State Ministry of the Interior, for Building and Transport, Germany, 2018)
- IFSTTAR (France)
- Daimler AG (Germany, Baden), GER State of Baden Württemberg

ERTICO also provided information about the experience gathered in the European Truck Platooning Challenge (ETPC). Details collected by OEMs in the different countries where the ETPC took place were provided, but the questionnaire was not completed.

In the following sub-sections, a summary of the results obtained through the questionnaire are presented.

4.1.1. Administrative Procedure

It is important to identify which are the administrative procedures requested and asked in the different Member States. Table 4 shows the summary of the answers collected via questionnaire.

Administrative Procedure				
QUESTION	IVECO	MAN Truck & Bus SE	IFSTTAR	Daimler AG
Is there, already, an applicable law/legal procedure to get the license exemption to drive in platoon mode or similar?	"Smart Road" decree law	<p>- Exemption to go below LSG: subject to the regulations of '§ 46 Abs. 2 Satz 1 StVO'</p> <p>- Exemption to operate modified vehicles: subject to the regulations of '§ 70 Abs. 1 Nr. 1 und 2 der StVZO'</p> <p>The procedure was to write an application to the ministry which described the plans for platooning operation specifically. The application also described a safety concept and safety measures, which were prepared by MAN and reviewed and observed by the German Technical Monitoring Association. The ministry referred to this presented information within the exemption. Additional requirements/measures were specified by the ministry.</p>	No law but a Decree will be signed by early 2020 in the "French Mobility" frame for Atlandes (A63 concessionaire). Each vehicle will require additional dedicated authorization in the current legal framework for autonomous / automated vehicle	No
What is the expected duration of the administrative process?	6 months	Approx. 6 months (partially due to the availability of a third party for evaluation, see answers below)	For the platooning trial in Aquitaine, the request was sent in December 2018. Still under investigation. Answer expected by Autumn 2019. But no standard duration, and it is the first request for platooning. There are a	6 month (est.)



			lot of questions to be resolved.	
What is the required information from the driver?	Drivers ID card and driving licence, training received	The MAN safety concept included selecting the drivers: <ul style="list-style-type: none"> - drivers must possess a truck driver's licence (CE) for 5 years without pause - drivers must possess 5 years of professional logistics - max. 2 points in the German driving appropriateness index (Fahreignungsregister) - good level of health - good hearing - fluent knowledge of German language - specific safety and platooning training 	The driver must be updated with the continuous training plan. Some specific training will be likely required. The companies involved will have to deliver all the common legal papers.	Contact authority for details
Is it mandatory to have a specific insurance?	No, standard insurance	It was mandatory to have a liability insurance covering risks, which are resulting from operating highly or fully automated motor vehicles.	Under discussion. Provided that experimental framework is legally defined (Decree), extra insurance might not be needed.	Contact authority for details
Is it needed to specify the route in the application for a permission?	Yes; before to ask to the MIT, it is needed to ask for the permission to the road operators that operate the identified route	Yes, the route was specified	Yes. Only A63 will be open to platooning	Yes (it was 2016)
Is there any defined way to report an incident during testing?	Not specified	Not specified	Not yet fully specified, but a detailed report should be provided in case of any incident, to the local authorities and the DSR.	Contact authority for details

Who is the responsible for the procedure?	MIT representative	respective MAN project leader, MAN head of departure	The request of exemption was introduced by Altandes (the motorway concessionaire). The procedure should be approved by the DGITM and DSR (MTES and Ministry of Interior). The liabilities are not yet fully decided. However, in the phase 1 (SAE level 1 or 2) the drivers and companies will remain responsible of their vehicles.	Ministerium für Verkehr und Infrastruktur Postfach 103452 70029 Stuttgart
How is the technical information presented to the road authority?	Request via certified e-mail (PEC) then F2F discussion	Application for an exceptional permission by written letter with annexes and with extensions by written letter and e-mail	Questionnaire + face to face meetings.	Mail

Table 4. Administrative procedure questions

The main highlights of the questionnaire are as follow:

- MAN Truck & Bus SE replied based on platooning project EDDI in cooperation with DB Schenker. MAN described the procedure followed in Germany. Here, unlike the other countries, had an exception to driving in platoon mode. In the project, they prepared an application to the Ministry which described the plans for platooning, the safety concept and safety measures. The driver also had some requirements to evaluate the experience, the health, and aptitudes, for example the language.
- ETPC also gives information about the driver requirements, who needs to be trained in using platoon systems and during the test. Furthermore, the following trucks were required to have co-drivers.
- The administrative procedure for the MAN project had an approximate duration of six months.
- IVECO gives information about Italy, which has a decree “Smart Roads Decree” where platoon can be considered. The decree defines the requirement to test AV systems on public roads e.g., autonomous to manual driver transition, cybersecurity and data



recording. The procedure to be followed in order to obtain the ministry's AV testing authorization is also detailed in this document.

- France, as the French Institute of Science and Technology for Transport, Development and Networks (IFSTTAR), does not have any law to drive in platoon mode yet. They are working on a Decree to make a legal procedure. There is not much information about it, but it is known that A63 will be open to test platooning.

4.1.2. Vehicle Control

It is important to identify all the requirements that Member States consider when providing an exemption. This part of the questionnaire focused on these requirements from the vehicle point of view.

Vehicle Control				
QUESTION	IVECO	MAN Truck & Bus SE	IFSTTAR	Daimler AG
Is there any vehicle-type regulation to be exempted?	Any	Does this question address the prototypes' road worthy certificate as opposed to the exemption from the road traffic regulations? If so, then the answer is yes. There was an exemption from the vehicle-type approval (comp. question about applicable law).	For the phase 1 (SAE level 1 or 2) no specific vehicles.	Exception according to §42 Abs. 2 StVO von §2 StVO
Shall the vehicles be type-approved?	Proto vehicles allowed with the specific plate	Generally, the basic vehicle must be type-approved (of course). For the prototypical parts, there must be an exemption from the type-approval.	No specific type-approval (but the standard one).	Technical report by certification authority (TÜV, DEKRA) needed
How to declare the number of vehicles involved?	Within the documentation it is needed to specify the involved vehicles VIN	Exact number was declared: - 3 vehicles for the highway operation - additionally 2 vehicles for tests on highways - trailers, noting that all combinations are allowed	At this stage, it is planned to have several platoons of 2 to 3 vehicles, may be 1 more later.	Contact authority for details

How are those vehicles identified?	Not specified	VIN	Not yet. But every single vehicle will have to be identified and will require a dedicated driving authorization (see above).	Contact authority for details
Is there any way to register the on-board results?	Everything is needed to be logged. Not specified the format	We saved some vehicle data to postprocess several values, which had to be generated and documented as a result of the conditions of the exemption.	Under investigation. The phase 0 of the project is devoted to the definition of the on-board and road side instrumentation and the data collection and processing.	Contact authority for details

Table 5. Vehicle control questions

Table 5 details some of the truck requirements to drive in platoon mode.

Information about vehicle requirements from Germany was obtained through MAN and ETPC. It is important to highlight that in a project consisting of two trucks doing platooning, the 'basic vehicle' had to be type-approved and have an exemption for the specific functions to drive in platoon mode which are not included in the regulation.

In all cases, specific documentation is needed, type-approval/technical report and the vehicle needed to be identified (either through VIN or another way).

4.1.3. Test Control

Not only vehicle requirements are important when applying for an exemption, also which conditions related to the tests need to be detailed and specified.

Test Control				
QUESTION	IVECO	MAN Truck & Bus SE	IFSTTAR	Daimler AG
Is there a specific technology mandatory to test?	Not specified	No additional conditions (in comparison to platooning operation in productive logistics)	Not yet defined.	Contact authority for details

Are third party witnesses required during testing?	Not specified	A THIRD PARTY had to execute an evaluation of the platooning system. This evaluation included tests, which were defined by the third party and executed by MAN. The third party required to be present during these tests.	The motorway police will be required at least for the first tests. The research providers (IFSTTAR, University of Bordeaux, etc.) will be monitoring all the tests.	Contact authority for details
Which is the gap between truck limitation?	Not specified, OEM responsibility	No specific number mentioned within the exemption. ('The minimum distance must only be undershot, if a hazard of others is excluded.')	In the phase 1 and a level 1-2 (SAE) the gap will be at least 15 or 20 m. To be defined later.	Contact authority for details
Are extra visibility elements required?	Not specified	<ul style="list-style-type: none"> - stickers - yellow rotating light beacons 	Some marks at the back of the last vehicle of each platoon is planned, but not yet fully specified. All-round identification light might be required.	Contact authority for details
Is there any restriction due to climate conditions?	Not specified	Clear sight, 'good weather', ambient temperature above +5°C, no severe wetness (in case of limited wetness, the gap must be increased to defined value)	The test will not be carried out under adverse weather conditions (heavy rains, fog, snow, etc.).	Contact authority for details
Is there any actuation procedure in case of	Not known	- (ideally) defined uncoupling sequence, triggered by driver or system	In case of unexpected event, the test may be suspended until the solution is found or the issue resolved.	Contact authority for details

unexpected events?		- if necessary, system override of the following driver (manual gap opening)		
In which situations should the platoon break?	Not specified	<ul style="list-style-type: none"> - system failure (v2v connection, sensor object loss, general system failures etc.) - accidents, construction sites, big motorway interchanges - system misuse 	The project team will define the use cases and the situations of platoon break, and ask for the approval of the authorities. The aim is not to break the platoon will going through entries and exits since entries and exits on A63 "lands" are low traffic roads.	Contact authority for details
Shall the technology be previously tested in test tracks?	Yes, 3000km on test track	Yes, tests defined, executed and documented by MAN Additional tests defined and supervised by a THIRD PARTY	Some specific features or measuring devices may be previously tested in test tracks. But to be decided case by case. No predefined list.	Contact authority for details

Table 6. Test control questions

This part of the questionnaire was focused on the identification of specific test requirements such as weather limitation, the need to preform previous tests on a test track, the definition of the manoeuvres or traffic situations among others.

In some countries the vehicles shall be tested on test tracks before open road. In Italy for example, the truck shall be tested for three thousand kilometres. In other countries tests may be required but are not predefined.

It has been identified that the requirements related to the gap between trucks, can be defined by distance or by time. In some cases, this factor is defined during the test.

According to the experiences analysed, it has been identified that in Germany test requirements are partly defined. During the test, a third party must execute and do the evaluation of the system. The trucks must have stickers and yellow beacons to be easily identified. The tests, which shall be defined and documented by the OEM, shall be performed under good conditions, otherwise the gap between trucks must be increased.



During ETPC project in Germany, the following trucks had to have monitors with image (in colour) from a camera attached to the first truck. The second truck had to have an extra brake pedal. Also, they were equipped with surrounding lights in such a way that all surrounding traffic could recognize the platoon as such. Lights warn if a vehicle closes in or comes too close. The last vehicle in platoon had to have a big warning sign on the back 'keep distance, test vehicle', accompanied by a pictogram, with the same message.

As observed from the questionnaire, there are important factors that need to be taken into account:

- definition of the gap between vehicles,
- trucks signposting to be easily identified during the test,
- good weather conditions and how they may affect the test results and maximum speed.

4.1.4. Other Information

This part of the questionnaire was aimed at considering any other requirements not taken into account in the previous table sections.

Other Information				
QUESTION	IVECO	MAN Truck & Bus SE	IFSTTAR	Daimler AG
Is the any extra requirement not taken into account yet?	Extra test can be requested, 3000km on simulation	Respective authorities must be informed before each platooning drive	The procedure of exemption is under investigation. It is the first request thus additional requirements may come at any time.	Contact authority for details
Could previous tests with others road authorities be recognized?	Not specified	No information available	This is the first test in France. Tests outside France may be considered for information.	Contact authority for details

Table 7. Other questions

Table 7 details these requirements not considered before. In any case, all tests should be analysed by the authorities, and depending on the features, these authorities have the right to request extra information on a case-by-case basis.

5. STATE OF THE ART OF EXISTING EXEMPTION PROCEDURES FOR OPEN ROAD TESTING

After the analysis of the Questionnaire results, an in-depth analysis of the current exemption procedures for some Member States (mainly focused on the Member States where the final event will probably take place) has been included in this section.

Once all the information and assessments required in each exemption procedure is obtained, it is possible to align and harmonize all the requirements in one handbook that would make it easy for the manufacturers to apply the exemption in different countries. Of course, this is important for the ENSEMBLE project, as it is intended to cross different countries, but also for all these automated and connected functionalities that will arise in the coming years.

The first step is the analysis of the different documentative and functional requirements to find a common point, if possible. In the event that the differences between procedures make it not possible to align them, a method covering all the requirements will be proposed. This will make up the basis of Deliverable 6.13, so this section only includes the state of the art and analysis of some of the existing exemptions.

It is important to remark that all the exemption procedures explained in this section are at national level and are not related in any case to type-approval. The exemption procedures are temporary and are intended for testing systems that are not already type-approved on open road. These licenses can cover both conventional and autonomous systems, but due to the high complexity of autonomous and connected vehicles, most of the countries have developed a dedicated procedure with specific requirements in order to assess the safety of these systems.

These documents are quickly evolving along with the technology, because the importance of simulating real road conditions during testing is a key aspect of assessing it.

Section 3 includes information about the type-approval status of autonomous and connected systems, not regulated yet.



5.1. Netherlands: Connected automated vehicle admittance procedure

Under relevant European legislation, new technologies and functionalities are only allowed if they have been proven safe and operable. However, in order to validate safety and operability of the system, it is important to test on public roads with real conditions.

Accordingly, on July 2015 a new regulation came into force in the Netherlands, introducing provisions for open road testing, as long as the applicant meets certain previously set conditions.

These conditions are described in the admittance procedure for Connected & Automated Vehicles [8]. The functionalities or technologies under this procedure are:

- Automatic following
- Lane keeping assist
- Vehicle following
- Lane change
- Traffic jam assist
- Overtaking
- Valet parking
- Collision avoidance
- Emergency stop
- Self-driving vehicles

The admittance procedure is performed through the Netherlands Vehicle Authority (RDW), which is responsible for validating all the stages defined in the procedure before permitting the open road exemption. The main steps are:

- 1- Intake
- 2- Desk research
- 3- Testing on a closed proving ground
- 4- Admittance based on an exemption
- 5- Evaluation

5.1.1. The Netherlands Admittance Procedure

In the following section, a detailed description of each step is given.

1- Intake

An application form shall be filled out by the applicant and sent to the RDW. This application form includes information about the intended tests, systems to be proven, places and duration.

If the assessment of the plan is considered viable, then the Authority asks for more information such as:

- Why the technology that is going to be proven does not comply with any existing regulation.
- Safety measures taken into account and environmental considerations.
- Tests done in a secure environment (test track), and results obtained. In this step it is intended to demonstrate that a minimum level of safety has been obtained and tested.
- If it is a cooperative system, reliability of data communication.
- Failure Mode and Effect Analysis (FMEA).
- EMC test showing that adapted vehicles are not vulnerable to unwanted signals.

2- Desk Research

At this second step, the national authority RDW, evaluates together with road authorities and road safety experts all the relevant factors involving the vehicle, infrastructure and behavioural aspects in detail. This evaluation considers that:

- The vehicle performance must be comparable to that of a vehicle without the new system.
- Roads to be considered from highway to city centre.
- Risks of the vehicle when the driver is using the system, and interaction with other traffic.

3- Testing in a proving ground

Once the most important risks from the risk analysis have been evaluated and obtained, RDW together with the road authorities, determines additional scenarios or measures to be tested on a proving ground.



4- Admittance on the basis of an exemption:

If the results are positive, then a temporary admittance on the basis of an exemption is issued by RDW.

The authority may determine additional measures for the tests, such as the supervision by road inspectors.

5- Evaluation

Finally, all the results and documentation obtained during the process are used by RDW as input for new regulations in the discussion groups of United Nations or European Commission.

5.2. Spain: Instruction 15/V-113, Authorization to conduct tests or research trials of automated vehicles on roads open to general traffic

In order to promote the development of automated technologies, the Spanish Government issued a law to authorize the testing of vehicles equipped with automated technologies in open road scenarios (Instruction 15/V-113 [9]). This instruction was issued by the main Spanish body in charge of the traffic organization, the “*Dirección General de Tráfico (DGT)*” (General Directorate for Traffic) and was created with the aim of granting special authorizations to those automated vehicles which are tested in normal traffic conditions. The document was published in November 2015, and since then all tests with automated vehicle on Spanish roads are required to fulfil the requirements of this law.

As conventional and automated/connected vehicles are going to share the roads and this should be done under the safest conditions it is necessary to regulate conditions for these tests. However, it is important to remark that this instruction is only for testing and not for the normal driving of automated vehicles.

Vehicles authorized by this law are prototypes and their safety is not completely proven, this is why the Spanish DGT ask for a safety assessment before the performance of the test in open road conditions.

These test vehicles can be derived from already approved vehicles, which means a vehicle which is on the market and to which the manufacturer is incorporating some automated technologies. And additionally, it is also possible for the manufacturer to test a completely new vehicle with these technologies already integrated. Of course, it is necessary for both kinds of vehicles to fulfil a minimum safety level in order to avoid compromising situations on the roads

This authorization can be requested from the DGT by the vehicle manufacturer, the automated technologies component manufacturer or by an official laboratory. The universities and consortia

involved in research projects are also allowed to apply for this authorization. In this case, the ENSEMBLE consortium could be the authorization's applicant.

The authorization holder is responsible for ensuring that the vehicles fulfil the minimum safety prescriptions to perform the test on public roads. The holder is also responsible for performing the test under authorized conditions. Any test or vehicle driving out of the declared boundaries must be done in manual driving mode.

Once the authorization is issued, it shall be valid for 2 years with the possibility to extend this period for another 2 years.

An important requirement for the test vehicle is that it must be properly registered and using a legal registration plate. If the vehicle is a prototype and has not been registered, then it is compulsory to get a temporary authorization according to the Spanish GRV (General Regulation on Vehicles).

5.2.1. Spanish requirements for obtaining the authorization

The instruction is requesting requirements for the manufacturer/requester of the authorization, for the driver and of course for the test vehicle. In the following paragraphs the requirements in the instruction are specified.

Requirements for the manufacturer/applicant

- The applicant must be a legally identifiable entity with legal personality.
- The entity must have experience regarding the activities for which it is applying for the accreditation or similar automotive test.
- The applicant must initiate the accreditation process with ENAC.
- The applicant must provide to the DGT and the test laboratory a complete description of the test vehicle.

Requirements for the drivers

- It is mandatory for the applicant to declare a test driver (or some of them if necessary). No other drivers will be allowed to drive the vehicles during the test execution. In the ENSEMBLE case, it is necessary to declare the drivers for all the test vehicles.
- These designated drivers must provide a statement of their aptitudes. They also declare that they know the automated technologies installed on the vehicle and they have received training for the test required. In the ENSEMBLE project, the drivers are provided by the manufacturers, so they are responsible to inform the driver about the automated technologies they are driving.
- The driver of the autonomous vehicle will always be responsible for the driving of the vehicle.



- The drivers must be able to take full control of the vehicles during the test, whether it is inside the passenger compartment as if driving remotely. In the ENSEMBLE case, the drivers must take full control of the vehicles in the event of any eventuality risk situation for the occupants of the vehicles or other road users.
- The driver of the automated vehicle must be a holder, with a minimum of two years, of the driving license corresponding to the category of the vehicle subject to the test or tests. All the drivers of the ENSEMBLE project must fulfil this requirement.

Requirements for the automated vehicle

- The vehicles subject to this instruction must be autonomous vehicles, there are some other procedures for testing conventional vehicles on Spanish open roads (one of them is described in section 6.1.1 of this deliverable).
- Test vehicles must be uniquely identified by the applicant.
- It is mandatory to have insurance and keep it in force during the tests. It shall cover at least the civil liability for injuries/damage to other road users.
- In order to guarantee the safety and reliability of the vehicle, it is necessary to prove that the vehicle has got the certificate issued by an accredited Technical Service with regards to the fulfilment of the tests specified in annex II of the Instruction (see appendix B of this deliverable).
- It is also valid to prove to the Spanish DGT that the competent authority of another Member State has issued, through an equivalent prior control procedure, authorization to conduct tests on roads open to general traffic to automated vehicles.

Submission of applications

In order to prove the fulfilment of all the requirements mentioned above, the manufacturer is required to submit the following documentation to the DGT:

- An application document addressed to the DGT including minimum information about the test vehicles, the roads where the tests are going to be performed and the type of tests.
- A more complete description of the tests to be performed. This document shall include at least information regarding the following items:
 - o Description of the technology used in the vehicle, explaining among others the principles to ensure its safety and the activation mode. It is also requested to reflect the level of automation according to the SAE Levels defined in SAE J3016

- A detailed characterization of the tests to be performed. In the ENSEMBLE case it should reflect a description including: the number of the vehicles comprising the platoon, the test speed, the manoeuvres to be performed (e.g. cut-in, cut-out,...), scenarios to be tested (e.g. two/three lanes, highway exit,...),...
 - It is necessary to prove to the authority that the driver has been trained to drive this vehicle using automated technologies. The plan used to train the drivers must be submitted to the DGT. Regarding the ENSEMBLE project, all the manufacturers should declare the training plans given to their drivers.
 - A clear description of the roads/areas where the tests are going to be performed. This is important because the DGT can set restrictions to the test vehicle (e.g.: maximum speed or escort vehicles...) or even to the other road users. Probably for a platooning test the DGT may oblige the vehicles to show a kind of signal/indicator to inform the other drivers about the excessive length of the platoon.
- It is mandatory to pay a fee to the DGT and they request to submit a proof of this payment. The amount of this fee is set by the Article 6 of Law 16/1979.
 - Additionally, a certificate from an accredited Technical Service confirming that the verifications set out in Annex II of the instruction has been fulfilled. It is important to remark that an equivalent document from a competent authority of another EU Member State can also be used. It means that the tests/verifications included in Annex II can be avoided if the same tests have been performed before on the open road in another EU member state and a document from an authority of this member state can be provided to the DGT.

The necessary tests and verifications to obtain the certificate from the accredited technical service will be described in Appendix C. Certificate to perform road test of automated vehicles. In order to give this certificate, the laboratory needs to have technical documentation before the execution of the tests, the minimum content of the manufacturer's documentation is also included in Annex II of the instruction. The following flowchart gives an overview of the procedure to be followed in order to get the certificate from the accredited Technical Service.

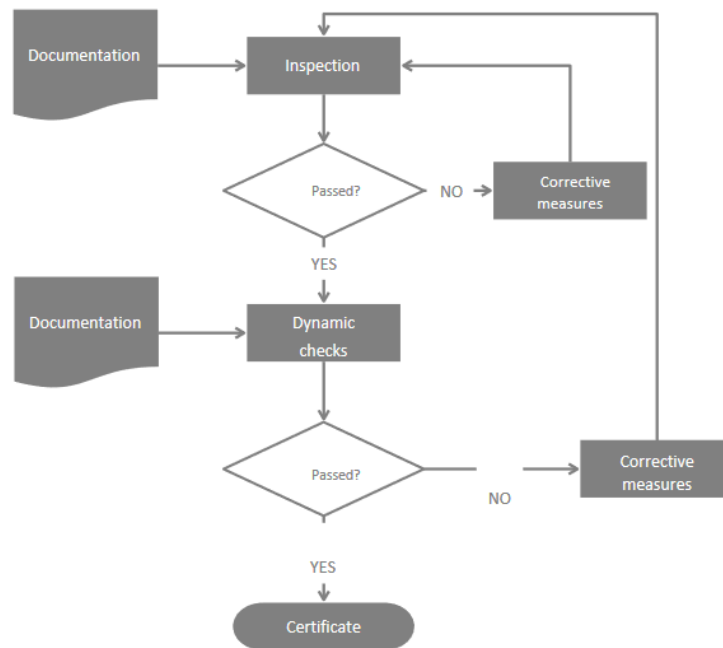


Figure 4. Flow chart showing the Technical Service procedure

In the environment of the ENSEMBLE project, these tests should be performed in IDIADA as it is an accredited Technical Service for this instruction. The manufacturer would be responsible for delivering the appropriate technical documentation.

Final decision

Once all this documentation has been submitted to the DGT, they have one month (maximum) to give a definitive answer to the applicant and this decision can be to reject or grant the authorization.

5.3. Belgium: Code of Practice for testing

In 2016, Belgium presented the Code of Practice for testing. This code was developed by the regional authorities and the Belgian Institute for Road Safety [10].

It is based on a document issued by the UK Department of Transport, called “The Pathway to Driverless Cars: A Code of Practice for Testing”

The Code of Practice covers driver assistance and partially or fully automated vehicle technologies on public roads. It sets out several requirements that shall be verified before testing in order to ensure road safety, driver experience and licenses, among others. The requirements are as follows:

- General requirements.
- Requirements for test drivers, test operators and test assistants.

- Vehicle requirements.

Within the vehicle requirements, the applicant shall demonstrate that specific tests have been carried out on test tracks, and the results obtained are good enough to ensure the safety of the road users. An audit report shall be presented to the competent authorities with all the results obtained.

Additionally, information about the transition between the automated mode and the manual mode shall be given. These transitions shall ensure minimal risk by means of testing on a test track.

Other requirements such as cybersecurity validation of the system, or identification and integrity verification of the software versions shall also be taken into account in the application time.

5.4. Austria: Code of Practice, Testing of Automated Driving on Public Roads

In 2018, Austria developed and published a Code of Practice for testing automated vehicles on public roads [11].

The objective of the document is to provide support to the manufacturers and testing organizations on the development of new technologies related to automated and connected vehicles.

Vehicle manufacturers must ensure that automated vehicle technologies have been developed and tested extensively before they go into mass production. The initial tests must take place on private test grounds and tracks. As a minimum, these tests must demonstrate and ensure that a test driver or test manager can take manual control of the vehicle from the automated driving mode in order to ensure the necessary safety during testing.

Closely aligned to Belgium and UK Code of Practice, the document establishes requirements for the following topics:

General Provisions:

- Requirements for the test driver and the test manager.
- Vehicle requirements.

The tests are regulated in the Ministry's Automated Driving Regulation (AutomatFahrV [12]).

Only the following use cases are permitted at present after a permit has been issued: autonomous minibus (less than 20 kph), motorway pilot with automatic lane change and self-driving military vehicles. Depending on the different use case, evidence for a certain number of test kilometres needs to be provided. For vehicles or systems that are not currently regulated in accordance with the AutomatFahrV, the planned test shall be described by the manufacturer and can lead to a new amendment of the regulation for its inclusion.



As an important point, the tested vehicles shall be equipped with an accident data recording system, and the system shall be used during test operation. It shall not be possible to modify the data obtained.

5.5. France: Authorization to conduct automated vehicles tests on open roads

In France the performance of automated vehicles tests on open roads is regulated by *Ordonnance* n° 2016-1057 of August 3rd, 2016. It is a fairly short legal text signed by the president of the French Republic which establishes a regulatory framework for these tests.

The first article of this *Ordonnance* specifies that vehicles equipped with automated driving systems which are aimed at testing on open roads need a special authorization to guarantee the safety of the tests. This article was modified in 2019 in order to ensure the test vehicle will be equipped with the means to neutralize automated driving of the vehicle at any moment. So, a person must be constantly supervising the vehicle's behaviour (from inside or outside the vehicle).

The second article designates the Ministry of Transport in agreement with the Ministry of Interior as the entities to issue these authorizations. In a later modification in May 2019, it is stated that the driver will not be responsible when, in automated mode, the vehicle commits a traffic law offence. In this case, the responsibility lies with the requester of the testing authorization.

The content of the third article is aimed at indicating that the conditions to get the permissions and the content of the dossier necessary for requesting the authorization will be issued in a dedicated decree.

Finally, the last paragraph of the *Ordonnance* sets out corresponding responsibilities among the concerned Ministries.

In 2018, a different decree was published in order to regulate the authorizations: the *Décret n° 2018-211* of March 28th, 2018. One month later, a complementary decree was issued in order to define the content of the requesting dossier necessary to get the authorization.

The *Décret* 2018-211 is divided into five different titles:

- Title I: Issue of the testing authorization: Comprising articles from No. 1 to 7
- Title II: Certificate "WW DPTC": Article No. 8
- Title III: Conditions regarding the execution of the tests: Composed by two sections:
 - o Section I: General Conditions for testing from article No. 9 to 14

- Section II: Special provisions for vehicles assigned to a transport service: from article No. 15 to 17
- Title IV: Controls and Sanctions: Article No. 18
- Title V: Transitional provisions and final provisions: Articles No. 19 and 20

The certificate used for the temporary tests of partially or fully automated vehicles is named according to this regulation “WW DPTC”. “WW” is usually used in French vehicle plates as an identification for a temporary vehicle registration and DPTC comes from: “*Délégation Partielle ou Totale de Conduite*” that means “full or partial automated driving”

This decree allows the testing of fully or partially automated vehicles in the following cases: technical tests and fine tuning of the automated functions, verification of the vehicle performance under the real conditions or public demonstrators.

The public roads involved in the tests must be specified in the authorization and the performance of the tests is limited only to these mentioned areas. The permission is given for a maximum of two years, but it can be extended one additional time.

One important point is that the vehicle has to be equipped with the means to record the vehicle mode (conventional or automated driving). In case of accident, the requester must provide to the authorities the recording corresponding to five minutes before the accident.

During the automated mode driving, a driver must be available to control the vehicle at any moment, especially in case of emergency or when the vehicle is out of the operational domain. The driver has to be properly trained regarding the automated functions and the boundary conditions of the system.

Other restrictions are that the vehicle is not allowed to carry goods or people during the tests which are not included in the authorization. If the vehicle is dedicated to public transport, first it is mandatory to perform tests without passengers, and once the safety of the tests is demonstrated, then a second test stage with real passengers can be performed. When the tests are going to be carried out with real passengers, it shall be indicated for public information that the vehicle is equipped with automated driving technologies.

In the event that the conditions specified in the authorization are not fully met, the authorization may be suspended or additional restrictions may be added to the tests.

Finally, it is the French instruction which specifies the content of the requesting dossier necessary to get the *WW DPTC* certificate. It is the “*Arrêté du 17 avril 2018 relatif à l'expérimentation de véhicules à délégation de conduite sur les voies publiques*”. It is made up of 7 articles divided into 2 different sections and 5 technical annexes.



The first article is the scope of the law and the second one is dedicated to collecting some important definitions for the correct understanding of the instruction.

Section 1 is comprised of articles 3 and 4 and the whole section is related to the request for the authorization. The other articles are included in section 2 which is dedicated to the tracking of the tests.

Regarding the request for the authorization it is important to fulfil the following items in order to finally get the permission:

- The applicant must be the owner of the vehicle or if otherwise, it is necessary to demonstrate the relationship between the requester and the owner of the test vehicle
- The authorization can be requested for one or more vehicles participating in the same tests
- All the documentation shall be filled out in the French language
- Every single modification of the conditions reflected in the authorization shall be immediately communicated to the corresponding authority
- The applying dossier must be comprised of the following documents properly filled in:
 - o Questionnaire according to Annex 1 to this instruction
 - o Technical features of the vehicle according to Annex 2 to this instruction
 - o Detailed tests explanation according to Annex 3 to this instruction
- A letter addressed to the French Transport Minister and Interior Minister duly signed by the applicant.
- In case of applying for an authorization renewal, it must be sent to the Ministry at least 3 months before the finalization of the previous authorization.
- A WW DPTC certificate is only valid for one single vehicle (addressed to one VIN).
- The certificate is only valid for the automated driving tests in the specified areas, however, it is valid in the whole French territory when the vehicle is driven in conventional mode.

The second section is dedicated to the tracking of the tests and in these articles the requirements for this tracking are covered. It is mandatory to fill in a six-monthly report according to Annex 5, with the information corresponding to the last period. This report must be sent to the French authorities during the month following the reported period. A final evaluation of the tests must also be sent to the authorities.

The French ministry is building a database with all these reports sent which can only be accessed by the French authority and it is not available for the public consultation. Please refer to Appendix B. Questionnaire for applying WW DPTC Certificate.

5.6. Mutual recognition approach

As observed, the different Member States each have their own requirements always looking for safety.

The main objective of the analysis above is to identify what Member States have in common and set the pillars for a possible future mutual recognition framework when testing automated driving vehicles on open roads.

Although the analysed countries ask for similar requirements, there are some differences on the processes. This would mean that a manufacturer should apply on each country with different documentation or tests for obtaining the license exemption on all of them.

However, it is important to note that there are some countries that willing for this harmonization between procedures and mutual recognition in EU Member States, currently accept license exemptions previously given by other Member States.

As example the Spanish Road Authority agrees on accepting license exemptions granted by other Member States.

Given that some countries currently accept other licenses, the best option would be to agree a common procedure for all the Member States, that would allow simplifying applications of OEM's that want to test automated technologies on open roads. In this case all the parts should agree an assessment criterion to ensure minimum safety of the systems, and also technical requirements.

If it is not possible to obtain a common procedure, another option is to agree on the acceptance for other Member States exemptions, but this would lead to certain differences between the requirements and assessment methods.



6. EXEMPTION TEST IN SPAIN

A very important part of the ENSEMBLE project is to validate the project results on open road. In order to do so, WP5 is working to set the necessary tests on test track to validate the system performance and safety.

With the aim of providing a detailed explanation of the steps to be followed by the OEMs when applying for the exemptions in Spain, the following section has been defined.

6.1. Introduction to the Exemption procedure

The National Road Traffic Authority in Spain is called *Dirección General de Tráfico* (DGT) and coordinates the traffic across the country. The DGT is a government department depending on the Interior Ministry of the Spanish Government and guarantees road safety. Among its responsibilities, DGT is also in charge of road traffic management and is responsible for the licence exemption process for testing on Spanish Roads (<http://www.dgt.es/es/>).

The following sections show the different steps and tools to request the license exemptions from the Spanish administrators:

6.1.1. TRAZA application tool

Since 2018, all the open road testing and other permits are handled through the software TRAZA. This software has been created to speed up the application process for different kinds of tests/request. To be able to use this tool, a user and a password are needed. To obtain them, each interested party shall fill out an application form and send it to the DGT through a specific e-mail address. Once access to the tool is granted, the process to request the license exemption for the open road tests can start (<https://sede.dgt.gob.es/es/tramites-y-multas/autorizaciones-especiales-de-circulacion/autorizaciones-especiales/>).



Figure 5. TRAZA portal

6.1.2. Step 1: New simulation

Each manufacturer shall apply for a new simulation on the main page. It is not necessary to fill out all the data required on each page at the same time, as the application allows it to be saved when necessary. If something is wrong or incomplete, a disclaimer will appear beside the field.

Note that the word “Simulación” (simulation) will be used until the application is submitted.

The first step is to define if the vehicle is modular or not, as per Figure 6.

Figure 6. Creation of a new simulation

Once the simulation has been created, a new window is opened where general data is required, see Figure 7.

Datos generales Vehículos motor Modular Conjunto Itinerario Observaciones

Tipo de expediente

☒ Con itinerario ☐ Sin itinerario

Tipo de transporte

☒ PRIVADO PARTICULAR ☐ PRIVADO COMPLEMENTARIO ☐ PÚBLICO ☐ NO APLICA

Autorización de transporte

☒ PRECISA AUTORIZACIÓN DE TRANSPORTE ☐ NO PRECISA AUTORIZACIÓN DE TRANSPORTE ☐ NO APLICA

Figure 7. General data

1. On the first selectable, it is necessary to indicate that a defined itinerary is set out for the tests.
2. Indicates the kind of transport that is going to operate: in this case Particular Private.
3. Special plates are needed.

Solicitante

* Identificador: NIF

* Documento: []

* Nombre y Apellidos, razón social o denominación: []

* Calle: [] * Número: [] Escalera: [] Piso: [] Letra: []

* Ciudad: [] * Provincia: [] * CP: [] * País: []

Teléfono: [] Fax: 0 [] Correo electrónico: []

☐ Añadir nueva dirección a esta organización

Adjuntar Guardar Borrar

Figure 8. Applicant data

If the applicant is already registered in the application, all the data will be filled out automatically. If it is the first time using the application, the gaps will be in blank.

6.1.3. Vehicle data

Then, the application will ask for more specific information regarding the technical characteristics of the vehicle.

Figure 9. Vehicle data selectable

The applicant shall introduce the plate number (“*Matrícula*”) of the motor vehicle. If the vehicle is already registered, then the other fields will be automatically filled out.

The technical characteristics of the vehicle shall be introduced on the sheet, and the Certificate of Conformity must be attached in order to check the values introduced.

At the end of the sheet it is also necessary to indicate the number of axles of the motor vehicle and its maximum weight.

If it is the first time that the plate number is introduced into the application, it will appear in red on the database. That means that this registration is pending to be validated by a user of DGT. Once revised, the plate switches to green.

Figure 10. Vehicle plate validation

6.1.4. Trailer data

The same procedure and data is needed for the trailer on “*Remolque*” sheet.

6.1.5. Itinerary

All the information regarding the itinerary of the tests is included in this part of the application.

First, fields containing the beginning and the end of the route are added, with the length in km.

Figure 11. Route creation

In this case, as there are 3 different routes, this procedure shall be repeated for each one.

Datos incluidos en el itinerario

		Provincia	Titular del tramo	Carretera/Red	Denominación Tramo	Población o enlace con la siguiente vía	
▼	1	TARRAGONA	UNIDAD DE CARRETERAS DEL ESTADO EN TARRAGONA (2-8)	AP-2	De Tarrés (L.P. Lleida) a Banyeres del Penedés (AP-7) 181 k. + 110 m. a 234 k. + 60 m.		 
↕	2	LLEIDA	UNIDAD DE CARRETERAS DEL ESTADO EN LLEIDA (1-82)	AP-2	De Fraga (L.P. Huesca) a Tarrés (L.P. Tarragona) 120 k. + 550 m. a 181 k. + 110 m.		 
▲	3	TARRAGONA	UNIDAD DE CARRETERAS DEL ESTADO EN TARRAGONA (2-8)	AP-2	De Tarrés (L.P. Lleida) a Banyeres del Penedés (AP-7) 181 k. + 110 m. a 234 k. + 60 m.		 

Figure 12. Definition of the route

6.1.6. Remarks

On the last selectable it is possible to indicate other remarks related to the test, as if support vehicles are needed during the tests. In this case it is necessary to add that the test is not limited to one vehicle, and due to the characteristics of the system, seven vehicles are going to be tested at the same time. Additionally, it shall be declared that cameras and other instrumentation is going to be used only for internal data collection of the project, that will not be shared in any case.

Once all the simulation is finished, it can be printed and sent. The application can be presented telematically.

At the end of the page there is a summary of the application, that indicates if each sheet is correctly filled out and saved as per Figure 13.

Resumen de proceso

Datos generales	Vehiculos motor	Remolques	Conjunto	Itinerarios
✗	✗	✗	✗	✗
Simulación: Autorización Sin Especificar.				
Estado: Simulación incompleta.				

Figure 13. Summary of the application

7. PROVING GROUND TESTS FOR APPLICATION FOR EXEMPTION

In the previous section, a detailed explanation of the TRAZA app and its steps has been included. In addition to the process explained, the road authority may request extra documentation related to safety.

The aim of this section is to assess which kind of tests will be requested before performing the open road test in order to prove safety and validate the technology. For the platooning functions, there are two different cases that will also need two different approaches.

- Platooning Support Function: where the driver is responsible for the driving task. The vehicle system is performing the longitudinal control while the driver is in charge of the lateral control at all times.
- Platooning Autonomous Function: where the driver is not responsible anymore. The system performs the complete driving task within the specified operational design domain.

The first case is the one which is going to be performed within the ENSEMBLE project on the open road scenario.

Nevertheless, and taking into account that the aim of the project is to adopt multi-brand platooning in Europe, it is also considered necessary to assess this second case to cover the platooning technology in the long run.

The analysis in the following sections will mainly cover the case for the platooning support function as it is directly applied in the project. However, these use cases can also be applicable for the platooning autonomous function. The changes from one case to the other are basically the expected output from the test.

7.1. General assessment of platooning as a support function

The analysis will start with the assessment of the Platooning Support Function. The main properties of the Platooning Support Function are based on Adaptive Cruise Control (ACC) as defined in ISO-15622, 2018 [13].

The first one refers to the driver's responsibilities and the second one refers to the longitudinal coordinated automated control as per below.

This section will describe a possible minimum assessment for platooning as a function taking into consideration what could be possibly implemented in the project.

7.1.1. The driver

According to the ISO-15622, 2018, *“the driver is responsible for the full driving task, in line with the current state of the art support functions, and this will be clearly indicated via the HMI”*.

Considering this definition, it will be useful to have all the HMI strategies to test that they are implemented as intended. This could be tested in line with the requirements for HMI requirements in UN R79 for ADAS functions, that includes:

- Clear recognition of the signal stating the operation status (standby / working / deactivated).
- Check that this signal clearly indicates when the system is carrying out this platooning task.
- Check, if necessary, that additional signals (e.g. audible, haptics warnings) are implemented when sudden deactivation of the PSF occurs.
- These different requirements for the HMI will be checked for each one of the test cases discussed below, guaranteeing that the driver is always aware of the current state of the function.

7.1.2. Longitudinal coordinated automated control

According to the ISO-15622, 2018, longitudinal coordinated automated control is performed for the complete speed range from 0 (brake to standstill; acceleration from standstill optional) to maximum cruise speed (depending on country regulations and OEM implementations).

At the moment, there is no specific UN regulation for an “ACC function”. For resemblance, it should be considered to test the function as if it was an ASLD as described in UN R89. However, considering the particularities of the platooning system, overriding by using the accelerator pedal may be dangerous. Therefore, other override methods are explored (such as leaving the platoon by steering away). The most useful information comes then from the HMI requirements included in the regulation, that are in line with what will be assessed in the tests.

7.1.3. Other considerations

Besides the driving task responsibilities, there are other shared characteristics with the ACC function that will help to shape the test requirements, as they are described in Deliverable D5.7:

- Following distances according to ACC (specific form each OEM) with minimum distances such as the time gap is ranging between 1.4s and 1.6s. The driver selects the following distance.
- Limited decelerations ($< 3.5 \text{ m/s}^2$).



- Under adverse conditions such as bad weather, slopes, etc.... the drivers have the responsibility to increase the time gap or disengage platooning completely.

Again, for the conditions mentioned above, it would be necessary to check how the HMI would warn the driver in order to take this responsibility, with the test discussed below.

This general overview helps to better understand the case-by-case assessment that is detailed in section 7.3.

7.2. Safety of non-platooning functions in the vehicle

It is important to bear in mind that independently of the platooning function, the vehicle must comply with the rest of partial approvals. This has been previously discussed in point 4.1.2, leading to the conclusion that, depending on the road authority, it can be demonstrated whether with the complete type-approval, or at least with a report stating its equivalence.

For the specific platooning Support Function developed in the project, OEMs have chosen to have an independent ECU for the platooning function, separating as much as possible this feature from the rest of the systems in the vehicle.

Also, most OEMs would use a “gateway” from this specific ECU to the vehicle dynamic control (accelerator, brake...), so this would at the end lead to an actuation at approved systems, but this system can be directly overridden with no further actuation.

For those reasons, it shall be enough with the overriding and failure tests discussed in section 7.3 to justify that the previously approved systems are still compliant with the regulation

Referring to regulations that are still being prepared, most of them will affect the platooning functions and components. As has been explained in section 3, cybersecurity and software update regulations are at a final development stage, and surely will have an impact on all the systems that require an approval.

This leads to the also discussed new “platooning” regulation, which has been recently announced to be elaborated in the 2019/2144 Regulation. This will imply, once implemented, not only its fulfilment, but the addition of the interaction with other regulations (such as the aforementioned CS and SU regulations) to be taken into account, once it is known if this regulation will refer to platooning as an autonomous or as a supportive function.

7.3. Safety of the platooning function

This section will focus in the minimum necessary tests in order to guarantee safety before going out on open road tests.

The aim of Deliverable D5.7, was to “describe testing procedures and definition in the ENSEMBLE project to validate the implemented function and to ensure interoperability between different brands”. Among such a wide selection of tests, those that are considered to be enough to guarantee the safety of the open road tests are included in this section.

The classification will be made attending to two inherent properties of the scenarios:

- The scenarios that can or will appear during the open road test. Tests for these scenarios will be considered as necessary for justifying the safety of the technology to the road authority.
- The scenarios that are considered whether not to be safety critical, or not likely to be caused by a skilled driver, or highly unlikely to happen during the open road tests. Tests for these scenarios will not be necessary to get the permissions.

Nevertheless, as the platooning regulation mentioned in section 3 is being written, all these tests may be used as an input for this new platooning regulation, whether as a starting point or as a direct application.

In Table 8, the different tests considered in deliverable D5.7 are selected, and then discussed.

Test Case	Scenario likely to happen	Scenario not critical/unlikely to happen
Joining from behind by single vehicle	X	
Joining from behind by an existing platoon		X
Merge in between by single vehicle		X
Refuse joining due to maximum number of trucks		X
Non-joinable situations		X
Steady state following constant speed	X	
Steady-state acceleration	X	
Steady-state deacceleration	X	
Steady-state gap variation	X	



Follow braking target (use case 3.2)	X	
Lead vehicle doing an emergency braking	X	
Following vehicle doing an emergency braking	X	
New minimum distance policy (only HMI information)		X
New maximum speed policy (only HMI information)		X
Cut-in (example: constant speed cut-in, cut-in and brake)	X	
Cut-through	X	
Cut-out (example: cut-out and continue, cut-out and brake, cut-out and accelerate)	X	
Steady-state multiple vehicle cut-in	X	
GPS failure	X	
Communication failure	X	
Package loss (V2V). (HMI Expected)	X	
Forward range sensor failure	X	
Leave by trailing truck	X	
Leave by following truck	X	
Leave by leading truck	X	
Split platoon (system initiated)		X
Leave by steering-out as following truck (+ deaccelerate)		X
Leave by steering-out by leading truck (+ deaccelerate)		X
Closing gap at maximum set speed	X	

Closing gap at maximum acceleration and speed performance (example: different truck loads)	X	
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Table 8. List of tests to perform in closed test track as per Deliverable 5.7

7.3.1. Test required for exemption application

As has already been mentioned, the aim to carry out these tests before going on open road is to guarantee the correct function of the technology developed within the project as described in Deliverable D5.7 (for more test details please refer to it).

This section gives a detailed explanation about why the tests to be performed in a *scenario likely to happen* are needed.

The scenarios taken from Table 8 are as follows:

- **Joining from behind by single vehicle.** It is highly probable that open road tests include routes with several vehicles. That is why, once the platoon starts its merging manoeuvre, this “joining from behind” scenario will take place. Taking this into account, it makes sense to have evidence of this manoeuvre before the open road test.
- **GPS failure / Communication failure / Package loss (V2V) / Forward range sensor failure.** It is widely used to test the failure modes that are expected to be most common. In this case, these are the selected ones to be simulated, as they are the most likely to happen during an open road test. It is remarkable that, due to the level of automatization in the ENSEMBLE project, only a coherent HMI response is expected.

If a higher automatization level is reached, it would also be expected to have at least a partial operation manoeuvre that guarantees safe transition to a manual driving mode once this failure is detected.

It is also important to take into account that the selected subsystems prior to failure are selected due to the implemented technology. For future applications, a case-by-case analysis is needed to check which specific technologies are implemented (e.g.: using positioning beacons instead of GPS) and adapt the failures to be checked.

- **Steady-state situations (constant speed, acceleration, deacceleration).** On open road, this is the status in which the platoon will be most of the time: normal circulation, with mild acceleration and deacceleration to adapt to the road and traffic. Functional tests assessing a stable behaviour and an acceptable gap between vehicles shall be performed in order to obtain the road authorities authorization.



- **Steady-state gap variation.** The need to perform this test on a closed track is going to depend on the Road Authority conditions. If Road Authorities request to have a bigger gap than expected in the project requirements, this test would verify that this change can be done dynamically without dissolving the platoon.
- **Follow braking target.** This test is a compromise between the steady-state deacceleration and the emergency braking, in which the leading vehicle starts to firmly deaccelerate from the maximum platooning speed to 30 km/h. As this situation is likely to happen, this functionality will need to be tested prior to start open road testing.
- **Lead/Following vehicle doing an emergency braking.** Both cases are likely to be requested by road authorities. This manoeuvre supposes a high-risk situation in an unplanned, not controllable environment.

This scenario was already considered in the COMPANION project. In that project, in order to guarantee safety, the braking scenario was simulated with vehicles in parallel in different lanes. With this approach, the testing risk on the test track was controlled and reduced.

- **Cut-in / Cut-through / Cut-out / Steady-state multiple vehicle cut-in.** These four scenarios are described in Deliverable 5.7 and all have a common origin: once on open roads, smaller vehicles could try to interfere with the platoon. The proposed scenarios summarize all the interactions that those vehicles could have with the platoon, being the last one a special case in which multiple vehicles interact with the platoon at the same time.

As one of the main goals of the different road authorities is to guarantee road users' safety, and that the average driver has had no previous contact with a platoon, this test will be needed. The goal is to ensure that the safety distance is respected during the route.

The inclusion of the cut-out manoeuvre in this category is arguable, as the platoon retaking the tight gap could be considered a functional test.

- **Leave by leading / following / trailing truck.** During an open road test, the platoon may face different situations in which a platoon is not allowed (for instance, if there is too much traffic density).

By performing these tests, it is guaranteed that all the vehicles, irrespective of their position in the platoon, can leave it. In case of reliability problems in one of the vehicles, it can safely leave the platoon, having a method to disengage the platoon progressively.

- **Closing gap at maximum set speed / acceleration.** During the route, there will be different situations in which the following or trailing vehicle cannot reach the speed of the leading vehicle. This can be caused by numerous reasons, such as different payloads, power or a difference in the slope.

This is why this situation will be simulated on a closed track, so as to check that the leading truck can quickly detect the situation and decrease its speed (or acceleration, depending on the case) to minimize the vehicle separation and thus, avoid undesired cuts-in during the open road tests.

7.3.2. Further tests

In this section, it will be further discussed why other manoeuvres are not considered safety critical regarding the open road tests to be performed. Nevertheless, they can have an important role to widely deploy the platooning technology:

- **Joining from behind by an existing platoon.** This manoeuvre consists of two different platoons joining in a given situation. Taking into account that the manoeuvre would be planned, the driver initiating the joining can cancel the manoeuvre if they detect any malfunction. Nevertheless, it makes sense to perform the manoeuvre to further know the vehicle's behaviour.
- **Merge in between by single vehicle.** As described in Deliverable 5.7, this manoeuvre is not expected as a casualty, but caused voluntarily by the active driver. Taking into account that the vehicles will be driven by experienced drivers, the cancellation of the manoeuvre is possible in a safe way if the outcome is not desirable. This makes the manoeuvre not safety critical for road authorities in this case.
- **Refuse joining due to maximum number of trucks.** During the open road tests, the maximum number of trucks for the authorization will never be exceeded, and so this test only makes sense for a future implementation of the technology.
- **Non-joinable situations.** Again, a previously trained driver will be able to detect those situations and to act accordingly, not requesting to join the platoon. It is sensible to include it for further implementation in the market.
- **New minimum distance policy / maximum speed policy (only HMI information).** This test is intended to check the correct interaction between the infrastructure and the different vehicles in the platoon. Even though they will be performed for functional purposes, they are not considered to be essential in terms of the authorization, mainly because the infrastructure is at this moment not implemented on open roads in Europe. On top of that, drivers will be warned about the routing restrictions, having the leading vehicle the capacity to module the speed.
- **Split platoon (system initiated).** Once the technologies reach a point in which it is widely spread across the European Union, route planification to optimize platooning time may become usual. This supposes that the vehicles, with different starting points and destinations, may merge or split several times during the route.



For the open road demonstration, this manoeuvre is not strictly needed, although it can be performed once the closed road tests take place successfully.

- **Leave by steering-out as following / leading truck (+ deaccelerate).** Both situations are supposed to exist as a misuse of the developed technology. Trained drivers that had previous contact with the technology will leave the platoon with the correct protocol to guarantee safety.

Nevertheless, once the platooning technology is widely implemented, distractions can lead to this kind of malfunction, making it a situation that should be taken into account in future assessments.

8. SUMMARY AND CONCLUSION

In this document, a brief, yet complete summary of the ongoing regulatory discussions both at a European and a global scale has been presented. This regulatory framework will cover in the long run all the requirements to approve vehicles with high levels of automatization in the European Union.

A survey was sent to the involved OEMs to collect all the valuable information regarding their past experiences with platoon open road tests. A summary of the notable information from the past experiences is shown. It is worth noting that Germany and its different “Länder” are more specific regarding platooning requirements for open road testing. It is also remarked that other countries in the EU are committed to detailing their regulation for open road testing, so it includes the peculiarities of highly automated driving functions, such as platooning.

With the collected information from past experiences, and as a first step towards the harmonization of the license exemption, a wide analysis of the existing procedures on relevant European countries has been done. In this case, the criteria have been according to these countries where the final platooning demonstration is planned.

These exemptions have been broken down into different requirements:

- Technical documentation previous to tests.
- Functional safety analysis.
- Proving ground tests.
- Reporting of the results.

Due to the high complexity of autonomous systems, most of the requirements are not totally defined yet, and it is not possible to relate all the criteria defined on the procedures. However, it is clear that the main idea is to define a minimum safety level before testing on open road, and verify it through testing, documentation and functional safety assessments.

In the Spanish case, the Instruction that covers all the requirements for license exemptions of automated and connected vehicles is explained in detail, willing to cover all the requirements for tests that will be performed on Spanish roads in September 2020. After an official discussion with the Spanish road authority and considering that the drivers are always responsible for the actions of the system, it was considered that an exemption procedure for conventional vehicles could be done in order to make things easier. The specific procedure for the OEM's application has been detailed. This application is done through TRAZA, a Spanish Road Authority tool exclusive for allowing license exemptions for new technologies not covered by Instruction 15/V-113[9].



To sum up, a clear differentiation between the tests has been performed. They have been categorized whether as intended to prove the safety on open road tests, or to further investigate and understand the platoon functionality. This selection is indicative and the different open road test authorities could require different tests. However, the criteria for selecting each use case as safety critical or not has been clearly presented.

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10. APPENDIX A. GLOSSARY

10.1. Glossary

10.1.1. 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 $<-4 \text{ m/s}^2$
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.

Term	Definition
ODD (operational design domain)	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, 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,



Term	Definition
	which is depends on the operational safety based on vehicle dynamics and human reaction times is given). A.k.a. leave platoon
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

Term	Definition
	Platooning Level, optimization 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 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	<p>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.</p> <p>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</p>



Term	Definition
	(normal & alternative e.g. successful and failed in relation to activation of the system / system elements).

10.1.2. 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

Acronym / Abbreviation	Meaning
GN	GeoNetworking
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GUI	Graphical User Interface
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



Acronym / Abbreviation	Meaning
QM	Quality Management
RSU	Road Side Unit
SA	Situation Awareness
SAE	SAE International, formerly the Society of Automotive Engineers
SCH	Service Channel
SDO	Standard Developing Organizations
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

11. APPENDIX B. QUESTIONNAIRE FOR APPLYING WW DPTC CERTIFICATE

Question	Answer	Remarks
Tests description		
What is the test type?	<ul style="list-style-type: none"> - Technical tests and adjustments; - Performance evaluation in situation of use for which the DPTC vehicle is intended; - Public demonstration, especially during events 	
What are the objectives of the tests? (To be detailed)		
What is the autonomy level of delegated driving vehicles during the experimentation? (levels from 0 to 5 according to the SAE J3016 standard)	<ul style="list-style-type: none"> - 0 ; - 1 ; - 2 ; - 3 ; - 4 ; - 5 	
What are the overall modalities of the tests? (Brief test description)		
Who are the stakeholders of the tests and their respective roles? (Manufacturers, transport operators, service providers, local authority, traffic police authorities, mobility organizing authorities, etc.)		
Test Conditions		
Location		
Starting date of the tests (Do not forget the preparation periods for the experiment, in particular for running a demonstration, etc.)		
End date of the tests		
Vehicle type	<ul style="list-style-type: none"> - Private car; - Public transport of people; - Haulage ; 	



	- Agricultural vehicle; - Other	
Number of vehicles		
Tests carried out during the experiment (If it is not a pure demonstration operation or a presentation to the media)		
Road networks on which the tests will take place (complete the road network form and provide the plans and information necessary to process the request in the authorization request file)		
Will the vehicle be driven in conventional mode on road networks other than those used in automated mode, in particular to reach the experimental sites (connection route)? (Specify which ones)	- Yes ; - No	
Will the tests take place partially on roads closed to public traffic? (If yes, specify)	- Yes ; - No	
Is the route of the vehicle protected? (if yes, specify by what means)	- Yes ; - No	
Are additional equipment and facilities on the road planned for the tests? (If yes, specify: signals, roads, communication Please note: certain installations (in particular the installation of non-regulatory signals) may be subject to a specific authorization from the delegation for road safety and the General Directorate of Infrastructure, Transport and the Sea requiring a request for authorization separate from that concerning the circulation of CAV vehicles)	- Yes ; - No	
Are traffic police measures planned for the tests? (Modification of signaling, restriction of circulation, lowering of speed, change of priority regimes at intersections...)	- Yes ; - No	
What will be the interactions with the usual vehicle flows (private vehicles, bus, tram, clean sites, cycle lane, etc.)? (Specify the type and geometry - crossroads, roundabout ... - if necessary by means of attached diagrams)		
Are interactions with vulnerable users possible?	Pedestrians	- Yes ; - No
	Cyclists	- Yes ; - No

	2 motorized wheels	- Yes ; - No	
	Others (specify)	- Yes ; - No	
Maximum vehicle speed during tests (It can be different from the speed by construction of the vehicle)			
Driving and boarding passengers			
Is the person responsible for driving the vehicle on board the vehicle?	- Yes ; - No		
Who are the people responsible for driving (expert drivers, employees, service providers, etc.)?			
What are the means of control (lateral and / or longitudinal) available to the person responsible for driving the vehicle?			
If the person responsible for driving is not on board the vehicle: - specify where it is; - describe the feedback it has from the experimental vehicle and the experimental site; - specify the protocols for switching to autonomous mode and returning to conventional mode.			
Does the experimental protocol provide for the presence of a supervisor in the vehicle? (A supervisor is a different person from the driver, present in the car during the experiment, who has all the means to control the vehicle, and who during certain phases of the experiment, can become the driver of the car. If yes, specify the conduct of the supervisor and the procedures for transferring the conduct from the driver to the supervisor and from the supervisor to the driver.	- Yes ; - No		
When the vehicle is traveling in conventional mode, if applicable, specify who will be the driver and how?			
What is the type of driver's license of the persons responsible for driving the vehicle?			
Is the training of those responsible for driving the vehicle internal or external? (Specify its content)			
Besides the person (s) responsible for driving the vehicle, will there be other people in charge of the tests on board the vehicle?	- Yes ; - No		



(If yes, specify the context, the number, and if they are professionals and / or employees of the company)		
Besides the experimenters, will there be passengers in the vehicle? (If yes, the applicant has the obligation to comply with the prescriptions of decree n ° 2018-211 of March 28, 2018 and of this decree relating to the testing of vehicles with delegated driving on public roads)	- Yes ; - No	
Vehicle specifications		
Motorization	- Thermal; - Electric; - Hybrid; - Other	
Serial number (s) of vehicle (s)?		
Number of seats including driving position (s) if applicable		
Number of standing places including driving position (s) if applicable		
Maximum speed by vehicle construction		
What is the classification to which the vehicle belongs if there is an approved series configuration, if not the classification to which the vehicle could be attached?	- Bus or coach; - Articulated bus / coach; - Pick-up truck; - Moped; - Motorcycle; - Light motorcycle; - Heavy weights ; - Light motor quadricycle; - Heavy motor quadricycle; - Motor tricycle; - Public transport vehicle; - Private car; - Other	
In conventional mode, is the vehicle approved?	- Yes ; - No	
Has the vehicle been modified in relation to the homologation rules for this category? (If yes, describe these changes.)	- Yes ; - No	
Has the test vehicle been tested before the requested experiment? (If yes, specify in particular with regard to delegation systems, systems ensuring the safety of people on board and that of road users.)	- Yes ; - No	

Does the vehicle have specific sound or light signals? (- If it is a modified homologated vehicle, specify if the vehicle will have specific warning devices; - In the case of an unlicensed vehicle, describe the audible and visual warning devices available to it; - If it is an electric vehicle, specify if it will have a courtesy warning to signal its presence)	- Yes ; - No	
In what form (s) does the mention <i>test vehicle with partial or total automated driving</i> appear in the vehicle? (specify locations, size, formats...)		
Indicate the data that is saved by the Event Data Recorder and the periods of retention of this data. (How and where are they saved? Under what conditions can these data be made available to the authorities in the event of an accident on the roads?)		
Will a logbook, handwritten or electronic, be present on board the vehicle? (If yes, specify the elements indicated in this journal)	- Yes ; - No	
Will the vehicle be supervised from a fixed checkpoint? Only during the experimentation phases? (If yes, describe)	- Yes ; - No	
Describe the systems of automated driving. (What automated systems? How does the vehicle go into automated driving mode? What are the driver alert systems?... Refer to the documents in the file for detailed descriptions)		
Implementation of a transport service		(Answer the following questions only if the vehicle (s) will be used for a transport service)
Authority organizing this transport service		
Nature of transport service	- public transport of people; - private transport of people; - haulage	
Partner transport operator (if applicable)		
What is the registration number of this operator in the passenger road transport register or in the goods road transport register, depending on the type of transport service provided?		



How long is the experimentation phase without transport service (blank run)? (Indicate the period [start date, end date] and the program for this phase)		
If it is a public passenger transport service: describe the route and the stopping points of the planned routes.		
If it is a public passenger transport service: what are the time slots during which the service will be open?		
If it is a public passenger transport service: what information is available to the public concerning this service? (at the stops, website, multimodal information system, in the press, by flyers, etc.)		
If it is a public passenger transport service: how is each passenger informed that this service is based on automated technologies? (Specify if necessary)		
If it is a public passenger transport service: what are the conditions of access to this service, and what is the pricing policy applied? (Specify if necessary)		
If it is a public passenger transport service: what are the regulations applicable to passenger transport taken into account in the context of the tests? (Specify)		
Is your company registered in the electronic register of road transporters?	- Yes ; - No	
Specify the derogations from the decree of July 2, 1982 relating to the public transport of people.		
Safety		
How did you analyze the safety risks? (Specify the method used)		
Has the risk analysis been carried out by an external body? (If yes, specify)	- Yes ; - No	
What are the main risks associated with this test? (List and describe)		
What measures have been put in place to limit these risks? (List and describe)		

What are the procedures for detecting, analyzing and handling incidents? (Type of corrective measures implemented, etc.)		
What security event recording system have you implemented? (Specify)		
Cybersecurity		
How did you analyze the risks related to cybersecurity? (Specify the method used)		
Has this risk analysis been carried out by an external body? (If yes, specify)	- Yes ; - No	
What are the main cybersecurity risks linked to this test? (List and describe)		
What measures have been put in place to limit these cybersecurity risks? (List and describe)		
What are the procedures for detecting, analyzing and handling cybersecurity incidents? (Type of corrective measures implemented, etc.)		
How was cybersecurity taken into account? (Specify cybersecurity measures)		
What are the residual cybersecurity risks identified during security audits carried out on the information systems concerned by the test? (Specify)		
Did you use a service provider to carry out security audits of the information systems concerned by the test? (If yes, specify)	- Yes ; - No	
If you have used an audit provider, has it been the subject of a qualification by the ANSSI (Agence nationale de la sécurité des systèmes d'information) or by another body? (If yes, specify)	- Yes ; - No	
What security event recording system have you implemented? (Specify)		
Consultation of stakeholders		
Which road managers have been approached with?		
If traffic police measures on these infrastructures in direct relation to the tests, with which police authorities have steps been taken?		



(Specify which authorities, traffic police measures, dates of consultation, etc.)		
Are there any special demands on infrastructure managers? (If yes, specify: interventions, equipment, signals, road works, etc.)	- Yes ; - No	
By what means are the police and the emergency services informed of the conduct of the experiment and the specifics of the vehicle?		
By what means are other users informed of the tests (if necessary)?		
Does the applicant guarantee that the experiment will be covered by adequate insurance? (Specify the covered risks)	- Yes ; - No	

Table 9. Questionnaire for applying WW DPTC Certificate. Model in Annex 1

12. APPENDIX C. CERTIFICATE TO PERFORM ROAD TEST OF AUTOMATED VEHICLES

One of the main parts of the authorization for testing on open roads in Spain, is the one related with the obtaining of the certificate issued by the accredited Technical Service. This procedure consists of three main parts:

- Documentation

The documentation shall be the basis for identifying the type of vehicle that is intended to be tested. The documentation required is briefly summarized below.

- Simplified technical specifications sheet: This is a relation of basic data of the vehicle regarding the masses and dimensions, brakes, engine, conventional steering system, and light devices. This document is regulated in Real Decreto 750/2010 and has a different format depending on the vehicle category.
- Technical specifications sheet: it is a document generated from the simplified technical specifications sheet but with more detailed data. The Technical Service will compare the information in this document with the test vehicle in order to verify that the data reflected in the sheet is appropriate.
- Risk assessment: In this document the manufacturer shall include an evaluation of the potential risks concerning the test and its probability of happening. Identified risks cannot be accepted for driving on public roads and shall be controlled or mitigated before the tests. All operational modes and potential failures of the vehicle shall be assessed. This assessment can be made by means of using a HARA (Hazard Risk Analysis), FMEA (Failure Mode Effects Analysis) or an equivalent method
- Control of software versions: It is mandatory to declare the software version of the autonomous systems, of course, the software version of the system to be tested on open road must be the same as the system tested in the laboratory.
In case of implementing new software versions during open road tests it is allowed to justify the safety of the new software versions by means of documentation, simulations or bench tests
- Emergency stop and override system: It is necessary for the applicant to bring to the Technical Service documentation that during the design phase of the vehicle the following considerations have been taken:
 - o Emergency shutdown; It's mandatory to install in a place accessible to the driver an emergency button which stops the action of the actuators at any moment.
 - o Override: the vehicle manufacturer must demonstrate to the Technical Service that the driver is able to override the actuation of the system by means of actuation on the brake pedal, the accelerator pedal or the steering wheels. That means that the system actuations must stop all the actuations in case the driver actuates one of the above-mentioned devices.



- Additionally, the manufacturer must proof that both systems are independent.
- Functionalities and test design scenarios: The manufacturer is required to provide a complete description of the AD functionalities working on the vehicle. The purpose of this information is to identify critical situations to be avoided during the open road tests.
- Scenarios: it is also important to define the scenarios to be evaluated during the open road test. It is important because authority will allow only the automated driving in the scenarios described in this section. For this section it is mandatory to include features of the scenario as the type of road, traffic conditions during the test, weather conditions or the manoeuvres to be performed.
- Restricted scenarios: It is equally important to include a description of the scenarios to be avoided by the vehicle during the tests. The description of these restricted situations must be detailed in the same way as the test scenarios.
- Cybersecurity: The manufacturer/applicant must demonstrate to the Technical Service that they have considered cybersecurity aspects during the system design phase.
- Electromagnetic Compatibility (EMC): It must be proven by the applicant that the electronic components used during the tests are not influenced by the working of other electronic devices to avoid unexpected reactions of the system. It is mandatory to fulfil the existing EMC regulations in order to prove this compatibility.
- Inspection

The inspection shall evaluate the parameters regarding exterior, interior, engine bay, wheels and wheel arches and others such as ballast, measuring equipment, display screens or auxiliary batteries.

The inspection shall be performed by an Authorized Technical Service and using the corresponding template for each category of vehicle (Annex III of the Instruction 15/V-113).

- Dynamic check

In addition to the documental verifications mentioned above, dynamic tests shall make it possible to certify that the vehicle can be driven manually, that it can regain manual control as required by the drivers or at the request of the operator and in automated driving mode can maintain the level of safety.

Several tests must be performed:

- Conventional driving: even if in automated driving mode, an occupant with access to the vehicle's manual controls. It is imperative that the vehicle can be driven in manual mode at any time.
- Override (steering wheel, brake pedal, accelerator pedal, emergency shutdown): At any stage of automated driving, driver override must be detected after applying a maximum torque at the wheel, when actuating on the brake pedal, when actuating on the accelerator pedal and when actuating emergency shutdown system, respectively.
- Longitudinal control: to assess the ability of the vehicle to maintain the longitudinal control and to brake in an emergency.

- Braking test: to check and ensure the correct operation of the braking system.
- Automated emergency braking: to check and ensure the correct operation of the automated emergency braking system.
- Lateral control: to assess the vehicle's ability to stay in a lane marked with road markings (solid/broken line). The vehicle must be able to stay in different conditions in a lane marked by road markings. It shall not be assessed whether the system is capable of operating on an open road without road markings.
- Recognition and compliance with the traffic signs: To ensure the testing of vehicles with automated capabilities on public roads and sharing the road with others, it is essential to ensure that these vehicles in automated mode are able to recognize and respect both traffic signs and road markings, either vertical or horizontal signs.

