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

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FIGURES

1. EXECUTIVE SUMMARY

1.1. Context and need of a multi brand platooning project

Context

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

Project scope

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

- Year 1: setting the specifications and developing a reference design with acceptance criteria
- Year 2: implementing this reference design on the OEM own trucks as well as perform 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 analyses the current state of the European regulation on Truck Platooning which is part of the Task 6.3. Regulatory framework evolution for platooning. Part of this work consists of analysing the current state of the art of vehicle regulations regarding the functions used in platooning and to develop a future regulatory framework proposal.

Firstly, this document reviews the discussions being held within the working groups under the supervision of the United Nations. The regulations and regulations proposals reviewed are related to autonomous and automated functions and with connected vehicles, their general safety provisions and road safety. The main regulations that play an important role regarding platooning technology are: UN Regulation No. 79 (1), UN Regulation No. 155 (2), UN Regulation No. 156 (3), UN Regulation No. 157 (4).

Moreover, the ongoing discussions within the informal working groups are being analysed. These discussions are key in the development and implementation of platooning, as they will potentially become a new amendment of the current regulations, or even in new regulations.

Finally, this deliverable provides a proposal of a regulatory framework regarding platooning system,which is an important step in terms of ADAS regulation. In this case, the structure adopted in the development of the proposal has been the one used in the draft of the European Regulation for Automated Driving System. To develop this regulation the topics reviewed in the first part of this deliverable are taken into account.

2. INTRODUCTION

2.1. Aim

This deliverable analyses the current EU regulatory framework taking as a base D6.10 (5) and D6.11 (7), in order to allow an EU-wide deployment of multi-brand platooning. The General Safety Regulation (9) states that a new regulation about platooning system is going to entry into force in 2022 and at the moment, there is not any proposal or draft about that framework.

As in the Deliverable 6.10 (5), the analysis of the state of the art of European, local and international regulations is already done, as well as the recommendations and guidelines for future changes in the actual regulations. The aim of this deliverable is a proposal for a regulation about platooning.

2.2. Structure of this report

The core body of this report is divided into 3 parts:

1. Description of the current topics under discussion in the UNECE working groups relating to current regulatory acts that could concern platooning technology and affect possible system future regulations.

2. Future recommendations for a suitable regulatory framework for platooning solutions. These recommendations will be a future scenario according to the detected necessities.

3. Regulatory framework draft for a future regulatory act regarding homologation safety tests, such as system vehicle behaviour, handling the equipment during all prescribed use cases, according to the platooning system to ensure that the system is safe enough for road safety and their users.

3. UPDATE ON TOPICS UNDER DISCUSSION

In this chapter, an analysis of the main topics being discussed in the working groups in the scope of the UNECE is shown. These discussion topics have been monitored along the project, since their feedback is crucial for the development of platooning regulatory framework.

Within the scope of the UNECE, there are two working parties whose scope influences the application of the platooning technology, the Road Traffic Safety (WP.1) and the World Forum for Harmonization of Vehicles Regulations (WP.29). Both bodies are working on creating the legislation needed to bring to market new automated vehicle technologies.

3.1. World Forum for Harmonization of Vehicle Regulations (WP.29) UNECE

The Inland Transport Committee (in the scope of the Transport Division of UNECE) has a working party dedicated to the world harmonization of the vehicle regulations. Under the supervision of WP29 there are six expert groups, each one specialised in different topics:

- GRBP: Working Party on Noise and Tyres
- GRE: Working Party on Lighting and Light-Signalling
- GRPE: Working Party on Pollution and Energy
- GRVA: Working Party on Automated/Autonomous and Connected Vehicles
- GRSG: Working Party on General Safety Provisions
- GRSP: Working Party on Passive Safety

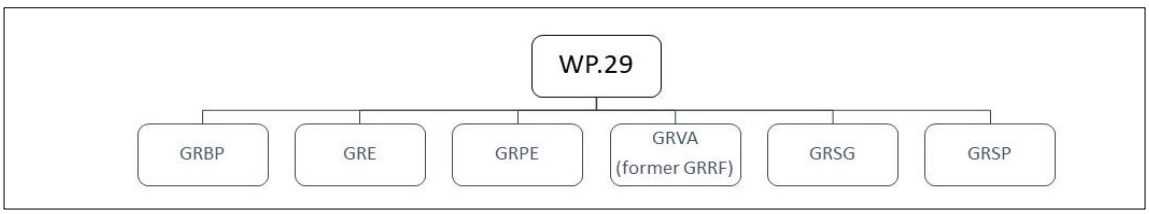

Figure 1. WP29 working groups

Among the working groups that are part of the WP.29, the ones that develop activities related with the functions used while platooning are GRVA, GRE and GRSG, their recent activity is detailed below.

3.1.1. GRVA: Working Party on Automated/Autonomous and Connected Vehicles

This working group was created in the WP.29 session on June 2018 and all the working sub-groups related with autonomous driving were moved under the scope of this new GRVA working group. (10) Since its creation, the GRVA working group has had eleven meetings, the last one being held in September-October 2021. Under the supervision of the GRVA there are several Informal Working Groups (IWG) dedicated to different topics:

- Functional Requirements for Automated and Autonomous Vehicles (FRAV)
- Validation Method for Automated Driving (VMAD)
- Cyber Security and (OTA) software updates (CS/OTA)
- Data Storage System for Automated Vehicle and Event Data Recorder (DSSAD/EDR)
- Special Interest Group on UN Regulation No. 157 (SIG on R157)
- Task Force on ADAS (TF ADAS)
- AEBS for Heavy Duty Vehicles (AEBS for HDV)
- Modular Vehicle Combinations (MVC)

The ones dedicated to autonomous and connected vehicles are waymarked in the image below.

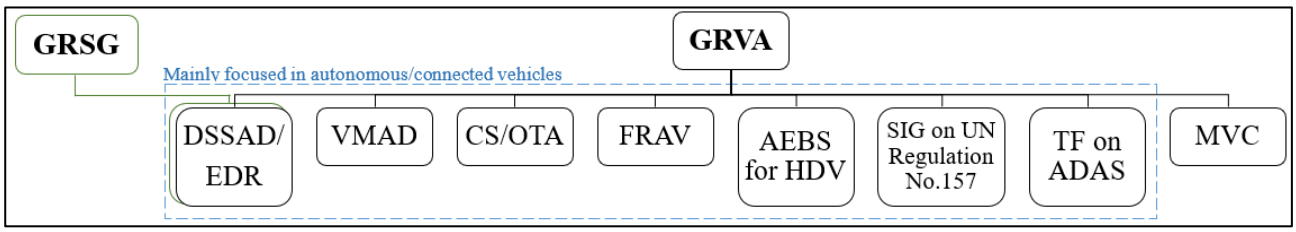

Figure 2. WP29 groups working in vehicle's autonomous and driving assistance functions.

In the fourth session of the GRVA working group, the Validation Methods for Automated Driving informal Working Group (VMAD IWG) informed about the creation of three different subgroups: one aimed to the creation of traffic scenarios, the other group dealing with the proving ground tests, audits and real world tests and the last one focused on the virtual tests. The other informal Working Group under the scope of the GRVA is the one for Functional Requirements for Automated and Autonomous Vehicles (FRAV). This group is in continuous collaboration with VMAD in order to align the requirements with the test procedures.

During the session held in March 2020, the GRVA working group presented the final draft documents of the Regulations on Cyber Security (2), Software Updates (3) and Automated Lane Keeping Systems (ALKS) (4). Both regulations were approved by the WP.29 and the Administrative Committee of the 1958 Agreement (AC.1) at the session held in June 2020. These regulations entered into force in January of 2021 designated as UN Regulation 155 (2), UN Regulation 156 (3), and UN Regulation 157 (4) respectively.

UN Regulation No.157 Automated Lane Keeping System

The Automated Lane Keeping System (ALKS) is a system designed to keep the vehicle within its lane by controlling the lateral and longitudinal movements of the vehicle for prolonged periods of time with no need of input from the driver. This is the first and only, at this moment, regulation that addresses an automated driving function with a SAE Level 3 as defined in ECE/TRANS/WP.29/1140 (11). The intention of the Regulation is to establish uniform provisions concerning the approval of category M1 vehicles with regard to Automated Lane Keeping Systems (ALKS). The Regulation lays down:

- The administrative provisions suitable for type approval, technical requirements, audit and reporting provisions and testing provisions for the ALKS.
- General requirements regarding the system safety and the failsafe response. Annex 4 in the regulation includes information about functional and operational safety of the ALKS, provided by the VMAD group.
- Requirements on how the driving task shall be safely handed over from the ALKS to the driver, including the capability for the system to come to a stop in case the driver does not reply appropriately.
- Requirements on the Human-Machine Interface (HMI) to prevent misunderstanding or misuse by the driver.
- Some prescriptions about Cyber-Security and the Software Updates, these requirements are much related with new regulations on these topics.
- It also includes a chapter with DSSAD (Data Storage System for Automated Driving) requirements. These prescriptions have been provided by the informal working group in charge of drafting the future EDR/DSSAD Regulation.

There are currently several topics under discussion in the GRVA which aim to expand and improve the scope of this regulation. In order to address, in the most efficient and complete way these subjects, in January of 2021, the Special Interest Group on UN-R157 met for the first time and in the session of the GRVA held in February 2021 they announced their willingness to continue meeting every month in order to finalize their activities until September 2021. The topics under discussion in this Special Group more relevant for the extension of this project are listed in the following points:

- During the 7th session of the GRVA held in September of 2020, it was proposed by the expert of from Germany to increase the maximum speed for ALKS from 60km/h to 130km/h. The increasement of the maximum speed is directly related with the possibility to allow the vehicle lane change to these systems. This issue came up as rather controversial as there were several countries supportive and others against, in the last record published from March of 2021 this issue was still under discussion.

- In the September 2020 GRVA meeting, an amendment aiming to include heavy vehicles within the scope of the regulation with ideas was proposed. In March 2021, it was noted that the reference deceleration values, at this moment present in UN Regulation 157, were taken from the UN Regulation No.13-H (braking regulation for passenger cars). In case of heavy duty vehicles are going to be added under the scope of UN Regulation No. 157 the deceleration values for other vehicle categories should be taken from UN Regulation No.13 (12) instead (braking regulation for other vehicle categories)

UN Regulation No.155 Cyber Security and Cyber Security Management System

On the other hand, the Cyber Security Regulation establishes uniform provisions concerning the approval of category M, N, O, L6 and L7 vehicles with regards to cyber security and cyber security management system. The regulation includes provisions on governing the access by authorized parties to the vehicle, its data, functions and resources, and conditions of such access. It also includes prescriptions about the protection of natural persons with regard to the processing of their personal data. In addition, the regulation applies to the development and installation or integration in the system of replacement parts and components, physical and digital, with regards to cybersecurity.

UN Regulation No.156 Software Update and Software Update Management System

Approved in June 2020, this regulation concerns vehicles of categories M, N, O, R, S and T, that are able to receive software updates. In relation to this regulation, important discussions were held about the competence of the Technical Services and finding a solution for those vehicles developed before the creation of the regulation but placed on the market after the entry into force of the regulation.
At the end, no consensus was achieved and the discussions are still going on among the different stakeholders.

UN Regulation No. 79 Steering equipment

This regulation applies to vehicle categories M, N and O and its main target is to define the regulation related to the steering equipment and the possible automatically commanded steering functions (ACSF). Out of the scope of this regulation are the autonomous steering systems, in which the vehicle is commanded to follow a preestablished route and the driver does not have to be in primary control of the vehicle.

At this moment there are some issues under discussion with regard to this regulation:

- ACSF of Category B1 assists driving in such a way that, by influencing the lateral movement of the vehicle, helping to keep the vehicle in a chosen lane. In the 9th session of the GRVA held in March 2021, it was discussed whether this function may cause confusion and overreliance by the driver side.

- Also, in the same session, the European Commission introduced a document to propose new amendments for this regulation or to develop a new regulation if considered necessary. The intention is to provide a safe approach for Human Machine Interface (HMI) as it is expected to become more and more complex in vehicles. This proposal was highly supported by several parties, however this is a long term project which is intended to be developed in several phases, the first phase will show its outcome in September 2021.

3.1.2. GRE: Working Party on Lighting and Light-Signalling

It is a matter of study whether if there is a safety requirement for automated vehicles to indicate their status and to communicate intended actions. The work will be developed by a Working Party on Lighting and Light-Signalling (GRE) Task Force on “Automated Vehicle Signalling Requirements (AVSR)” and it should evaluate and report on the safety needs for AVs to signal their status and communicate their next intended actions using visual or audible signals or a combination of both.

The task of the Task force is given by the following questions:

1. Is there a safety requirement for AV’s to provide signals to indicate their status and to communicate their next intended actions?

2. If so, shall such signals be visual, audible, or a combination of both?

The Task force has discussed the first question and has decided that this principal question is not in the mandate of this task force. Assuming that a “driving mode indicator” is needed, the task force concluded that it should be a visible function (under normal traffic conditions and active autonomous driving) without excluding other type of signalling that may be taken into account in further discussions. However, final conclusions have not been achieved yet by the task force as it is considered that WP.29 should analyse the view of the task force and give further guidance to continue the work. Therefore, a common understanding with WP.1, and also GRE, GRVA and WP.29, so that the Task Force could continue to work on this item is needed.

3.1.3. GRSG: Working Party on General Safety Provisions

The Working Party on General Safety Provisions (GRSG) is the subsidiary body of the World Forum for Harmonization of Vehicle Regulations (WP.29) that prepares regulatory proposals on general safety to WP.29. This group of experts conducts research and analysis to develop general safety requirements for vehicles, in particular buses and coaches.

GRSG convenes officially twice a year and entrusts informal groups with specific subjects that need to be considered urgently or that require special expertise. More than 100 experts participate at the sessions of GRSG. The Working Party on General Safety Provisions (GRSG) is the subsidiary body of the World Forum for Harmonization of Vehicle Regulations (WP.29) that prepares regulatory proposals on general safety to WP.29. This group of experts conducts research and analysis to develop general safety requirements for vehicles, in particular buses and coaches.

GRSG convenes officially twice a year and entrusts informal groups with specific subjects that need to be considered urgently or that require special expertise. More than 100 experts participate at the sessions of GRSG.

DSSAD/EDR: Data Storage System for Automated Vehicle and Event Data Recorder

On the basis of the UN Regulation 157, inside the Working Party on Automated / Autonomous and Connected Vehicles (GRVA) working papers are redacted in the sessions of the IWG for Data Storage System for Automated Driving / Event Data Recorder (DSAAD / EDR) in the different meetings imparted inside these groups for future points covering these regulations.

3.2. Global Forum for Road Traffic Safety (WP.1) UNECE

The Global Forum for Road Traffic Safety (WP.1), is the body from the United Nations focused on improving road safety. It typically meets twice a year in Geneva and its main goal is to address and discuss the topics with influence on road accidents in order to improve road safety through the harmonization of traffic rules.

The main topics that are currently being addressed in the meetings and which have influence in this project are:

- Automated driving: the concept of activities other than driving and the definition of highly and fully automated vehicles.
- Amendment proposals to the 1968 Convention on Road Traffic with relation to distracted driving.

With the arrival of the concept of automated vehicles, the need of regulating the activities other than driving appeared. In that way, the WP.1 meetings started dedicating time to the definition of which activities where considered safe to be developed in the situation where the vehicle takes longitudinal and lateral control of the vehicle, considering the cases of fully and partially automation. This is still a topic that is being discussed, but a first approach has been made with the establishment of the criterion to determine which activities, other than exercising dynamic control, can be performed by the driver of the vehicle while the vehicle has conditionally automated or highly automated driving systems engaged. The four criteria, that could be used to determine if the candidate activity can be executed while the automated system is in control of the vehicle, have been defined in a document

that is still being revised. Based on that document, the driver may undertake activities other than driving provided the following four criteria are met, in combination with each other:

a) These activities do not prevent the driver from responding to demands from the vehicle systems for taking over the driving task.

b) These activities are consistent with the prescribed use of the vehicle systems and their defined functions.

c) The driver complies with traffic laws applicable in the country regarding activities other than driving.

d) The driver has and maintains the capabilities necessary to fulfil their respective duties regardless of whether a conditionally automated or highly automated driving system is engaged or not.

Since the realization of activities other than driving is being considered, WP.1 has detected the need to update the 1968 Convention on Road Traffic in order to include this concept. Therefore, amendment proposals to Article 8 and Article 34 of the 1986 Convention on Road Traffic are being prepared and discussed in the latest WP.1 session.

The amendment proposal to Article 8 suggests the inclusion of two new paragraphs so as to include the possibility of some vehicle systems taking over dynamic control of the vehicle and thus, allowing the driver to be exempted from the driving task. The amendment would allow the driver to exercise activities other than driving provided these activities would not prevent the driver from responding safely to demands for taking over the driving task.

On the other hand, the amendment proposal to Article 34 refers to the inclusion of some definitions related to automated driving, this proposal was approved in the 81st session of the WP.1 and forwarded to the Office of Legal Affairs. Finally, the new concepts to be defined in Article 1 are: “Automated driving system”, and “Dynamic control”, and it was agreed to add an Article 34 bis adding requirements for “Automated driving” situations.

3.3. Cooperation between Global Forum for Road Traffic Safety (WP1) and the World Forum for the Harmonization of Vehicle Regulation (WP29)

In order to facilitate the safe deployment of automated vehicles, the Inland Transport Committee invited the Global Forum for Road Traffic Safety (WP.1) and the World Forum for the Harmonization of Vehicle Regulation (WP.29) to cooperate closely given the importance of automation to the work developed by both working parties. Therefore, in March 2019, a joint event between WP.1 and WP.29 took place under the name of “Automation in Transport: Safe deployment of automated vehicles in traffic”. The topics that were discussed in the event are summarised below:

- The first panel, “Aiming at a common terminology in the area of automated driving vehicles”, described and discussed various aspects of terminology, pointing out that clarity in the “ language of automation” would facilitate regulatory action, and would benefit both the society and industry.

- The second panel, “Current technical capacity of vehicle automation systems”. What should the role/s of WP.1 and WP.29 be? Presenting various vehicle automation systems as well as discussing the scenarios of assessing safety of the systems, and the related technical and legal challenges.

- The third panel, “Activities other than driving”. The panellists focused on the driver’s challenges related to properly and safely engaging with automated vehicles systems, as well as on the human capability to undertake tasks other than driving while the vehicle is in motion.

- The final panel, “The safe interaction between automated vehicle and driver, and automated vehicle and other road users in traffic”. The discussion mostly focused on how vehicle technology can be used to facilitate mobility of all road users, including those with special needs

Both working parties, pointed out that the outputs of the discussions held in the joint event would be taken into account in the agendas of their respective working parties. Subsequently to the event, WP.1 expressed interest in developing a common methodological approach on how WP.1 and WP.29 could cooperate. As a result, the ECE/TRANS/WP.1/2020/3 (13) which describes a framework for collaboration and common approaches between WP.1 and WP.29. In this context, WP.1 and WP.29 held a second joint session, in March 2020, where several Bureau members from both Working Parties provided information on ongoing activities. From this latest session, a document proposed the methodological approach on how WP.1 and WP.29 could cooperate. The three priority areas that have been identified are:

- The development of a common glossary of terminology for AVs to be updated as the technology evolves.

- Research on HMI and Human Factors to further define activities a driver can engage in without compromising road safety.

- Hosting a joint annual meeting starting in 2020 as appropriate to foster discussion and share knowledge/expertise among both working parties.

An approach to automated driving has been submitted, pending to be discussed. The indicated topics such as artificial intelligence, ethics, social benefits of vehicle automation will be considered for the work program of the future Group of Experts on drafting a new legal instrument on the use of automated vehicles in traffic, when it becomes operational.

3.3.1. Informal document nº.8 (ITC session December 2020) - Establishment of Group of Experts on drafting a new legal instrument on the use of automated vehicles in traffic

It is important to reconcile the work done by other international organisations with the work of the UNECE. Furthermore, the work carried out by WP.1 and WP.29 must be aligned with each other so that 'the big picture' will remain clear. This requires, for example, that the definitions used and the understanding of the development of road transport automation will be the same.

In the informal document nº.8, a discussion of the following issues, that are considered to be of key importance, has been launched:

- Performance-based, technology-neutral regulation
- Safety first principle
- Importance of how 'highly and fully automated vehicles' is defined
- Transparency
- Other central sectoral ethical principles
- Data security

4. FUTURE RECOMMENDATIONS

In this chapter, future recommendations for a suitable regulatory framework for platooning solutions are going to be provided. These recommendations will be for a future scenario, according to the detected necessities.

In the new General Safety Regulation (GSR), the Regulation (EU) 2019/2144, appears the term of platooning as a need of European Union to make a new regulation in order to harmonise the rules and the procedures about platooning. According to the list of requirements concerning driver and system behaviour of Annex II of the GSR, the subject about platooning doesn't have any regulation yet. Mentioned in the list of requirements, the vehicles of categories M2, M3, N2, N3 that will fit the system, shall be approved according the regulation from 6th of July of 2022 for new types, and from 7th of July of 2024 for new registrations. As was mentioned above there is no UN regulation or EU regulation about platooning, and not drafted at the moment. The only regulations that we can find at that moment about automated vehicles are the UN Regulation No.157 (ALKS) and a draft version of an EU Regulation regarding Automated driving systems (ADS). But there is no mention of platooning. Nevertheless, from the regulations mentioned before, the requirements regarding the Functional and operational safety, the minimum Risk Manoeuvre, the Human Machine Interface, Cybersecurity and Software-Updates, data recorder can be adopted and adapted to the future platooning regulation. That's why in that chapter, the recommendations that are going to be provided will be requirements that the system will have to comply with, and the test procedure that can be performed to approve vehicles regarding platooning.

Recommendations about how platooning affects the regulations of vehicles, use and infrastructures are already done in other projects, such as COMPANION, CATRE, ETPC 2016 Challenge event.

In September of 2021 some Real World Tests were performed as Platooning demonstrations. Due to the existing technology, only communication between vehicles was allowed. The infrastructure is not prepared yet to communicate with the vehicles.

A first proposal for a regulation will be done taking into consideration the actual state of the technology, which is mentioned above.

The structure followed in the next chapter is the one used in the draft of the European Regulation for Automated Driving System (ADS) (14), due to the common features between ADS and platooning systems. The scope is explained in the first part of this proposal, as well as definitions and general requirements, cybersecurity and software updates requirements and event data recorder requirements. In the second part, assessment and test procedures are described, additionally it is proposed which documentation shall be provided by the manufacturer. The use cases proposed in this document are based on the ones developed in the deliverable 2.3 (15) of this same project, ENSEMBLE, to verify that the system is safe for the occupants and rest of road users.

The UN Regulations and UN GTRs seek to improve the behaviour, handling and equipment of vehicles so as to decrease the possibility of a road crash. Some of the regulations seek to increase the driver's ability to detect and avoid hazards, while others seek to increase the driver's ability to maintain control of the vehicle.

5. PLATOONING REGULATORY FRAMEWORK

5.1. Performance requirements

5.1.1. Scope

This Regulation applies to the type approval of vehicles of Category M2, M3, N2 and N3 with regards to their Platooning System.

5.1.2. Definitions

- “Platoon” means 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 [16]

- “Platooning Support function” means a platooning level where the driver is responsible for the driving task. Hence the driver is also responsible to choose a safe following distance and monitor the system.

- “Platooning Autonomous function” means a platooning level where the driver is not responsible anymore, the system performs the complete driving task within the specified operational design domain. Here, the driver is out-of-the-loop.

- “Tyre Pressure Monitoring System (TPMS)” means a system fitted on a vehicle, able to perform a function to evaluate the inflation pressure of the tyres or the variation of this inflation pressure over time and to transmit corresponding information to the user while the vehicle is running as laid down in UN Regulation Nº141.

- “Emergency braking” means a braking demand for at least 4 m/s2 deceleration to a service braking system of the vehicle as laid down in UN Regulation Nº13.

- “Adaptive Cruise Control (ACC)” means a system capable of controlling the speed of a vehicle set by the driver, which allows the subject vehicle to follow a forward vehicle at an appropriate distance by controlling the engine and / or the powertrain and potentially the brakes, as laid down in ISO 15622:2018.

- “Platooning-ACC” means a platooning communication protocol as laid down in new ETSI regulation XXX.1

- “Brake Performance Estimator” means a function estimating the available friction brake performance taking into account the effect of brake heat, operating by models considering inputs such as for example type and position of the brakes, number and intensity of brake applications, vehicle speed or ambient temperature.

- “Human Machine Interface (HMI)” means all parts of an interactive system (software or hardware) that provide information and control that is necessary for the user to complete a certain task with the interactive system.

5.2. General Requirements

- The effectiveness of the system shall not be adversely affected by magnetic or electrical fields. This shall be demonstrated by compliance with the 05 or later series of amendments to UN Regulation No. 10.

- The manufacturer shall take measures to guard against reasonably foreseeable misuse by the driver and tampering of the system.

- When the system can no longer meet the requirements of this Regulation, it shall not be possible to activate the system.

- The default status of the system shall be the off mode at the initiation of each new engine start/run cycle. This requirement does not apply when a new engine start/run cycle is performed automatically, e.g. by the operation of a stop/start system.

- The system shall perform self-checks to detect the occurrence of failures and to confirm system performance at all times.

- Deactivation by input to driving controls, the system shall be deactivated when at least one of the following conditions is met:

- The driver overrides the system by steering while holding the steering control and this override is not suppressed, or
- The driver is holding the steering control and overrides the system by braking or accelerating.

- The vehicles shall be equipped with:

[1] Platooning communication protocol will differ from the current ISO standard C-ACC, following an ETSI standard. It can be adapted and defined following the work developed in ENSEMBLE project (ENSEMBLE communication protocol).

  - Platooning-ACC and ACC.
  - TPMS.
  - Brake Performance Estimator or equivalent.

- When a problem exists in the communication between the vehicles of a Platoon, the Platoon has to be disengaged and as a first step the ACC has to be activated to separate the vehicles into a safe distance.
- A vehicle being leader of a platoon has to have the ACC activated.
- A vehicle being a follower of a platoon has to have the Platooning-ACC activated.
- The vehicles have to be equipped with a Human Machine Interface (HMI).
- The following information shall be indicated to the driver:
  - The system status
  - Any failure affecting the operation of the system with at least an optical signal unless the system is deactivated (off mode),
  - Emergency braking of other vehicle in the platoon.
  - The optical signals above shall be adequate in size and contrast. The acoustic signals above shall be loud and clear.
- Speed range from 0 to top speed. And when the braking goes below 30 km/h, accelerating again shall be with manual intervention.
- While the vehicles are engaged in a platoon the time gap between the most rear part of the leading truck and the most forward part of the following vehicle shall be separated at least by a gap of [X] seconds.
- Any braking demand exceeding 4 m/s2 shall be considered as an emergency braking.
- Failure cases to disengage the platoon:
  - In case of a warning in the “Brake Performance Estimator”.
  - Puncture in the tyres (TPMS warning).
  - Malfunction in a dynamic system:

- Brakes (booster failure, circuit failure, EBD failure)
- Steering
- AEBS.

5.3. Specific requirements regarding Cybersecurity and Software Updates

5.3.1. Cyber security and cyber security management system

The effectiveness of the system shall not be adversely affected by cyber-attacks, cyber threats and vulnerabilities. The effectiveness of the security measures shall be demonstrated by compliance with UN Regulation No. 155.

5.3.2. Software update and software updates management system

If the system permits software updates, the effectiveness of the software update procedures and processes shall be demonstrated by compliance with UN Regulation No. 156.

5.3.3. Requirements for software identification

- For the purpose of ensuring the software of the system can be identified, an RxSWIN may be implemented by the vehicle manufacturer. If RxSWIN is not implemented, an alternative software identification system (i.e. software version) shall be implemented.
- If the manufacturer implements an RxSWIN the following shall apply:
    - The vehicle manufacturer shall have a valid approval according to UN Regulation No. 156 (Software Update Regulation).
    - The vehicle manufacturer shall provide the following information in the attachment to the information document of this Regulation.
    - The RxSWIN: How to read the RxSWIN or software version(s).
    - The vehicle manufacturer may provide in the communication form of this Regulation a list of the relevant parameters that will allow the identification of the vehicles that can be updated with the software represented by the RxSWIN. The information provided shall be declared by the vehicle manufacturer and may not be verified by an Approval Authority.

- The vehicle manufacturer may obtain a new vehicle approval for the purpose of differentiating software versions intended to be used on vehicles already registered in the market from the software versions that are used on new vehicles. This may cover the situations where type approval regulations are updated or hardware changes are made to vehicles in series production. In agreement with the testing agency, duplication of tests shall be avoided where possible.

5.4. Specific requirements regarding data recorder for platooning system

Each vehicle equipped with a platooning system shall be fitted with a data recorder that meets the requirements specified below

5.4.1. Recorded occurrences

- Each vehicle equipped with a data recorder shall at least record an entry for each of the following occurrences upon activation of the system:
- Activation of the system.
- Deactivation of the system.
- Involved in a collision.
- Platooning system failure.

5.4.2. Data elements

- For each event listed in paragraph 5.2, the data recorder shall at least record the following data elements in a clearly identifiable way:
- The recorded occurrence flag
- Reason for the occurrence, as appropriate
- Date (Resolution: yyyy/mm/dd)
- Timestamp
- Resolution: hh/mm/ss time zone e.g. 12:59:59 UTC
- Accuracy: +/- 1.0 s

- For each Recorded occurrence, the RXSWIN, or the software versions, indicating the software that was present at the time when the event occurred, shall be clearly identifiable.
- A single timestamp may be allowed for multiple elements recorded simultaneously within the timing resolution of the specific data elements. If more than one element is recorded with the same timestamp, the information from the individual elements shall indicate the chronological order.

5.4.3. Data availability

- The data of the data recorder shall be available taking into account requirements of national and regional law.
- Once the storage limits of the data recorder are achieved, existing data shall only be overwritten following a “first in first out” procedure with the principle of respecting the relevant requirements for data availability.
- Documented evidence regarding the storage capacity shall be provided by the vehicle manufacturer.
- The data shall be retrievable even after an impact. If the main on-board vehicle power supply is not available, it shall still be possible to retrieve all data recorded on the data recorder.
- Data stored in the data recorder shall be easily readable in a standardized way via the use of an electronic communication interface, at least through the standard interface (OBD port).
- Instructions from the manufacturer shall be provided on how to access the data.

5.5. Assessment and Tests

5.5.1. PART 1: Audit on functional and operational safety aspects of Platooning System

General:

- This annex defines tests with the purpose to verify the technical requirements on Platoon System. All the tests in this annex shall be performed or witnessed by the Technical Service during the approval process as specified below.
- The test specifications in this document are meant to be a minimum set of tests, the technical service authorities may perform any other test within the system boundaries and may then compare the measured results against the requirements.

Definitions:

- “Leader” means the first truck of a platoon.
- “Follower” means a truck in a platoon which is neither the leader and nor trailing truck.
- “Trailing” means the last truck of a platoon.
- “The system” means a “Higher-level Electronic Control” system and its electronic control system(s) that provide the platoon driving function. This also includes any transmission links to or from other systems that are outside the scope of this Regulation that acts on the platoon function.
- “The ego vehicle” means the vehicle which has primary interest in testing, trailing or operational scenarios, as laid down on ENSEMBLE Deliverable No D2.3.
- “The test target vehicle” refers to the vehicles other than the ego vehicle and have a valid platoon system.

Documentation

- Requirements

  The manufacturer shall provide a documentation package which gives access to the basic design of "The System" and the means by which it is linked to other vehicle systems or by which it directly controls output variables.

  The function(s) of "The System", including the control strategies, and the safety concept, as laid down by the manufacturer, shall be explained.

  Documentation shall provide evidence that the design and development has had the benefit of expertise from all the system fields which are involved.

  For periodic technical inspections, the documentation shall describe how the current operational status of "The System" can be checked.

  Information about how the software version(s) and the failure warning signal status can be readable in a standardized way via the use of an electronic communication interface, at least be the standard interface (OBD port).

  The Type-approval authority shall assess the documentation package to show that "The System":

(a) Is designed and was developed to operate in such a way that it is free from unreasonable risks for the driver, passengers and other road users within the declared ODD and boundaries;

(b) Respects, under the performance requirements specified elsewhere in this Regulation;

(c) Was developed according to the development process/method declared by the manufacturer and that this includes at least the steps listed in paragraph X.X.X.

- Documentation shall be made available in three parts:

The formal documentation package for the approval, containing the material listed in this paragraph 3 which shall be supplied to the Type Approval Authority for the purpose of conducting the product assessment / process audit. This documentation package shall be used by the Type Approval Authority as the basic reference for the verification process set out in paragraph 4 of this annex. The Type Approval Authority shall ensure that this documentation package remains available for a determinated period of at least 10 years counted from the time when production of the vehicle type is definitely discontinued.

Additional confidential material and analysis data (intellectual property) which shall be retained by the manufacturer but made open for inspection (e.g. on-site in the engineering facilities of the manufacturer) at the time of the product assessment / process audit. The manufacturer shall ensure that this material and analysis data remains available for a period of 10 years counted from the time when production of the vehicle type is definitely discontinued.

Description of the functions of "The System" including control strategies

A description shall be provided with a simple explanation of all the functions including control strategies of "The System" and the methods employed to perform platoon within the ODD and the boundaries under which the platoon system is designed to operate, including a statement of the mechanism(s) by which control is exercised. The manufacturer shall describe the interactions expected between the system and the driver, vehicle occupants and other road users as well as Human-Machine-Interface (HMI).

Any enabled or disabled platoon functions for which the hardware and software are present in the vehicle at the time of production, shall be declared and are subject to the requirements of this annex, prior to their use in the vehicle. The manufacturer shall also document the data processing in case of continuous learning algorithms are implemented.

- A list of all input and sensed variables shall be provided and the working range of these defined, along with a description of how each variable affects system behaviour.

- A list of all output variables which are controlled by "The System" shall be provided and an explanation given, in each case, of whether the control is direct or via another vehicle system.
- Limits defining the boundaries of functional operation including ODD-limits shall be stated where appropriate to platoon system performance.
- Information shall be provided about the means to activate, override or deactivate the system including the strategy how the system is protected against unintentional deactivation.

System layout and schematics

- Inventory of components.

  A list shall be provided, collating all the units of "The System" and mentioning the other vehicle systems which are needed to achieve the control function in question.

  An outline schematic showing these units in combination, shall be provided with both the equipment distribution and the interconnections made clear.

  This outline shall include:

  (a) Characterization of Decision-making.

  (b) The data storage system.

  (c) Perception and objects detection including mapping and positioning (if applicable).

  (d) Remote supervision and remote monitoring by a remote supervision centre (if applicable).

- Functions of the units

  The function of each unit of "The System" shall be outlined and the signals linking it with other units or with other vehicle systems shall be shown. This may be provided by a labelled block diagram or other schematic, or by a description aided by such a diagram.

- Interconnections within "The System" shall be shown by a circuit diagram for the electric transmission links, by a piping diagram for pneumatic or hydraulic transmission equipment and by a simplified diagrammatic layout for mechanical linkages. The transmission links both to and from other systems shall also be shown.
- There shall be a clear correspondence between transmission links and the signals carried between Units. Priorities of signals on multiplexed data paths shall be stated wherever priority may be an issue affecting performance or safety.

- Identification of units

- Each unit shall be clearly and unambiguously identifiable (e.g. by marking for hardware, and by marking or software output for software content) to provide corresponding hardware and documentation association. Where software version can be changed without requiring replacement of the marking or component, the software identification must be by software output only.

- Where functions are combined within a single unit, or indeed within a single computer but shown in multiple blocks in the block diagram for clarity and ease of explanation, only a single hardware identification marking shall be used. The manufacturer shall, by the use of this identification, affirm that the equipment supplied conforms to the corresponding document.

- The identification defines the hardware and software version and, where the latter changes such as to alter the function of the unit as far as this Regulation is concerned, this identification shall also be changed.

Safety concept of the manufacturer

- The manufacturer shall provide a statement which affirms that the "The System" is free from unreasonable risks for the driver, passengers and other road users.

- The manufacturer shall provide the Type Approval Authority with an explanation of the design provisions built into "The System" so as to ensure functional and operational safety. Possible design provisions in "The System" are for example:

  (a) Fall-back to operation using a partial system.

  (b) Redundancy with a separate system.

  (c) Removal of the platoon system function(s).

- If the chosen provision selects a partial performance mode of operation under certain fault conditions (e.g. in case of severe failures), then these conditions shall be stated (e.g. type of severe failure) and the resulting limits of effectiveness defined (e.g. initiation of a minimum risk manoeuvre immediately) as well as the warning strategy to the driver.

- If the chosen provision selects a second (back-up) means to realise the performance of the dynamic driving task, the principles of the change-over mechanism, the logic and level of redundancy and any built in back-up checking features shall be explained and the resulting limits of back-up effectiveness defined.

- If the chosen provision selects the removal of the platoon system function, this shall be done in compliance with the relevant provisions of this regulation. All the corresponding output control signals associated with this function shall be inhibited.

Verifications and tests

Taking into account the results of the analysis of the manufacturer's documentation package referred to in paragraph 3, the Type Approval Authority shall request the tests to be performed or witnessed by the Technical Service to check specific points risen from the assessment of the function and the safety concept of the manufacturer.

- The functional operation of "The System", as laid out in the documents required in paragraph 3., shall be tested as follows:

- Verification of the function of "The System"

  The Type approval authority shall verify "The System" under non-failure conditions by testing on a track a number of selected functions from those described by the manufacturer in paragraph 3.4. above, and by checking the overall behaviour of the system in real driving conditions including the compliance with traffic rules.

  These tests shall include scenarios whereby the system is overridden by the supervision centre.

  These tests can be based on scenarios listed in Part 2 and/or on additional scenarios not covered by part 2.

- Verification of the safety concept of paragraph 3.4.

  The reaction of "The System" shall be checked under the influence of a faults in any individual unit by applying corresponding output signals to electrical units or mechanical elements in order to simulate the effects of internal failure within the unit.

  The Type Approval Authority shall verify that these tests include aspects that may have an impact on vehicle controllability and user information (HMI aspects e.g. transition scenarios).

- The verification results shall correspond with the documented summary of the hazard analysis, to a level of overall effect such that the safety concept and execution are confirmed as being adequate and in compliance with the requirements of this regulation.

- Taking into account the results of the analysis of the manufacturer's documentation package referred to in paragraph 3, the Type Approval Authority shall audit specific points from the management system of the manufacturer.

Reporting

Reporting of the assessment the vehicle functional operation and safety concept of the ADS as well as the audit of the safety management system of the manufacturer shall be performed in such a manner that allows traceability, e.g. versions of documents inspected are coded and listed in the records of the Technical Service.

5.5.2. PART 2: Test

General provisions

Test cases created to assess vehicle safety shall be based on the requirements set out in Annex [X]. The requirements are defined in such a way that the pass/fail criteria can be derived not only for a specific set of test parameters, but also for all safety-relevant combinations of parameters that may occur in the operating conditions covered by the type approval and the specified operating range (Example: speed range)

These tests shall confirm the functionality of the system and the safety concept of the manufacturer as described in Part I of this Annex as well as the minimum performance requirements described in Annex [X].

Test site:

The test site shall have its characteristics that correspond to the specified ODD of the platoon system. The intended operational area may act as a test site itself provided that tests can be carried out safely in accordance with the applicable law of the Member State granting the approval.

Environmental conditions:

Tests may be carried out under different environmental conditions, within the limits of the defined ODD for the platoon system. For environmental conditions not tested that may occur within the defined operating range of the vehicle, the vehicle manufacturer shall demonstrate as part of the audit in Part I to the satisfaction of the technical service that the vehicle is safely controlled.

In order to test the requirements for failure of functions, self-testing of the system and initiation and implementation of a manoeuvre to reach a risk imminent condition, errors may be artificially induced and the vehicle may be artificially brought into situations when operating autonomously and exposed to environmental conditions where it reaches the limits of the defined operating range.

System modifications for testing purposes:

If platoon system modifications are required in order to allow testing, e.g. road type assessment criteria or road type information (map data), it shall be ensured that these modifications don't have an effect on the test results. These modifications shall in principle be documented and annexed to the test report. The description and the evidence of influence (if any) of these modifications shall be documented and annexed to the test report.

Subject vehicle conditions

- Test mass

  The subject vehicle shall be tested in a load condition agreed between the manufacturer and the Technical Service. No load alteration shall be made once the test procedure has begun. The vehicle manufacturer shall demonstrate, through the use of documentation, that the system works at all load conditions.

  The subject vehicle shall be tested at the tyre pressure recommended by the vehicle manufacturer.

- Test conditions:

The tests shall be performed under conditions (e.g. environmental, road geometry, location) that allow the activation of platooning system.

- Test equipment:

  Two (or more) vehicles equipped with platooning system as test targets.

  The target used for the tests shall be a regular high-volume series production vehicle of Category M or N or alternatively a "soft target" representative of a vehicle in terms of its identification characteristics applicable to the sensor system of the platoon under test according to ISO 19206-3:2020. (moving target)

  Details that enable the target(s) to be specifically identified and reproduced shall be recorded in the vehicle type approval documentation.

- Test parameter variation:

  The manufacturer shall declare the system boundaries to the Technical Service. The Technical Service shall define different combinations of test parameters in order to cover scenarios in which a collision shall be avoided by the system.

  If this is deemed justified, the Technical Service may additionally test any other combination of parameters.

Speed range

The test shall be performed at least within the vehicle speed range between 30 km/h and the maximum vehicle speed ≤ 90 km/h. The manufacturer shall agree with the Technical Service the test speed.

- Gap time

  The test shall be performed at different gap times.

  - The minimum gap time defined by the manufacturer, which has to be equal or more than [X] seconds.
  - The maximum gap time defined by the manufacturer.
  - 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)

Test scenarios to assess the performance of the system for vehicles equipped with platooning systems

- *Platoon engages:*

  The test shall demonstrate that the vehicle equipped with platoon system is capable of engaging with other vehicles in a safe way.

- The test shall be executed at least:

  Behind by single vehicle or existing platoon

  The vehicle speed shall be tested as specified in the paragraph 6.3.3. of this Annex.

  The system of the ego vehicle shall be in OFF/deactivated mode at the start of the test and the system of the test target vehicle(s) shall be in ON/activated mode.

  The ego vehicle shall be driven in the same lane behind the single vehicle or existing platoon separated for a safe distance using ACC during at least [X] min.

  After this time the driver shall activate the platooning system and remain in platoon for at least [X] min.

- The test requirements are fulfilled if:

- When the driver activates the platooning system the communication status shall turn from OFF/deactivated to ON/activated mode within [X] seconds.
- Once the communication has been stablished the Platooning-ACC system shall be activated automatically and the ego vehicle HMI shall notify the driver that the vehicle is in a platoon.
- The ego vehicle HMI shall notify the driver the position inside the platoon (trailing).
- The ego vehicle has a fixed time gap with a tolerance of – 0 + [X] seconds.

- *Front by single vehicle or existing platoon*
  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.
  - The system of the ego vehicle shall be in OFF/deactivated mode at the start of the test and the system of the test target vehicle(s) shall be in ON/activated mode.
  - The ego vehicle shall be driven in the same lane in front of the single vehicle or existing platoon separated for a safe distance using ACC during at least [X] min.
  - After this time, the driver shall activate the platooning system and remain in platoon for at least X min.
- The test requirements are fulfilled if:
  - When the driver activates the platooning system the communication status shall turn from OFF/deactivated to ON/activated mode within [X] seconds.
  - Once the communication has been stablished the Platooning-ACC system shall be activated automatically and the ego vehicle HMI shall notify the driver that the vehicle is in a platoon.
  - The ego vehicle HMI shall notify the driver the position inside the platoon (leader).
  - Merge in-between by ego vehicle in existing platoon
  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.
  - The system of the ego vehicle shall be in ON/activated mode at the start of the test and the system of the test target vehicles shall be in ON/activated mode.
  - At the start of the test, the existing platoon has to keep a distance between target vehicles bigger than the length of the ego vehicle (this distance has to be agreed between the

manufacturer and the Technical Service). Also, the ego vehicle shall be driven in the side lane of the existing platoon parallel to the gap created between the target vehicles.

- The ego vehicle shall merge with the platoon in the gap created between the target vehicles. The ego shall remain in platoon for at least [X] min.
- At the start of the test the platooning system shall be connected, therefore the communication status shall be ON/activated mode.
- Once the ego vehicle is in the same lane as the platoon and the communication has been stablished, the Platooning-ACC system shall be activated automatically and the ego vehicle HMI shall notify the driver that the vehicle is in a platoon.
- The ego vehicle HMI shall notify the driver its position inside of the platoon (follower).
- The ego vehicle shall maintain a fixed time gap with a tolerance of - [X] + [X] seconds.

- *Merge in-between by target vehicle in existing platoon (where ego vehicle is)*
  - A joinable vehicle cuts-in in a stablished, steady state driving, platoon. The vehicle behind this cut-in is the ego vehicle.
  - The ego vehicle shall remain in platoon for at least [X] min.
- The test requirements are fulfilled if:
  - At the start of the test the platooning system shall be connected, therefore the communication status shall be ON/activated mode.
  - Once the ego vehicle is in the same lane as the platoon and the communication has been stablished the Platooning-ACC system shall be activated automatically and the ego vehicle HMI shall notify the driver that the vehicle is in a platoon.
  - Once the cut-in vehicle is already merged in platoon lane, Platooning-ACC of the ego vehicle is deactivated and ACC is activated. This situation shall be maintained until the cut-in vehicle is directly in front of the ego vehicle and the ego vehicle get connected to the cut-in vehicle., so Platooning-ACC shall be connected again.
  - The ego vehicle HMI shall notify the driver the position inside the platoon when it is connected (trailing/follower).
  - The ego vehicle shall maintain a fixed time gap with a tolerance of – [X] + [X] seconds.
- *Platooning*

The test shall demonstrate that the vehicle equipped with platoon system is capable of platoon with other vehicles in a safe way. It is expected the ego vehicle does not collide with other road users.

- The test shall be executed at least:
  - Steady state platooning
  - A group of three cooperative vehicles shall be in line using wireless communication (V2V) forming a platoon with the system activated.
  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.
  - The gap time between vehicles shall be tested as specified in paragraph 6.3.4. of this Annex. The Technical Service shall perform the tests in both “gap time” conditions.
  - The test starts with the platooning already formed. The ego vehicle shall be a follower inside the platoon.
  - The platoon shall remain for at least [X] minutes.
- The test requirements are fulfilled if:
  - At the start of the test, the truck shall be communicating with Platooning-ACC connected.
  - The selected speed of the platoon shall be maintained with a tolerance of ± [X] km/h during the whole test.
  - The ego vehicle HMI shall notify the driver its position inside the platoon when it is connected (follower).
  - The ego vehicle shall maintain a fixed time gap with a tolerance of – [X] + [X] seconds [X] seconds.
- *Follow to stop*
  - The platooning system shall be able to follow the front platooning partner to a full stop.
  - Ego vehicle as leader.
  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.
  - The gap time between vehicles shall be tested as specified in paragraph 6.3.4. of this Annex. The Technical Service shall perform the tests in both “gap time” conditions.

- The test starts with the platooning already formed. The ego vehicle shall be the leader inside the platoon.
- The leader shall reduce the speed with an acceleration ≥ -[X] m/s2 to a full stop. The value of deceleration shall be agreed with the manufacturer and the Technical Service.

- The test requirements are fulfilled if:
  - At the start of the test the truck shall be communicating with Platooning-ACC connected.
  - The braking demand of the ego vehicle shall be ≥ -[X] m/s^2 during the whole braking.
  - The ego vehicle HMI shall notify the driver the position inside the platoon when it is connected (leader).
  - The ego vehicle shall receive via V2V the braking demand required by the following platoon vehicle.
  - The ego vehicle shall maintain a fixed time gap with a tolerance of - [X]+ [X] seconds until [X] km/h while braking.

- *Ego vehicle as a follower or trailing*
  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.
  - The gap time between vehicles shall be tested as specified in paragraph 6.3.4. of this Annex. The Technical Service shall perform the tests in both “gap time” conditions.
  - The test starts with the platooning already formed. The ego vehicle shall be the follower or the trailing inside the platoon.
  - The leader shall reduce the speed with an acceleration ≥ -[X] m/s2 to a full stop. The value of deceleration shall be agreed with the manufacturer and the Technical Service.
  - Once the platoon has stopped, it remains at standstill for at least [X] seconds.
  - Afterwards, the leader shall accelerate to a speed over than [X] km/h.

- The test requirements are fulfilled if:
  - At the start of the test the truck shall be communicating with Platooning-ACC connected.
  - The braking demand of the ego vehicle shall be ≥ -[X] m/s^2 during the whole braking.

- When the leader accelerates after remaining standstill, the ego vehicle shall not accelerate automatically, it shall be performed manually.

- The ego vehicle HMI shall notify the driver its position inside the platoon when it is connected (follower/trailing).

- The ego vehicle shall receive and communicate via V2V the braking demand desired by the leader of the platoon.

- The ego vehicle shall maintain a fixed time gap with a tolerance of -[X]+ [X] seconds until [X] km/h while braking.

- *Emergency braking*

  The ego truck shall be part of a platoon and any truck ahead in the platoon shall send a desired acceleration, which in combination with the gap and speed difference, results in an Emergency Braking situation for the ego truck.

  The Platooning function and AEBS shall be combined and the AEBS system warning shall already be on the basis of the V2V communication. The emergency braking shall be only initiated after confirmation of the onboard sensor(s). During the confirmation period, the system shall brake with a deceleration up to the system limit.

  Caused by an external vehicle of the platoon.

  In order to simulate an emergency braking situation caused by an external vehicle of a platoon, the scenario used to test this functionality is the vehicle to vehicle with a moving target as specified in UN Regulation No. 131.

- *Ego vehicle as leader*

  The gap time between vehicles shall be tested at the maximum distance as specified in paragraph 6.3.4. of this Annex.

  Before starting the test the platoon shall be already formed.

  The functional part of the test shall start when the platoon is travelling at a constant speed specified in paragraph 6.3.3. of this Annex. And it is at a distance of at least 120 m from the moving target.

  The moving target shall have a constant speed of [X] ± [X] km/h.

  The centreline offset between the leader of the platoon and the moving target shall be not more than [X] m.

The ego vehicle shall be the leader inside the platoon and shall perform an emergency braking of ≤ - [X] m/s^2.

- The test requirements are fulfilled if:
  - At the start of the test the truck shall be communicating with Platooning-ACC connected.
  - The braking demand of the ego vehicle shall be ≤ - [X] m/s^2 during the emergency braking period. And the ego vehicle shall not impact against the moving target.
  - The ego vehicle HMI shall notify the driver the position inside the platoon when it is connected (leader).
  - The ego vehicle shall communicate via V2V the braking demand required by the following platoon vehicle (s).
  - The ego truck driver shall be warned when the AEBS is activated as specified in UN Regulation No. 131.
- *Ego vehicle as a follower or trailing.*
  - The gap time between vehicles shall be tested at the maximum distance as specified in paragraph 6.3.4. of this Annex.
  - Before starting the test the platoon shall be already formed.
  - The functional part of the test shall start when the platoon is travelling at a constant speed specified in paragraph 6.3.3. of this Annex and it is at a distance of at least [X] m from the moving target.
  - The moving target shall have a constant speed of [X] ± [X] km/h.
  - The centerline offset between the leader of the platoon and the moving target shall be not more than [X] m.
  - The ego vehicle shall be a follower or trailing inside the platoon and shall perform an emergency braking according to the braking demand of the platoon leader.
- The test requirements are fulfilled if:
  - At the start of the test the truck shall be communicating with Platooning-ACC connected.

- The braking demand of the ego vehicle shall be ≤ - [X] m/s^2 during the emergency braking period. And the ego vehicle shall not impact against the forward vehicle.
- The ego vehicle HMI shall notify the driver its position inside the platoon when it is connected (follower or trailing).
- The ego vehicle shall receive and communicate, if applicable, via V2V the braking demand desired of the platoon leader.
- The ego truck driver shall be warned when the AEBS is activated as specified in UN Regulation No. 131.
- Caused by a driver braking input:

In order to simulate an emergency braking situation caused by a driver braking input, the driver of the leader vehicle in a platoon shall perform a braking of ≤ - [X] m/s^2.

- *Ego vehicle as leader.*
  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.
  - The gap time between vehicles shall be tested at the maximum distance as specified in paragraph 6.3.4. of this Annex.
  - The test starts with the platooning already formed. The ego vehicle shall be the leader inside the platoon.
  - The leader shall reduce the speed with an acceleration ≤ - [X] m/s2. The value of deceleration shall be agreed with the manufacturer and the Technical Service.
- The test requirements are fulfilled if:
  - At the start of the test the truck shall be communicating with Platooning-ACC connected.
  - The braking demand of the ego vehicle shall be ≤ - [X] m/s^2 during the emergency braking.
  - The ego vehicle HMI shall notify the driver its position inside the platoon when it is connected (leader).
  - The ego vehicle shall communicate via V2V the braking demand required by the following platoon vehicle(s).

- The ego vehicle shall maintain a fixed time gap with a tolerance of -0+ [X] seconds until [X] km/h while braking.

- *Ego vehicle as a follower or trailing.*

  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.

  - The gap time between vehicles shall be tested at the maximum distance as specified in paragraph 6.3.4. of this Annex.

  - The test starts with the platooning already formed. The ego vehicle shall be the follower or the trailing inside the platoon.

  - The leader shall reduce the speed with an acceleration ≤ - [X] m/s2. The value of deceleration shall be agreed with the manufacturer and the Technical Service.

- The test requirements are fulfilled if:

  - At the start of the test the truck shall be communicating with Platooning-ACC connected.

  - The braking demand of the ego vehicle shall be ≤ - [X] m/s^2 during the whole braking.

  - When the leader accelerates after remaining standstill, the ego vehicle shall not accelerate automatically, it shall be performed manually.

  - The ego vehicle HMI shall notify the driver its position inside the platoon when it is connected (follower/trailing).

  - The ego vehicle shall receive and communicate via V2V the braking demand required by the leader of the platoon.

  - The ego vehicle shall maintain a fixed time gap with a tolerance of -0+ [X] seconds until [X] km/h while braking.

- *Platoon gap adaptation:*

  Cut-in (An external vehicle from the platooning merges with the platoon and then cut-out).

  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.

  - The gap time between vehicles shall be tested as specified in paragraph 6.3.4. of this Annex. The Technical Service shall perform the tests in both “gap time” conditions.

- The test starts with the platooning already formed. The ego vehicle shall be a follower inside the platoon.
- At the start of the test the ego vehicle shall be in a platoon in the follower or trailing position.
- An external vehicle cut-in the platoon for at least [X] seconds. The ego vehicle detects the cut-in vehicle and reduces speed to increase the distance to this vehicle.
- As the external vehicle is not joinable in the platoon. The ego vehicle shall remain split from the platoon until the external vehicle cuts-out.
- When the external vehicle cuts-out, the ego vehicle shall re-join the former forward vehicle and restore the platoon.

- The test requirements are fulfilled if:
  - At the start of the test the truck shall be communicating with Platooning-ACC connected.
  - Once the cut-in vehicle is already in the platoon lane, Platooning-ACC of the ego vehicle is shall detect the cut-in vehicle and split from the forward vehicle of the platoon, Platooning-ACC shall be deactivated.
  - The ego vehicle shall adapt the speed and gap towards the cut-in vehicle and between the platoon members by onboard sensors only. ACC is activated.
  - The ego vehicle shall not cause any collision with cut-in vehicle.
  - This situation shall be maintained until the external vehicle cuts-out, then the ego vehicle shall rejoin the platoon and Platooning-ACC shall be connected again.
  - The ego vehicle HMI shall notify the driver its position inside the platoon when it is connected (leader/trailing/follower).

- *Cohesion request.*

  The aim of this test is to keep the cohesion of the platoon when one of the following or trailing trucks requests a lower speed than the speed at which the platoon is travelling on the road.

- *Ego vehicle as leader.*

  In this case the ego vehicle is the leader of the platoon and other vehicle requests a lower speed.

- The vehicle speed shall be tested and agreed with the manufacturer and the Technical Service.
- The gap time between vehicles shall be tested as specified in paragraph 6.3.4. of this Annex and agreed with the manufacturer and the Technical Service.
- The test starts with the platooning already formed. The ego vehicle shall be the leader inside the platoon.
- One of the target vehicles shall request a speed at least 5km/h lower than the speed of the ego vehicle.
- The ego vehicle shall accept the speed request and adapt the speed as requested by the target vehicle.

- The test requirements are fulfilled if:
  - At the start of the test the truck shall be communicating with Platooning-ACC connected.
  - The ego vehicle shall receive via V2V the speed request and the HMI shall notify the driver the speed requested by the target vehicle.
  - The ego vehicle shall be able to accept the speed requested by target vehicle and reduce the set speed to this maximum requested speed (or, when driving manually, the driver drives slower than this speed).

- *Ego vehicle as a follower or trailing.*

  In this case the ego vehicle is part of a platoon in a follower or trailing position. The ego vehicle requests a lower speed.
  - The vehicle speed shall be tested and agreed with the manufacturer and the Technical Service.
  - The gap time between vehicles shall be tested as specified in paragraph 6.3.4. of this Annex and agreed with the manufacturer and the Technical Service.
  - The test starts with the platooning already formed. The ego vehicle shall be in a following or trailing position inside the platoon.
  - The ego vehicle shall request a speed at least 5km/h lower than the speed of the platoon. This action shall be deliberately performed by the driver.

- The test requirements are fulfilled if:

- At the start of the test the truck shall be communicating with Platooning-ACC connected.
- The ego vehicle shall send via V2V the speed request and the HMI shall notify the driver the platooning status.
- The HMI of the target vehicle shall show to the driver the speed requested by the ego vehicle.

- *Platoon disengaging*

The test shall demonstrate that the vehicle equipped with platoon system is capable of disengaging from other vehicles in a safe way.

- *Leave by leading truck.*

  In this case, the leader truck disengages from the platoon by manual disconnection of the platoon system. When the leave procedure is ended, the leading vehicle continues as stand-alone truck, while the others continue as a new platoon; the first following vehicle takes over the role of the leading truck in the platoon.

- *The ego vehicle leaves the platoon.*
  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.
  - The test starts with the platooning already formed. The ego vehicle shall be the leader of the platoon.
  - The driver of the ego vehicle shall perform a deliberate action with means to leave the platoon in the same lane by disconnecting the system in OFF/deactivated mode.

- The test requirements are fulfilled if:
  - When the driver of the ego vehicle deactivates the platooning system the communication status shall turn from ON/activated to OFF/deactivated mode within [X] seconds.
  - Once the communication has been stopped the Platooning-ACC system shall be deactivated automatically and the ego vehicle HMI shall notify the driver that the vehicle is no longer in a platoon.
  - The ego vehicle shall communicate V2V to the backward vehicle in the platoon that it is leaving the platoon.
  - At the end of the test the ego vehicle shall be in a stand alone situation.

- *The ego vehicle remains in the platoon while other trucks leaves.*
  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.
  - The test starts with the platooning already formed. The ego vehicle shall be a follower inside the platoon being in the second position, at the beginning of the test.
  - The driver of the target and leader vehicle shall perform a deliberate action with means to leave the platoon in the same lane by disconnecting the system in OFF/deactivated mode.
  - Then, the vehicles shall remain in platoon for at least [X] min.
- The test requirements are fulfilled if:
  - The ego vehicle receives V2V the “leaving” maneuver of the leader truck.
  - The HMI of the ego vehicle shall inform the platoon status, now the leader truck.
  - The ego vehicle shall communicate V2V to the backward vehicle the change of the position inside the platoon. The remaining platoon members shall assure that they can continue platooning.
  - There shall be no negative effects on the remaining platoon once the leader target vehicle leaves the platoon.
- *Leave by the following truck*

  In this case, while the platoon is active, one of the following vehicles (not the leader nor the trailing vehicle) starts the leaving procedure. When the leave procedure is ended the driver of the leaving vehicle shall make a cut-out action and continue as a stand-alone truck. The remaining platoon members shall close the gap after the cut-out has finished and shall continue as one platoon.
- *The ego vehicle leaves the platoon.*
  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.
  - The test starts with the platooning already formed. The ego vehicle shall be in a following position of the platoon.
  - The driver of the ego vehicle shall perform a deliberate action with means to leave the platoon by disconnecting the system in OFF/deactivated mode.

Once the ego vehicle platoon system has been disconnected the driver of the ego vehicle shall perform a lane change manoeuvre.

- The test requirements are fulfilled if:
  - When the driver of the ego vehicle deactivates the platooning system the communication status shall turn from ON/activated to OFF/deactivated mode within [X] seconds.
  - Once the communication has been stopped the Platooning-ACC system shall be deactivated automatically and the ego vehicle HMI shall notify the driver that the vehicle is no longer in a platoon.
  - At the end of the test the ego vehicle shall be in a stand-alone situation.
- *The ego vehicle remains in the platoon while other truck leaves.*
  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.
  - The test starts with the platooning already formed. The ego vehicle shall be the forward vehicle of the one leaving the platoon (ego vehicle as follower or trailing).
  - The driver of the target vehicle shall perform a deliberate action with means to leave the platoon by disconnecting the system in OFF/deactivated mode.
  - Once the target vehicle platoon system has been disconnected the driver of the cut-out vehicle shall perform a lane change manoeuvre.
  - Once target vehicle has performed the cut-out and disconnection of the platoon, the ego vehicle and the one preceding the cut-out vehicle shall reduce their gap time and perform a new platoon connection.
  - Then, the vehicles shall remain in platoon for at least [X] min.
- The test requirements are fulfilled if:
  - The ego vehicle shall receive V2V the “leaving” maneuver of the cut-out truck.
  - The ego vehicle shall detect the disconnection of the leaving vehicle.
  - The HMI of the ego vehicle shall inform its driver that platooning support is no longer available.
  - At this point the status of the ego vehicle shall be with platoon ON/activated mode but not linked to a leader, being, if applicable, the ego vehicle the new leader of the platoon.

- The ego vehicle shall detect when the cut-out maneuver has been performed through onboard sensors.
- After this the ego vehicle shall communicate V2V to the former leader at the beginning of the test in order to close the gap time between them and form a new platoon configuration.
- The HMI of the ego vehicle shall inform its driver about the new platoon status.
- The ego vehicle shall communicate V2V to the backward vehicle, if applicable, the change of the position inside the platoon.
- There shall be no negative effects on the remaining platoon when target vehicle leaves the platoon.

- *Leave by trailing truck.*

  In this case, while the platoon is active, the trailing vehicle starts the leaving procedure in the same line. When the leave procedure is ended it shall continue as stand-alone truck.

- *The ego vehicle leaves the platoon*
  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.
  - The test starts with the platooning already formed. The ego vehicle shall be the trailer of the platoon.
  - The driver of the ego vehicle shall perform a deliberate action with means to leave the platoon in the same lane by disconnecting the system in OFF/deactivated mode or by pressing the brake pedal and incrementing the time gap with the forward vehicle.

- The test requirements are fulfilled if:
  - When the driver of the ego vehicle deactivates the platooning system the communication status shall turn from ON/activated to OFF/deactivated mode within [X] seconds.
  - Once the communication has been stopped the Platooning-ACC system shall be deactivated automatically and the ego vehicle HMI shall notify the driver that the vehicle is no longer in a platoon.
  - The ego vehicle shall communicate V2V to the forward vehicle in the platoon that it is leaving the platoon.

[Optional] The target vehicle starts to increase the inter-vehicle time gap in respect to the ego one

- At the end of the test the ego vehicle shall be in a stand alone situation.

- *The ego vehicle remains in the platoon while trailing truck leaves.*
  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.
  - The test starts with the platooning already formed. The ego vehicle shall be the second last vehicle inside the platoon, in a follower or leader position.
  - The driver of the target and trailing vehicle shall perform a deliberate action with means to leave the platoon in the same lane by disconnecting the system in OFF/deactivated mode or by pressing the brake pedal and incrementing the time gap with the forward vehicle.
  - The driver of the ego vehicle is warned about the new platooning status. At this point the ego vehicle becomes the trailer of the platoon.
  - Then, the ego vehicle shall remain in platoon for at least [X] min.
- The test requirements are fulfilled if:
  - The ego vehicle shall receive V2V the “leaving” maneuver of the trailing truck.
  - The HMI of the ego vehicle shall inform its driver about the new platoon status.
  - The ego vehicle shall communicate V2V to the forward vehicle the change of the position inside the platoon. The remaining platoon members shall assure that they can continue platooning.
  - There shall be no negative effects on the remaining platoon once the trailing vehicle leaves the platoon.
- *Split*

  While the Platoon is active, one of the follower vehicles (not the leader nor the trailer vehicle) starts the split procedure. The ego vehicle will increase the inter-vehicle time gap in respect to its preceding vehicle. The original platoon continues as 2 new platoons with the ego vehicle being the leading truck of one of the platoons.
- *The ego vehicle as following truck*
  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.
  - The test starts with the platooning already formed. The ego vehicle shall be the second last vehicle inside the platoon, in a follower position.

- The driver of the forward target vehicle shall perform a deliberate action with means to increase the gap of the platoon in the same lane. Alternatively, it may use a dedicated means to split the platoon.
- The driver of the ego vehicle is warned about the new platooning status. At this point the ego vehicle becomes the leader of the platoon.
- Then, the ego vehicle shall remain in new platoon for at least [X] min.

- The test requirements are fulfilled if:
  - The HMI of the ego vehicle shall inform its driver about the new platoon status.
  - The ego vehicle shall communicate V2V to the forward vehicle the change of the position inside the platoon. The remaining platoon members shall assure that they can continue platooning.
  - There shall be no negative effects on the remaining platoon once the trailing vehicle leaves the platoon.

- *The ego vehicle as trailing truck*
  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.
  - The test starts with the platooning already formed. The ego vehicle shall be the trailing vehicle inside the platoon.
  - The driver of the second target vehicle shall perform a deliberate action with means to increase the gap of the platoon in the same lane. Alternatively, it may use a dedicated means to split the platoon.
  - The driver of the ego vehicle is warned about the new platooning status.
  - Then, the ego vehicle shall remain in new platoon for at least [X] min.

- The test requirements are fulfilled if:
  - The HMI of the ego vehicle shall inform its driver about the new platoon status.
  - The ego vehicle shall communicate V2V to the other vehicle the new status. The remaining platoon members shall assure that they can continue platooning.
  - There shall be no negative effects on the remaining platoon once the trailing vehicle leaves the platoon.

- *Leaving by steering out.*

  The “leaving by steering out as follower” use case **is not a main use case** for platooning but will be a used case since it’s close to normal driving behaviours today. This will happen when taking exits or deciding to go faster than the platoon.

- *As leading truck*

  A group of three or more vehicles are platooning. The leader truck decides to leave and steers out by changing lane

- *The ego vehicle leaves the platoon.*

  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.
  - The test starts with the platooning already formed. The ego vehicle shall be the leader of the platoon.
  - The driver of the ego vehicle shall perform a steering out action with means to leave the platoon changing the lane. The driver of the ego vehicle shall perform the manoeuvre without disconnecting the platoon system.

- The test requirements are fulfilled if:

  - The ego vehicle shall be completely in a different lane than the platoon and the platoon system of the ego vehicle is disconnected from the former platoon within [X] seconds.
  - Once the communication has been stopped the Platooning-ACC system shall be deactivated automatically and the ego vehicle HMI shall notify the driver that the vehicle is no longer in a platoon.
  - At the end of the test the ego vehicle shall be in a stand alone situation.

- *The ego vehicle remains in the platoon while other trucks leaves.*

  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.
  - The test starts with the platooning already formed. The ego vehicle shall be a follower inside the platoon being in the second position, at the beginning of the test.
  - The driver of the target and leader vehicle shall perform a steering out action with means to leave the platoon changing the lane.

- The ego vehicle (which has the intention to stay in the lane) detects that is no longer following the leader and initiates a split in front.
- The driver of the ego vehicle is warned about the new platooning status. At this point the ego vehicle becomes the leader of the platoon.
- Then, the vehicles, except of the former leader, shall remain in platoon for at least [X] min.

- The test requirements are fulfilled if:
  - The ego vehicle shall detect that there is no vehicle in front of it, therefore it shall be assumed that there is no leader.
  - The HMI of the ego vehicle shall inform its driver that platooning support is no longer available.
  - The ego vehicle driver shall take full control of the vehicle.
  - The ego vehicle shall communicate V2V to the backward vehicle the change of the platoon status. The remaining platoon members shall assure that they can continue platooning.
  - There shall be no negative effects on the remaining platoon once the leader target vehicle leaves the platoon.

- *As following truck*

  A group of three or more vehicles are platooning. One of the follower trucks decides leave and steers out and takes an exit without using the leave button as for a normal leave.

- *The ego vehicle leaves the platoon.*
  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.
  - The test starts with the platooning already formed. The ego vehicle shall be the follower of the platoon.
  - The driver of the ego vehicle shall perform a steering out action with means to leave the platoon changing the lane. The driver of the ego vehicle shall perform the manoeuvre without disconnecting the platoon system.

- The test requirements are fulfilled if:

- The ego vehicle shall be completely in a different lane than the platoon and the platoon system of the ego vehicle is disconnected from the former platoon within [X] seconds.

- Once the communication has been stopped the Platooning-ACC system shall be deactivated automatically and the ego vehicle HMI shall notify the driver that the vehicle is no longer in a platoon.

- At the end of the test the ego vehicle shall be in a standalone situation.

- *The ego vehicle remains in the platoon while other trucks leaves.*

  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.

  - The test starts with the platooning already formed. The ego vehicle shall be a trailing truck at the platoon, at the beginning of the test.

  - The driver of the target and leader/following vehicle shall perform a steering out action with means to leave the platoon changing the lane.

  - The ego vehicle (which has the intention to stay in the lane) detects that is no longer following the leader and initiates a split in front.

- The test requirements are fulfilled if:

  - The ego vehicle shall detect that there is no vehicle in front of it.

  - If applicable, the ego vehicle shall decrease the gap

  - The HMI of the ego vehicle shall inform its driver that the new platoon status.

  - The ego vehicle shall communicate V2V to the other vehicle the change of the platoon status. The remaining platoon members shall assure that they can continue platooning.

    There shall be no negative effects on the remaining platoon once the target vehicle leaves the platoon.

- *As trailing*

- *The ego vehicle leaves the platoon.*

  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.

  - The test starts with the platooning already formed. The ego vehicle shall be the trailing vehicle of the platoon.

  - The driver of the ego vehicle shall perform a steering out action with means to leave the platoon changing the lane. The driver of the ego vehicle shall perform the manoeuvre without disconnecting the platoon system.

- The test requirements are fulfilled if:

  - The ego vehicle shall be completely in a different lane than the platoon and the platoon system of the ego vehicle is disconnected from the former platoon within [X] seconds.

  - Once the communication has been stopped the Platooning-ACC system shall be deactivated automatically and the ego vehicle HMI shall notify the driver that the vehicle is no longer in a platoon.

  - At the end of the test the ego vehicle shall be in a standalone situation.

- *The ego vehicle remains in the platoon while other trucks leaves.*

  - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.

  - The test starts with the platooning already formed. The ego vehicle shall be a leader/follower inside the platoon at the beginning of the test.

  - The driver of the target and trailing vehicle shall perform a steering out action with means to leave the platoon changing the lane.

  - The driver of the ego vehicle is warned about the new platooning status. At this point the ego vehicle becomes the following or trailing vehicle of the platoon.

  - Afterwards, the vehicles, except of the steering out vehicle, shall remain in platoon for at least [X] min.

- The test requirements are fulfilled if:

  - The HMI of the ego vehicle shall inform its driver that platooning support is no longer available.

  - The ego vehicle driver shall take full control of the vehicle.

  - The ego vehicle shall communicate V2V to the backward vehicle the change of the platoon status. The remaining platoon members shall assure that they can continue platooning.

- There shall be no negative effects on the remaining platoon once the leader target vehicle leaves the platoon.

- *Loss of communication*
- *The ego vehicle lost the communication.*
    - The vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.
    - The test starts with the platooning already formed. The ego vehicle shall be inside the platoon.
    - The ego vehicle simulates a loss of the communication, to the V2V or the GPS (in case of mandatory use for the correct operation of the platooning system)
    - Remain in the same lane for at least [X] min.
- The test requirements are fulfilled if:

  The ego vehicle HMI warns the driver the new status of the platooning system.

- *The target vehicle lost the communication.*
    - As trailing, the vehicle speed shall be tested as specified in paragraph 6.3.3. of this Annex.
    - The test starts with the platooning already formed. The ego vehicle shall be inside the platoon.
    - The target vehicle simulates a loss of the communication, to the V2V or the GPS (in case of mandatory use for the correct operation of the platooning system)
    - Remains in the same lane for at least [X] min.
- The test requirements are fulfilled if:

  The ego vehicle HMI warns to the driver the new status of the platooning system.

- System failures /readiness

  The following failures on the different system shall not increase the danger to other road users. As a result of this failures, the platooning system can not be activated. If the system is activated until the failure appears, it shall be deactivated on a safe way.

  Systems where the platoon system can not be activated if a failure appears:

- Brake booster
- Electronic Control System (ESC)
- Anti-lock Braking System (ABS)
- ACC and Platooning-ACC sensors
- HMI
- Advanced Emergency Braking System (AEBS)
- Front-Camera (in case of use)
- Other system related with Platoon System

The HMI shall inform to the driver the system can not be activated until the failure disappear.

To ensure the system can not be activated, simulate at least two of the system listed before. The simulated failure cannot be simultaneous.

6. SUMMARY AND CONCLUSION

This report responds to the Subtask 6.3.1.EU regulatory framework on Truck Platooning. It represents the first proposal for a regulatory framework for Platooning Systems.

Firstly, this deliverable provides a description of the structure of the regulatory bodies (mainly UNECE and EC) and its main players, the discussion groups. It has been found that the most relevant Working Groups that attain to this project are WP.29 and WP.1. The WP.29 has several informal working groups focused on automated and connected functionalities and vehicles.

Secondly, this deliverable provides a proposal of a regulation for Platooning Systems using the structure adopted by the European draft regulation regarding Autonomous Driving Systems (14). The regulation proposed accomplishes with the aim of safeguarding the feasibility and safety of platooning, at the same time that it ensures the safety of the other road users.

The tests proposed cover the general use cases that a platoon can encounter in different road situations and scenarios, since the platoon is formed until it is dissolved.

In order no to limit the development and implementation of the platoon technology the numerical parameters are not specified in the proposal regulatory framework. At the moment of creating this draft a detail research shall be done to specify the safest and realistic values.

The proposed regulation only takes into consideration the actual state of the art of the technology of platooning systems, so only V2V and platoon support function are included in that proposal.

In the future, when the technology and the infrastructures, in terms of platooning, will be improved, the regulation may could be updated with new supplements and new series of amendments, including aspects such as communication I2V and platooning autonomous function.

ENSEMBLE is a European Commission project finishing in 2022, thus the follow-up of these discussions is crucial for the performance of Task 6.3 Regulatory framework evolution for platooning.

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8. APPENDIX A: GLOSSARY

Definitions of terms used in ENSEMBLE

Term	Definition	
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, increase traffic safety by use of additional ADAS-technology, and improve traffic throughput because vehicles are driving closer together and taking 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.	
Requirements	Description of system properties. Details of how the requirements shall be implemented at system level	
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	
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	
Truck Platoon	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	

Manoeuvre ("activity")	A particular (dynamic) behaviour which a system can perform (from a driver or other road user perspective) and that is different from standing still, is being considered a manoeuvre.
ODD (operational 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.
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.
Use case	Use-cases describe how a system shall respond under various conditions to interactions from the user of the system or surroundings, e.g. other traffic participants or road conditions. The user is called actor on the system and is often but not always a human being. In addition, the use-case describes the response of the system towards other traffic participants or environmental conditions. The use-cases are described as a sequence of actions, and the system shall behave according to the specified use-cases. The use-case often represents a desired behaviour or outcome. In the ensemble context a use case is an extension of scenario which add more information regarding specific internal system interactions, specific interactions with the actors (e.g. driver, I2V) and will add different flows (normal & alternative e.g. successful and failed in relation to activation of the system / system elements).
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.
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.
Strategic layer	The strategic layer is responsible for the high-level decision-making regarding the scheduling of platoons based on vehicle compatibility and Platooning Level, optimisation with respect to fuel consumption, travel times, destination, and impact on highway traffic flow and infrastructure, employing cooperative ITS cloud-based solutions. In addition, the routing of vehicles to allow for platoon forming is included in this layer. The strategic layer is implemented in a 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.
Service layer	The service layer represents the platform on which logistical operations and new initiatives can operate.
Leading truck	The first truck of a truck platoon
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.
Trailing truck	The last truck of a truck platoon
Ego Vehicle	The vehicle from which the perspective is considered.
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 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 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 disengaging	The ego-vehicle decides to disengage from the platoon itself or is requested by another member of the platoon to do so. When conditions are met the ego-vehicle starts to increase the gap between the trucks to a safe non-platooning gap. The disengaging is completed when the gap

	is large enough (e.g. time gap of 1.5 seconds, which is depends on the operational safety based on vehicle dynamics and human reaction times is given). A.k.a. leave platoon
Platoon dissolve	All trucks are disengaging the platoon at the same time. A.k.a. decoupling, a.k.a. disassemble.
Platoon split	The platoon is split in 2 new platoons who themselves continue as standalone entities.
Emergency brake	Brake action with an acceleration of <-4 m/s2
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).
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.
Platoon candidate	A truck who intends to engage the platoon either from the front or the back of the platoon.
Time gap	Elapsed time to cover the inter vehicle distance by a truck indicated in seconds.

Acronyms and abbreviations used in ENSEMBLE

Acronym / Abbreviation	Meaning
ABS	Anti-lock Braking System
ACC	Adaptive Cruise Control
ACSF	Automatically Commanded Steering Function
ADAS	Advanced driver assistance system

ADR	Agreement concerning the International Carriage of Dangerous Goods by Road
AEB	Automatic 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
CS	Cyber Security
CSF	Corrective steering functions
DEN	Decentralized Environmental Notification
DENM	Decentralized Environmental Notification Message
DSRC	Dedicated Short-Range Communications
EC	European Commission
EMC	Electromagnetic Compatibility
ESF	Emergency steering function
ESP	Electronic Stability Program
ETSI	European Telecommunications Standards Institute
EU	European Union
FAD	Fully Automated Driving
FCW	Forward Collision Warning
FLC	Forward Looking Camera
FSC	Functional Safety Concept
GN	GeoNetworking
GNSS	Global Navigation Satellite System

GPS	Global Positioning System
GRVA	Working Party on Automated/Autonomous and Connected Vehicles
HAD	Highly Automated Driving
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
ITC	Inland Transport Committee
ITS	Intelligent Transport System
IVI	Infrastructure to Vehicle Information message
LDWS	Lane Departure Warning System
LKA	Lane Keeping Assist
LCA	Lane Centering Assist
LRR	Long Range Radar
MAP	MapData message
MRR	Mid Range Radar
MVC	Modular Vehicle Combinations
OBD	On-Board Diagnostics
OS	Operating system
ODD	Operational Design Domain
OEM	Original Equipment Manufacturer
OTA	Over the air
PAEB	Platooning Autonomous Emergency Braking
PMC	Platooning Mode Control
QM	Quality Management

RCP	Remote Control Parking
RSU	Road Side Unit
SAE	SAE International, formerly the Society of Automotive Engineers
SCH	Service Channel
SDO	Standard Developing Organisations
SIL	Software-in-the-Loop
SPAT	Signal Phase and Timing message
SRR	Short Range Radar
SW	Software
TF	Task Force
UNECE	United Nations Economical Commission of Europe
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)
VECTO	Vehicle Energy Consumption Calculation Tool
VMAD	Validation Method for Automated Driving
WIFI	Wireless Fidelity
WP	Work Package
WP.1	Working Party 1 - Global Forum for Road Traffic Safety
WP.29	Working Party 29 - World Forum for Harmonization of Vehicle Regulations