

## EUROPEAN TRUCK PLATOONING CHALLENGE

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### Abstract

This paper will report on the experiences and results of the first cross border truck platooning initiative in the world: The European Truck Platooning Challenge. In this showcase six truck platoons departed from different locations in Europe to arrive on the 6th of April 2016 in the Port of Rotterdam. The truck platoons mainly drove at daytime in a normal traffic situation. During the Challenge, each European truck manufacturer had one truck platoon in operation: DAF, Daimler, IVECO, MAN, Scania and Volvo. There was no competition between the OEMs on a technical level. The European Truck Platooning Challenge was much more a challenge in the sense of harmonization test procedures between authorities of the countries involved: Sweden, Denmark, Germany, Belgium and The Netherlands. The ultimate ambition is to create cross border corridors over Europe where truck platooning is allowed and facilitated by 2020.

The research results (benchmark of test procedures, aerial film recordings) and experiences (interviews with truck platoon drivers and stakeholders consultation) are used to come to recommendations for the further process of harmonization and deployment of truck platooning.

**Keywords:** Autonomous Vehicles, Vehicle-to-vehicle Communication, Field Operational Tests, Trials and Testing, Logistics Optimization.

### 1. Introduction

This paper reports on the experiences and results of the first cross border truck platooning initiative in the world: The European Truck Platooning Challenge.

During the Dutch presidency of The European Commission in the first semester of 2016, The Netherlands organized two showcases to underline the necessity of investment in smart mobility. Developments in smart mobility are going fast and society has to be prepared for the consequences. Besides that smart mobility opens up a whole world of new possibilities and a number of societal benefits are expected (traffic safety, fuel savings and CO<sup>2</sup> reduction). One

of the showcases was the European Truck Platooning Challenge (EU TPC). In this event six truck platoons departed from different locations in Europe to arrive on the 6th of April in the Port of Rotterdam at the APM Terminal. The truck platoons mainly drove at daytime in normal traffic situation. The results from this Challenge were presented on the 14th of April at the Informal Meeting of the Transport Board, the board of all Ministers of Transport in Europe.



Photo: Platooning truck arrived at Rotterdam

In the first place the EU TPC was a showcase and not a research project. Nevertheless the EU TPC provided several sources to learn from for future Field Operational Tests with truck platooning:

1. Stakeholders consultation
2. Benchmark of exemptions
3. Monitoring truck platoons (interviews and aerial footage)

### **Stakeholders consultation**

A stakeholders consultation was conducted in March 2016 among 79 stakeholders about their opinions, expectations and experiences regarding a road map for truck platooning cross border corridors. The following topics were dealt with: technology, logistics operation, infrastructure, legal issues, human factors, road user and drivers acceptance and deployment. Special attention was paid on the business case of truck platooning.

### **Benchmark of exemptions**

While every OEM had to apply for an exemption in each country / federal state passing through, in the end there were 19 different exemptions. Although the OEMs came to common boundaries, the technology behind the truck platoons still differed per OEM. The exemptions showed the differences between test procedures in each country / federal state and the way authorities tried to mitigate expected risks. The exemption benchmark can be seen as a starting point for the harmonization process.

### **Monitoring truck platoons**

Open data was mainly collected by aerial recordings. Rijkswaterstaat received the GPS signals from the first truck of each platoon via a special device. The truck platoons could be followed in real-time. The aerial recordings were made on the 5<sup>th</sup> of April. The main focus was the interaction between other road users and the truck platoons. Traffic situations of interest were for example merging traffic at entries, overtaking maneuvers and the behavior of regular trucks in interaction with the truck platoons.

On the morning of the 6<sup>th</sup> of April 2016, eighteen drivers of the truck platoons were interviewed to enrich the information got from the aerial footage.

After a more extensive explanation of the EU TPC, in the subsequent sections the analysis results of the three sources are described in more detail. The paper ends with some conclusions and recommendations for future Field Operational Tests with cross border truck platooning.

## 2. The European Truck Platooning Challenge

In the first place the EU TPC was a showcase. The main purpose was to get cross border truck platooning on the political agenda. In that sense the EU TPC was a great success. Especially the *learning by doing* approach is been seen as an adequate way of dealing with the fast pace of technological developments.



Photo: DAF trucks

During the Challenge, each European truck manufacturer had one truck platoon in operation: DAF, Daimler, IVECO, MAN, Scania and Volvo. There were three 2-truck platoons and three 3-truck platoons. The EU TPC has been a first step to harmonization between authorities of the countries involved: Sweden, Denmark, Germany, Belgium and The Netherlands. Instead of putting much time and effort in harmonizing afterwards, the EU TPC tried to show the benefits of harmonization at the beginning of a new technological development. The harmonization process started with *showing* how each country assesses the applications for exemption and organizes the truck platooning ride, and *sharing* experiences and results of The Challenge. In the end the purpose of the EU TPC is to create cross border corridors throughout Europe where truck platooning is allowed and facilitated.

From the first meeting at the ITS World Congress in Bordeaux, the participants of the EU TPC had six month to make it happen. The Association of European Automobile Manufacturers (ACEA) coordinated the process between the different OEMs; the Conference of European Directors of Roads (CEDR) coordinated the process between the different National Road Authorities. Rijkswaterstaat, the National Road Authority of The Netherlands, part of the Ministry of Infrastructure and Environment, provided the project team for the overall coordination. The RDW participated in the project team.

There was no competition between the OEMs on a technical level. The OEMs agreed on common technical boundaries. The level of automation within the EU TPC was SAE level 1: Driver Assistance, where the execution of acceleration and deceleration was done by the system. Steering remained the drivers' task. The system used was C-ACC: Connected Adaptive Cruise Control. The platoons rode in a 'master-slave' construction, where the following truck(s) took over acceleration, speed and deceleration from the first truck via wireless communication. With no reaction time needed from human drivers, the trucks could follow on shorter distances. The OEMs agreed on a minimal following distance of 0.5 seconds, depending on the robustness of the system. For the use of the C-ACC system and the shorter following distance, an exemption was needed.



Photo: Daimler trucks

Volvo and Scania started their ride from their production locations in Sweden, via Denmark and Germany to the Port of Rotterdam. Daimler and MAN started from their home towns in the south of Germany and DAF and IVECO departed from Belgium. All truck platoons arrived the day before on a secured parking area in the Port of Rotterdam. At the 6th of April, the last 20 kilometers of the EU TPC, all truck platoons could be followed by a live stream. The truck platoons were welcomed at the highly automated APM container terminal, by the Dutch Minister of Infrastructure and Environment Schultz van Haegen and the CEO's of ACEA (Erik Jonnaert) and CEDR (Steve Philips).

### 3. Stakeholder consultation

Seventy-nine members of the EU TPC network took part in the online Stakeholder Consultation survey. Key finding was that many parties agreed on the paramount importance of functional safety whereby this should drive deployment and acceptance of truck platooning in society at large. The Stakeholder consultation had two goals in mind:

1. To validate and build wide-ranging support for Vision Truck Platooning 2025.
2. To identify as many challenges as possible, and open questions on the road towards commercial deployment of truck platooning.

The questionnaire was structured in five topics: Safety and security; Technology; Legal; Logistics business; User acceptance and human behavior; and Infrastructure. Some highlights:

- Safety and security: Functional safety is crucial for acceptance by drivers and society at large. Other challenges involving Safety and Security revolve around safe and reliable braking behaviour in emergency situations and reliability of sensors, components, parts, wireless communication.

- **Technology:** Multi-brand platooning and standardization of communication protocols is high on everyone's agenda. Effective and real-time estimation of safe inter-vehicle gap distance is also considered important. This is partly related to the platoon sequencing problem in that gap distance is dependent on torque, braking power and loading of the trucks.
- **Legal:** There is a major challenge in harmonising legislation across Europe e.g. for vehicle type approval and gap distance between vehicles. Also, longstanding European directives for driving and resting times and use of the digital tachograph need to be adapted to driverless vehicles in order for truck platooning technology to reach its full potential. But most of all, there are still open questions on how to insure platoons. Liability and responsibility change when transferring control from the human driver to the system.
- **Logistics business:** A challenge is the identity of potential platooning partners, and how to join them for ad-hoc platooning operations. Certification of drivers and transport companies could be crucial in building driver acceptance – especially for drivers in the following trucks. Many parties are still unsure about whether the business case is strong enough in the short term, especially given the degree of uncertainty around the system cost of truck platooning.
- **User acceptance and human behaviour:** A potential public backlash about the 'wall of trucks' could be addressed by positive communication on the societal benefits of truck platooning. Communication apart, over the course of time technology can give a solution to this issue through automated gap making for other road users.
- **Infrastructure:** Whether or not lanes will be dynamically allocated to truck platoons, for instance at night, is still an open question. Traffic management could also prioritise truck platoons by means of green waves - making platoon driving more attractive. Also many respondents call for clear segmentation whereby platooning would be made possible, on the basis of road network suitability, high definition maps and reliable real-time traffic information.

#### 4. Benchmark of Exemptions

Every OEM had to apply for an exemption in the countries their truck platoon was passing through. In Germany federal states have their own authorities with the same competences as countries. For some OEM's that meant that they had to apply for exemption in at least 5 different countries / federal states. Each country / federal state has its own procedures and assessment criteria.



Photo: Iveco trucks

## National exemption procedures

Procedures differed from country to country, from no testing at all to extensive testing including tests on a closed proving ground. Some countries put full trust (and thereby full responsibility) in the knowledge and reputation of the truck manufacturers. Other countries researched documentation thoroughly. And in between, some countries accepted test results from the other countries. All countries issued exemptions.

In assessing the functioning of the vehicles, most countries included the vehicle, the road and the interface between the trucks and other road users. The Netherlands established this procedure in national legislation. Scandinavian countries did not carry out technical vehicle assessments. The Netherlands and Germany operate a strict EMC assessment.

Although the OEMs agreed on a minimal following distance of 0.5 seconds, the robustness of their system determined the real distance. Robustness was a result of redundancy and reliability of the system. Redundancy is a system that engages automatically and provides a safe new situation when the C-ACC no longer functions. Reliability of the signals is covered by EMC (electromagnetic compatibility). A vehicle with poor immunity and/or heavy emissions of EM radiation is vulnerable to interference of the data signals around the control. EMC requirements were not totally clear to everyone, giving this room for improvement.



Photo: MAN trucks

## Traffic safety considerations

Road authorities assessed the applications in terms of the impact on infrastructure, traffic flow and safety. Some examples:

- Layout of motorways and position of the truck platoon on the road: Schleswig-Holstein did not allow truck platooning on two-lane motorways, and Baden-Württemberg only allowed truck platooning on motorways with an emergency lane. Belgium confined truck platooning to the right lane, while the Dutch had a general ban on overtaking.
- Complex traffic situations: the following traffic situations were viewed as potentially risky: motorway junctions, traffic density, traffic jams, (mobile) roadworks and weather conditions. Traffic density and weather conditions are not so easy to define. One of the German federal states restricted truck platooning to dry and clear weather conditions.
- Tunnels: there were a number of discussions around the robustness of the systems in tunnels. The main conclusion was that the tunnels on the route were too short to make system failures likely. Belgium was the only country requiring truck platoons to decouple 200 meters before the start of the tunnel.

- **Maximum speed:** The maximum speed for trucks in Sweden, Denmark, Germany and the Netherlands is 80 kph, and in Belgium 90 kph. The German federal state of Baden-Württemberg differed, allowing a maximum speed of 85 kph, so a broken up platoon had a change to accelerate to re-form.

## 5. Monitoring truck platoons

While the Challenge was not a research project as such, driving cross border on public roads in mixed traffic was a unique opportunity to gain knowledge about platooning in general and interaction with other traffic in particular.



Photo: Scania trucks

### Aerial footage

Although only a limited amount of footage was gathered, it provided valuable information. There were no problems in merging traffic at on- and off-ramps, as most of the time the truck platoons gave way to traffic by creating larger gaps after deactivating (or decoupling) the systems, as set out in the Code of Practice. As a result of decoupling in the vicinity of on- or off-ramps, platoons have to regroup once they have passed by. This process takes some time, ranging from 30 to 60 seconds. The benefits of platooning will not materialise during this process.

When another vehicle “invades” the platoon the following truck automatically increases its headway.

There were quite a few normal trucks overtaking the platoons, probably because the platooning trucks were strictly observing speed limits without any margin.

The distance between the lead truck of a platoon and the traffic in front was often larger than for normal trucks. In general, for most platooning trucks the gaps were larger than with non-equipped, normal trucks. In other words: human drivers tend to drive to close to the vehicle in front.

### Interviews with the truck drivers

On the morning of the 6<sup>th</sup> of April 2016, eighteen drivers of the truck platoons were interviewed to enrich the information got from the aerial footage.

The main difference between driving a truck platoon and a single truck, is being part of an entity. When evaluating traffic situations, the lead truck driver has to take account of the full length of the platoon. He has a sense of responsibility for drivers in the following trucks.

Truck platoon drivers are strongly inclined to keep the platoon together. They viewed on- and off-ramps as the most challenging traffic situation. In the drivers’ experience interaction of the truck platoon with single trucks is more complicated than with car drivers. Minor speed differences could be a reason here. Miscommunication is mainly due to the fact that the truck

platoon is not recognizable as such. Some drivers would prefer a means of visibility/ recognition between the truck platoon and other road users. Maximum speed is a determining factor for the number of overtaking manoeuvres by single trucks. A maximum speed of 80 kph means that the truck platoon could hold up traffic flow. A speed limit tolerance 80-85 kph is needed to re-form the truck platoon when broken up.

Drivers decoupled at complex traffic situations on their own initiative, even when not required. The main traffic situations where the truck platoons decoupled were at motorway junctions, on- and off-ramps and in dense traffic situations. The platooning support systems functioned very well, also in complex traffic situations. The driving task is getting easier in free flow traffic situations, but it is getting neither easier nor more difficult in complex traffic situations; different driver competences are required than for a single truck.

The effectiveness of the truck platooning concept decreased apace with a large number of on- and off-ramps in close succession. A following distance of 0.5 sec. works better in keeping the truck platoon intact. A following distance of 0.8 sec. and above meant more frequent merging in traffic and overtaking manoeuvres.

## 6. From Challenge to real life cases

This chapter contains the synthesis of the previous chapters. Not scientifically based, but more than an educated guess and embracing the philosophy of learning by doing. The focus is aimed at Real Life Cases upcoming in the next two years. With testing of on-the-fly platooning not expected in the next several years, these results are confined to scheduled platooning.



Photo: Volvo trucks

Benefits of the truck platooning concept:

- Improved traffic safety due to the ACC and/ or emergency braking functionality. This applies both to the actual platooning trucks and between platoons and preceding traffic. The safety effect is even greater for platooning trucks, as connectivity enables a faster mutual reaction.
- Improved throughput. Platoons can better utilize existing road capacity if headways are shorter than with non-equipped trucks. However, during the Challenge it was observed that quite some non-equipped trucks actually drive closer together than platooning trucks, but safety levels are lower and this can lead to (predominantly head-tail) accidents. The resulting congestion can negatively affect throughput.
- Fuel savings and reduction of emissions, depending on several factors including (short) headways, position in the platoon, percentage of time trucks can actually platoon, weather conditions and layout of the network (slopes, curves, etc.). Fuel savings were not monitored during the Challenge.



- Three potential reductions in labour costs are expected in the future. Alternative use of driving time, driving time appreciated as resting time, and when no driver is needed in a following truck

The success of real life cases depends on four preconditions:

- Truck platooning needs pioneers and cross border initiatives: Further development of the concept of truck platooning will require the involvement of the end users: shippers and haulers. Development is needed for: multi-brand platooning, standardization of communication protocols and certification of drivers and transport companies to boost acceptance by the drivers.
- Current infrastructure as a starting point: Clear segmentations are needed to show where platooning can be operational, on the basis of road network suitability, high definition maps and reliable real-time traffic information. In the longer term, traffic management should make a determined effort to ensure that driving in a platoon is more attractive by prioritizing platoons, using green waves or dynamical allocation of lanes.
- Clarity on liability of the road authorities: The position countries take on liability has consequences for the discussion on the adaptation of the infrastructure to automated and connected driving. Example : if the quality standards for road markings are raised, road authorities will be obliged to maintain these markings in line with these standards.
- Monitoring and transparency: The learning by doing approach aims to shorten the feedback loop. Open questions are researched by monitoring real life cases. This accelerates learning. Transparency is a precondition. It should be made clear which data is indispensable in answering research questions with respect to competitive information. Another precondition is that research results are exchanged between countries.

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Photo: Dutch Minister of Infrastructure and Environment Schultz van Haegen