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Communication Needs and the Driver's Activity in Platooning Systems

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ABSTRACT

The platooning technology allows for two or more trucks running in convoy at a pre-defined distance between each other, being virtually connected using connectivity technology and automated driving support systems. This highlights the importance of human-to-human communication and the multiple human-system interactions towards the perfect coordination of actions. Due to a strong dependence on different types of communications by this system, recent studies mention the need of a new categorization for the automation levels presented by SAE. A new national research project (TRAIN) addresses these issues through an integrated approach that will identify the requirements for the development of truck platooning services and assess the requests for safe deployment in the real world. In a first stage, TRAIN selected professional truck drivers for Focus Groups (FG) aiming at collecting qualitative data about their acceptance, trust, reliance and willing to use levels. Then, the results will be discussed allowing for the simulations parametrization and tuning for the next experimental testing in driving simulator.

Keywords: Cooperative technology, Communication, Truck platooning, Truck driver's activity, Road safety

INTRODUCTION

The goods mobility needs impose transportation solutions for the provision of goods where they are needed, doing it in due time, following the environment protection related recommendations, and saving energy costs. In Australia, where the distances between cities impose long road trips, the solution consisting of physically connected trucks, called road trains, was adopted for the provision of goods to meet the people needs around the country. It lasted until today, but despite the system effectiveness, it remains available just on the Outback Region due to their impact on roads capacity and road safety around main cities (Smart-Trucking, 2023). The technological development in the automotive industry is shaping the future of transportation services.

In such cases, truck platooning systems seem to be the good solution to meet everyone's mobility needs and the provision of the required goods, when and where they are needed saving energy costs and being economically advantageous for the service providers, resulting from the use of appropriate and new technological solutions. Truck platooning consisted on a virtual linking of two or more trucks in convoy, enable to follow each other closely, using connectivity technology and automated driving support systems (PPMC, 2021). This way of travelling allows to reduce air drag and improving fuel economy (Bergenhem, 2010). Platooning also has the potential to increase vehicle capacity on our highways, particularly along freight corridors. The truck at the head of the platoon acts as the leader, with the vehicles behind reacting and adapting to changes in its movement – requiring little to no action from drivers (Bergenhem, 2010). In the first instance, drivers will always remain in control, so they can also decide to leave the platoon and drive independently.

A combination of production safety systems and connected vehicle technology allows trucks to closely follow each other in a safe manner by enabling the trucks to continuously communicate and coordinate travel with other trucks in proximity. Truck platooning deployed across the country is expected to improve national freight movement and the national economy.

In past and current Federal Highway Administration (FHWA) projects, the trucks are partially automated, meaning that the vehicles control the coordinated speeds and braking with the lead vehicles in the platoons, but the drivers always maintain steering control (FHWA, 2021). The drivers are expected to continuously monitor the driving situation to be ready to assume full control of the vehicles at any time. This situation requires important adaptation and imposing human behavioral adaptation together with new training needs. Such changes introduce as well, human factors issues that must be studied and put into the new equations towards the service improvement without compromising road safety. These two important outcomes of the platooning technology implementation in the context of freight industry require deep research addressing such technology transfer. Then, the urgence of studying was identified leading to the submission of a research proposal to the Portuguese research authority, giving rise to the national TRAIN research project (Mapping risks and requirements for truck platooning using a driving simulator).

NEW COMMUNICATION NEEDS

Automation is being implemented in all sectors. In the cargo transport industry, platooning technology is already being developed by several academic institutions and with the support of the main truck manufacturers so that its implementation is close.

When talking about levels of automation in vehicles, the levels defined by the Society of Automobile Engineers (SAE) are considered. According to SAE (2018), there are five levels of automation and one manual level. However, the researchers involved in the ENSEMBLE Project (Willemsen et al., 2022), consider that the first three automation levels of the SAE J3016 shouldn't be applied to truck platooning, once these vehicles strongly depend on different types of communications. That is, these vehicles will have a greater capacity to collect information from different sources, to help drivers in their task, as well as communicate with the infrastructure and other vehicles (Gouy et al., 2014).

In this way, the ENSEMBLE team proposes two new categorizations: Platooning Support Function (PSF) and Platooning Automated Function (PAF). For this categorization, the following were considered: time between vehicles, lateral automation, speed lane, and the required operational areas. On the PSF, the driver is responsible for the driving task, the time gap minimum is between 1.4s and 1.6s, controlled by Adaptative Cruise Control (ACC), while the lateral is controlled by the driver. The system should be capable to deal with cut-in and cut-through. On the PAF, just the leader has the responsibility of the driving task, being not responsible for the safety of the platooning, while the followers are equipped with full automation, being on-the-loop. The targeted distance is 0.5 s, which represents increased risks (Willemsen et al., 2022).

This requires deep research to avoid compromising road safety by the introduction of new risks, together with specific and intensive training for all drivers.

Truck Drivers' Activity and Behavior Regarding In-Vehicle Technologies

In Portugal and similarly to the study carried out by Passey et al. (2014), the profession of long-haul truck drivers is characterized by shifts of 10 to 11 hours a day, rotating shifts, and time pressure imposed by customers and fleet managers to reach their destination within the schedules. Furthermore, professional drivers recognize that their profession is not enough respected by the society, being boring (Williams & George, 2013). Thus, it is not attractive to new generations due to its low pay and the absence of a career progression. Additionally, it is characterized by a lonely activity, spending much time away from home and family. This is due to the monotony and routine of their journeys, as referred by truck drivers considering that the in-vehicle technology has greatly contributed to their safety. However, according to some literature (Neubauer et al., 2019), truck drivers don't consider that the platooning technology increases safety, largely due to their experience with automatic brakes and the type of load they often transport.

In the frame of transportation, safety is a major concern independently on the transport mode, being truck platooning a safer and more efficient freight transport system. Although platoon systems are increasingly present on the roads, the information about the system is not enough disseminated. Thus, it happens that, when driving unequipped vehicles, drivers are prone to perform the same maneuvers that are just relevant when driving partially automated vehicles (Gouy et al., 2014). The same behaviors were referred in the focus groups carried out with Portuguese truck drivers, as frequently adopted when driving in manual mode. Such behavior neglects safety and introduces new risks increasing the probability of accidents, since the human reaction time is lower than automatic braking systems (Reis et al., 2020). According to FHWA (2021), automatic braking is immediate, requiring just one-fifth of the human reaction time.

Thus, truck platooning automated systems aim to warn and inform drivers about potentially dangerous situations resulting from the human reduced resources compared to the high workload imposed by the situation. This explains the relation between the human exception of their abilities to deal with the information imposed by the driving task (Fuller, 2005). The "looked-but-failed-to-see" common failure in the information processing (Brown, 2002) is explained by such limits of the individual ability to process information as a result from fatigue or drowsiness.

In addition, the platooning technology allows to develop a feeling of traveling in a group and to interact or communicate with their colleagues (Castritius, Hecht, et al., 2020). That's why truck manufacturers are eager to bring these platoons to Europeans roads, and the first real-life tests are already underway (FHWA, 2021).

The Importance of Communicating With Others Through In-Vehicle Technologies

As such trucks share the road with a great diversity of vehicles and road users, a general awareness about the platooning system allowing for a clear identification of such vehicles on the road is important to avoid risks. For instance, it happens to see a car or a powered two wheels vehicle (PTW) on the road cutting-in vehicles in platooning when changing lane. This is relatively frequent and explains why European truck drivers prefer driving at short distances between the vehicles in platooning to avoid such interference (Castritius, Lu, et al., 2020; Castritius et al., 2021). Cut-in vehicles in platooning will impose a fast adaptation of the ACC to keep the pre-defined distance between vehicles. Differently, in USA, truck drivers prefer longer distances between vehicles in platooning allowing other road users to cut in (Castritius, Lu, et al., 2020; Yang et al., 2018). These behavioral differences are also related to the road infrastructure features in each country (Castritius, Lu, et al., 2020).

Given that some studies perform tests with three to seven virtually connected trucks (Willemsen et al., 2022), with a trail of approximately 16 meters, the remaining users of the motorways will face trains of 48 meters or approximately 112 meters. These distances may have influence on the main actions related to the ingress to and egress from the highway by the other vehicles' users. In the study from Jallais et al. (2020), during the ingress maneuver, drivers low their speed to a lower than the minimum speed limit at highways, showing higher levels of anxiety, fear and alertness when facing a seven trucks platoon. In the Egress action, the driver waits behind the platoon until arriving at the exit. Also, anger and anxiety were manifested when overtaking and when the platoon was following with the short time gap (Jallais et al., 2020).

Once a vehicle in platooning is allowed to leave the platoon and take another road on a junction, or a new vehicle merging the highway can integrate the platoon, a strong coordination based on communication technology and ADAS support is required. An easy identification of vehicles in platooning is important to avoid cut-ins from other vehicles. Also, truck platooning should be viewed as a system of systems requiring coordination rules to keep its integrity while accomplishing its missions having road safety in mind.

The Importance of CACC Technology and the Related V2V Communications

As previously mentioned, the first truck in a platoon is referred as the "leader", having its driver the responsibility for the driving task, which is supported by the Adaptative Cruise Control (ACC), having the system monitoring control as well (Willemsen et al., 2022). The second truck and the following ones are defined as the "followers", being responsible to react and adapt their speed and position in the lane without (or very little) human action (Janssen et al., 2015).

These vehicles maintain the distance using automated driving technology, radar-based collision avoidance system and connectivity technology with wireless vehicle-to-vehicle communication (V2V) (Janssen et al., 2015; Willemsen et al., 2022). For highly-automated trucks (ERTRAC, 2019), the gap between vehicles can be as low as 0.2 seconds, which at 80 km/h represents a distance around 6,7 meters. However, for lower automation levels, a distance between 15 and 30 meters is recommended for safety requests (Kuhn et al., 2017; Zhang et al., 2020).

The inclusion of V2V communications enable cooperative adaptive cruise control (CACC) for enhanced stability and responsiveness of truck platooning operations. Furthermore, the CACC allows trucks to travel at short distance on a safer way, controlling the time gap between trucks more smoothly, exchanging information between trucks and automatically adjusting engine and brakes in real time as conditions vary (FHWA, 2022). In order to mitigate a lack of confidence and decrease the feeling of fear, it is important that infrastructures enable the exchange of information through vehicle-to-infrastructure (V2I) technology, allowing for faster communications between vehicles and the road equipment in order to increase road safety (Teague, 2021).

THE TRAIN RESEARCH PROJECT

Being a totally new technology in freight industry, truck platooning represents an important change onto the freight transport and requires deep research to avoid compromising road safety by the introduction of new and unexpected risks. In Portugal, as in other European countries, very few research studies or projects exist being devoted to the perception and awareness of truck platooning, as well as to the driver's activity and behavior study in the same context.

The implementation of the platooning technology in Portugal will require an improvement of the national infrastructures. However, Portugal has a strong number of export activity to several European countries, which justifies the necessary investment in vehicles and infrastructure. Thus, the main Portuguese freight companies preview this technology with some expectations. Aiming to disseminate this technology among freight companies, a new national funded research project (TRAIN - Mapping risks and requirements for truck platooning using a driving simulator) addresses these issues through an integrated approach that will identify the requirements for the development and implementation of truck platooning services and assess the risks for a safe deployment in the real world. In a first stage, TRAIN is engaging professional truck drivers and representatives of freight companies in Focus Groups (FG) interviews aiming at collecting data about their feelings, attitudes and behaviors influencing their acceptance of the platooning technology, together with the development of acceptance, trust, reliance and willing to use (Krueger & Casey, 2009). Considering that the FG sessions didn't allow for a convenient number of participants, the analysis and results of the collected data allowed to identify key questions for the design of an extensive survey to be applied to truck drivers working or performing training on platooning systems.

Focus Group Results

One of the main concerns to conduct the FG sessions and achieve the defined objectives, was to define the characteristics of the participants that should take part on the FG. The main criterion for recruiting participants is that they hold a valid driving license, have some experience using driving assistance systems and work for an important long-distance transport company.

Table 1 summarizes the total sample that has participated in the FG sessions that have been carried out in two companies from the north region of Portugal.

A total of 22 truck drivers participated on the three sessions. The sample is 100% male truck drivers aged 44–62 (mean 53.9 ± 4.9), being 100% of the drivers operating on long haul transport. However, only one driver (4.5%) operates nationally while the rest (95.5%) operate internationally. On average, the subjects have a heavy-duty license for 30.3 years (± 7.4) and had been operating as truck drivers for the company 24.2 years (± 5.3).

Table 1. The sample for the FG sessions.

		Automated Vehicles	
		Age Group	
Total		44–53	54–63
Company A	15	6	9
company B	7	2	5
Total	22	8	14

The summarized discussion topics and their main contents are organized on Table 2 according to results of the FG sessions.

The following topics have been launched for discussion in every FG session in order to get participants' opinions, feelings and attitudes regarding automated vehicles in freight industry, more specifically about platooning technology, and to identify any potential resistance to their use: Previous experience with in-vehicle technology; Representations about automated vehicles in freight industry; Opinion about truck platooning; Perception of

Table 2. Main results of focus group sessions.

			FOCUS GROUPS RESULTS
Characterization			**Results**
In-Vehicle Technology	Use it	Yes	Cruise Control.
			Navigations Systems.
		No	Lane Keep assistance.
			Emergency brake system.
	Evaluation	Positive	Consider an helpful on driving task.
			Recognize that technology has contributed to safety.
		Negative	Lane keep systems it's annoying and scares, specially at night.
			The brake system interferes with road signs on motorways and blocks the vehicle in the lane.
			Given the characteristics of the load being transported, the braking system can compromise driver safety.
Representations about automated vehicles in Freight Industry			
			Remote controlled trucks or driven on specific roads equipped with sensors that connect to GPS
			Existence of a lead truck with a driver who defines what the followers do.
			Could be a way to overcome the lack of drivers
			Concerns about unemployment and civil liability in the event of an accident with a driverless vehicle
Opinion about Truck Platooning	Positive		May represent a greater rest for drivers and fuel savings
			Recognition that it will be necessary to continue to have drivers due to the different destinations
			It works for the safety of the drivers who park together

Continued

Table 2. Continued.

FOCUS GROUPS RESULTS		
Characterization		**Results**
	Negative	A combination of several factors for working is required: load weight, available driving time and type of truck.
		Distance increases due to cut-ins, and difficulty position recovery, if keeping speed doesn't bring benefits
		Requires specific driving and be more monotonous.
	Safety related Concerns	The behavior and characteristics of the load in case of emergency braking
		Concern about not knowing the lead driver
Communications	Type	SMS, E-mail and voice
	Device	Personal mobile phone
		ASTRATA System
	Intervenient	Drivers from their company and other companies
		Between driver and operations managers
Dealing with Technology	Notion of the limits	Technology failure
		Humans make mistakes, but machines do too.
	Training Request	Requires a specific training to know how to deal with situations.
		In the future we will be technicians.
	Acceptance	Everything that is technology is welcome.
		I am against this evolution. This for me… I'm against this.
	Implications for safety	The safety distance must remain the same.

the limits of technologies, their implications on safety and the willingness to experience this technology.

THE NEXT STEPS

At the present stage, a survey is being designed to be applied to truck drivers working on Portuguese Freight companies. Thus, a questionnaire has been designed based on the FG results with the aim of collecting quantitative data from a representative sample of truck drivers working in Portuguese Freight Companies. Addressing several variables related to the platooning technology, such as the notions of the technology limits, the truck drivers' acceptance, trust, and intention to use, among other, the collected data will be analyzed and discussed towards the parametrization of the previewed experimental simulation activity. Being the related scenario under development, the experimental details will be defined accordingly.

Being the previewed experiments on the driving simulator of major interest for the TRAIN Project, it is expected that the tests results will allow for a better understanding of the platooning system and the future procedures required for the system implementation in Portugal.

It is previewed that the experimental part of the project will involve truck drivers interacting in the previewed events on the scenario under development.

So far, the main outcomes of the TRAIN project are:

- An acceptance model to predict the market adoption of truck platooning;
- Driver behavior models to assess the risks of cognitive underload, drowsiness, and distraction in partially-automated truck platoons;
- Guidelines and recommendations to the truck platooning industry, operators, and regulatory bodies directed to both:
    - the improvement of safety, usability, and market acceptance of truck platooning,
    - the definition of regulations and training needs.

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