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The Technology Era, Truck Platooning, Truck Drivers' Activity, and Risk Awareness

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ABSTRACT

Technological development in the automotive industry is shaping the future of transport services to meet the mobility needs of the population and ensure the timely provision of the required goods, when and where they are needed. Thus, innovative solutions for decarbonization and economic improvement are being put into practice, imposing risk awareness and behavioral adaptation. In the field of Transport, the coming years will require a focus on providing transport systems with robust adaptability to rapid, unexpected changes, planning, and learning from each one. This requires human resources to be prepared for continuous learning, adapting their activity to the technological development, and stimulating creativity as a resource to anticipate, adapt, and improve. In this perspective, new needs and priorities have been identified to be met by anticipating and reinforcing adaptation capacity and by constructing innovative knowledge and tools to support the required adaptation to a changing world and rapid technological development. Automation appears to be an appropriate solution, particularly the introduction of truck platooning to improve efficiency in the European freight transport market. Driver-assistive truck platooning involves a convoy of two or more trucks, with a human driver in the lead truck and a partial automated system controlling the following trucks. These vehicles use connectivity technology, such as Vehicle-to-Vehicle (V2V) communication and Cooperative Adaptive Cruise Control (CACC), to automatically maintain a close, predefined distance. The technology offers benefits such as reduced fuel consumption through aerodynamics, improved traffic flow, and enhanced road capacity, while drivers remain in control and can intervene when necessary.

Keywords: Truck Platooning, Road Safety, Drivers' activity, Connectivity, Communication.

INTRODUCTION

The Freight Industry represents a transport sector having a major importance in our life as it represents the way to provide our needs for goods with the required frequency to ensure the desired quality in due time. However, the importance of this transport sector is not socially well recognized. Nobody thinks about the long driving hours spent at the wheel day or night to provide our communities with the required goods. In this technological era, new trucks are equipped with in-vehicle technology that are supposed to improve safety. However, most truck drivers, who are approaching their retirement, don't feel comfortable with new in-vehicle technology, which represents to

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them a difficulty instead of a safety tool. Furthermore, the truck driver's profession is not attracting the new generation, which explains the increasing shortage of truck drivers in the most industrially developed countries. Thus, something must be done about the access to the truck driver's profession providing the potential candidates with the required training adapted to the present reality, develop the new skills required for a successful profession, and insure the behavioral adaptation to the new truck platooning.

Technical and organizational working conditions provided to truck drivers impose heavy workload and stress, frequently accompanied by passive fatigue, which leads to drowsiness and increased risk of sleeping at the wheel. In road traffic, risk is a function of four elements. The first is the exposure, defined as the amount of movement or travel within the system by different users or a given population density. The second is the underlying probability of a crash, given a particular exposure. The third is the probability of injury, given a crash. The fourth element is the injury outcome.

A study based on a survey carried out in France with 515 truck drivers from eight European countries has highlighted their poor quality of sleep and the related probability of occurrence of crashes resulting from passive fatigue. Furthermore, a poor health state along with tobacco habits and unbalanced diet have been reported. These results are in line with others issued from prior investigation to this one. Since the driver is not alone on the road, social processes can be expected to influence the driver's behaviour. The fact that truck platooning systems share the road with different kinds of vehicles, each one from different technology-related generations, together with the diversity of users, increase the complexity and uncertainty of the entire environment with an important impact on users' safety perception. This requires more information about truck platooning systems leading to increasing information and communication needs.

Being the linking of two or more trucks in convoy, truck platooning works by creating a close, constant coupling between platooning vehicles, separated by limited distances, and operating as a unit. Trucks are equipped with on-board computers, monitor sensor systems, and integrate data from adaptive cruise control, automatic braking, lane-departure warning systems, and vehicle-to-vehicle (V2V) communication systems, such as dedicated short-range communication (DSRC) systems, and use cooperative adaptive cruise control (CACC) to form a platoon of two or more trucks.

Low level automated trucks organized in platooning is an emerging technology that allows those trucks to follow in convoy at previous defined distances and speed with automated speed control and direct wireless communications between vehicle systems. This technology, known as cooperative adaptive cruise control (CACC), allows vehicles to detect and respond rapidly to changes in the speed of the vehicle ahead to maintain a set following gap. Automated truck platooning is expected to offer several economic and environmental benefits in a mixed-fleet environment, including improved traffic flow, reduced fuel consumption, and fewer emissions of harmful greenhouse gases. However, the way common drivers are driving on our roads, different kind of vehicles, how light-vehicle drivers will respond to truck platoons on public roads, is unclear so far. Research projects are still necessary to identify, explore, and conduct research related to key anticipated human factors issues that may arise from the operation of partially automated trucks on public highways.

THE TRUCK PLATOONING SYSTEM

Driver-assistive truck platooning involves a convoy of two or more trucks, with a human driver in the lead truck and a semi-automated system controlling the following trucks. These vehicles use connectivity technology, like Vehicle-to-Vehicle (V2V) communication, and Cooperative Adaptive Cruise Control (CACC) to automatically maintain a close, pre-defined distance. The technology offers benefits such as reduced fuel consumption through aerodynamics, improved traffic flow, and enhanced road capacity, while drivers remain in control and can intervene when necessary.

HOW IT WORKS

a. The Leading Truck:

The lead truck is driven by a human driver who has the responsibility for steering, monitoring the system, and intervening when necessary.

b. Following Trucks:

The trucks behind the leader are controlled by automated driving support systems. Other road users driving a small car or a motorized 2 wheels may be attracted by the platoon and decide to enter on the free space between two vehicles of the platoon, which is very risky to both sides of the conflict. The previously defined distances between trucks in the platoon (15 m or 21 m) may be attractive to a small car or a motorized 2 wheels to cut-in, which is very risky and dangerous to both. Cut-ins are an invasion of the space between two trucks from a platoon, which is stressful and risky to both sides: the close truck drivers and the cut-in intrude[1].

c. V2V Communication:

The trucks communicate wirelessly to exchange information about their speed, acceleration, and position.

d. Coordinated Control:

This information is used to automate the speed and braking of the follower trucks, allowing them to maintain a consistent and close following distance with the vehicle in front.

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[1]Note: The previously defined distances between trucks in a platoon are frequently defined between 15 and 21 meters.

e. Driver Oversight:

Drivers in the following trucks can monitor the system and take over the control of the vehicle at any time.

THE BENEFIT

f. Fuel Efficiency:

Trucks in close formation create a "slipstream" that reduces aerodynamic drag, leading to significant fuel savings for the entire convoy.

g. Traffic Flow & Road Capacity:

Smoother, more coordinated movement of trucks can improve traffic flow and increase the effective capacity of roadways.

h. Safety:

The rapid, consistent reaction times of the automated systems can be faster than those of human drivers, potentially enhancing safety.

KEY TECHNOLOGIES

- **Adaptive Cruise Control (ACC):**
  The base technology that allows trucks to maintain a set speed and distance from the vehicle ahead.

- **Cooperative Adaptive Cruise Control (CACC):**
  An enhanced ACC that uses V2V communication to further automate speed and braking, enabling closer following distances.

- **Vehicle-to-Vehicle (V2V) Communication:**
  A technology allowinhg trucks to exchange real-time data wirelessly, coordinating their movements.

- **Advanced Driver Assistance Systems (ADAS):**
  These systems may include features such as automated steering, braking, and acceleration to assist human drivers.

- **Attitudes toward a transition to platooning systems**
  The platooning technology allows for two or more trucks running in convoy, like a "short train", being virtually connected.

THE RISKS AND LIMITS OF TECHNOLOGY

Another issue requiring deep research refers to the limits of technology and the user's awareness of such risks. Recent literature discusses the main problems related to the wide adoption of automated driving, particularly the level of maturity of the vehicle technology (Bagloee, Tavana, Asadi & Oliver, 2016) and its constraints and limits, mainly at level of the road environment perception (Färber, 2016). These issues pose new challenges in terms of accuracy, reliability, and the driver's trust in the in-vehicle advanced technology.

The body of literature on the limits of technology in automated driving tends to report different kinds of current constraints, which can be split into two complementary dimensions: (1) the technology design and its status in relation to the human activity in terms of the role assigned to the human in the presence of the automation technology; (2) and the implementation of technology in the road transport system, as a dynamic open system characterized by uncertainty resulting from obstacles and unexpected events, together with the human limits and variability.

Merat et al. (2018) suggest that, when the vehicle is controlled by an automated system, the driver may still be *in*, *on* or *out of the loop*. Thus, the authors defined *in- on-* and *out of the loop* as follows:

1. Being *In the loop* means that the driver is in physical control of the vehicle and monitoring the driving task.
2. Being *On the loop* means that the driver is not in physical control of the vehicle, but s(he) is still monitoring the driving task.
3. Being Out of the loop means that the driver is not in physical control of the vehicle and s(he) is not monitoring the driving task.

Being *in-*, *on-* or *out of the loop* should not be viewed as discrete states, but rather as levels of engagement along a continuum. This could be, for example, applied when an automated system is responsible for performing the steering task, but provides continuous force feedback to the driver, thus keeping the driver in the lateral control loop, to some degree.

The paper published by Kyriakidis et. al (2015) pointed out that those challenges, such as, the levels of acceptance, trust, and reliance on the automated system, are not yet resolved. The authors stressed the needs for more research to avoid overreliance together with unintended use, misuse, or even abuse.

With the introduction of the truck platooning technology, both operational conditions impose different tasks, and thus, different drivers' activity. This means that the main task of the leader is driving a low-level automated truck, which means that his/her activity is represented by the corresponding regulation loop to perform the driving task, being ready to take over the vehicle control when requested by the system. The follower(s) don't perform a driving task, but instead, their activity is mainly centred on monitoring the information provided by the system and the leader, following instructions. As it is quite known, this is a role that humans are poor in performing for long durations. With increasing trust on the system, it is possible that leaders will start performing secondary tasks (Simões et al., 2020) having gained a sufficient level of trust in their performance (Popken et al., 2008). This overreliance and the change of task priorities reflect major safety concerns in the context of truck platooning (Popken et al., 2008,) increasing the risk of accidents as a result from a cognitive underload and reduced situation awareness, giving rise to drowsiness and consequently, a decrease of the operator's ability to promptly react (Simoes et al., 2020).

THE UNIFIED THEORY OF ACCEPTANCE AND USE OF TECHNOLOGY

The Unified Theory of Acceptance and Use of Technology (UTAUT) is a model that explains a user's intention to adopt and use new technology, based on four key constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions. These factors are moderated by individual differences, such as gender, age, experience, and acceptance of use. The theory states that the actual use of technology by a person is a result of a behavioral intention to use it. Different theoretical models have been developed to predict the technology adoption and use. The Unified Theory of Acceptance and Use of Technology (UTAUT) is a framework developed by Venkatesh et al (2003) to predict the technology acceptance in organizational settings.

Based on extensive work and review, Venkatesh et al (2013) updated the theory and developed the UTAU 2, incorporating three constructs: hedonic motivation, price value and habit, considering that individual differences (age, gender and experience) could moderate the effects of these constructs on behavioural intention and technology use. Results from a two-stage online survey with technology users, the collected data from 1.512 mobile internet consumers supported the model (Venkatesh et al. 2013). This one should be applied in a research project to assess the drivers' trust and reliance in the technology for each operating condition in a low level truck platooning. Both the leading and the following conditions, aiming at assessing the effects of the three constructs on the drivers' attitudes (trust) and behavioural intentions (reliance) when using level 3 automation in truck platooning (Nordhoff et al, 2019).

Truck platooning systems are referred as making road transport faster, cheaper, cleaner and safer while, at the same time, increase the road capacity. However, other studies found some aspects less positive, particularly depending on the traffic density. It is the case of a study conducted by Calvert et al. (2019) proposing a set of recommendations to overcome some found limitations of the system, particularly depending on the traffic flow. This is an example of the enthusiasm around a new and innovative system before achieving its maturity. So, the idea is good, but is it enough mature to be put into practice without enough testing? Is a human- system integration approach behind the system development?

A truck platooning is a system evolving on the road transport system, which is actually, a system of systems, each one composed of three interactive elements: technology, organisation and people.

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