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On the viability of autonomous follower truck convoys

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Abstract

Autonomous follower truck convoy (AFTC) is a concept that addresses the major shortage of truck drivers and increasing transport costs. The AFTC concept can be described as a vehicle convoy concept consisting of two or more vehicles where the first, lead vehicle has a human driver and where the following vehicles in the convoy are driverless. The argument is made that this technology is less technically complex than single autonomous vehicles and targets higher economic values compared to driver-assisted platooning functions. The contribution of this paper is a viability study of the AFTC concept. The conclusions from the study are that the concept viability depends on the continuous evolvement of three main factors. The emergence of autonomous capabilities, legal frameworks, and logistics actors' interest in adapting current processes and infrastructure to meet the operational limitations of the concept.

Keywords: Autonomous vehicles, platooning, platooning autonomous function, autonomous truck convoy

Introduction

A sustainable freight industry is vital for our society. In 2020, road freight accounted for 77.4% of inland freight transportation in the European Union, the highest figure recorded in the past decade [1]. The road freight market has increased with 27.5% since 2010 and some 1,764 billion kilometres were driven in 2019. Data from industry associations show that the shortage of heavy truck drivers is widespread in Europe, with a shortage of 400,000 in the EU [2]. In 2019, 24% of the driver positions were unfilled and the IRU forecasts an increase to 26% in 2022 [3].

The quest for new autonomous driving technology that can help solve this accelerating challenge is in full swing and a host of solutions are currently being developed and tested at great expense. However, as is evident in early phases of disruptive innovations, there is still uncertainty as to exactly how the future dominant solution will look [4]. Indeed, early on, several solutions generally compete for attention, funding and adoption. These solutions are typically considered more or less disruptive, depending on how much they differ from current technologies in use. In the transport automation domain two significant concepts, truck platooning and self-driving trucks have been on the horizon for several years to address the sustainability challenges. But the concepts have not yet delivered on their full potential to increase energy efficiency and address the truck driver shortage and costs.

The autonomous follower concept can be described as a vehicle convoy concept consisting of two or more vehicles where the first, lead vehicle has a human driver and where the following vehicles in the convoy are driverless. The driverless follower vehicles can thus benefit from the lead vehicle human drivers' capabilities e.g., perception, situational awareness, mission management and dynamic abilities [5]. Relevant information is transferred digitally, in real-time, from the lead vehicle to follower vehicles through a wireless link. The distance between the vehicles can range from just a few meters to 50 m or more. Technically the distance can be much longer, but the longer the distance the less advantages can be assumed to be transferred from the lead vehicle as the situational difference in between vehicles increase over time and distance. When the situational difference increase, so will the need of capabilities of the following vehicles to be managed independently by an autonomous system.

The concept has similarities with the platooning concept, which has been the focus of recent research. The platooning concept is often described as an SAE L1 or L2 [6] convoy concept where a human driver is present in all vehicles, including the follower vehicles. The follower vehicles are guided with the same principles from the lead vehicle. The human driver in the platooning follower vehicles is then driver-assisted or expected to take control when needed and drive parts of the planned route or in specific situations manually. The main target is often described as energy efficiency obtained by improved aerodynamical effects such as decreased drag which requires that the distance in-between the vehicles is rather short.

Instead of the targeted effects from the platooning research, the autonomous follower concept removes the need for human drivers present in the follower vehicles during transport. The platooning effects of decreased energy consumption could be achieved as well. But the main intended feature is to reduce the number of drivers required, alleviating driver shortage challenges and driver cost.

In doing this it is addressing the same challenges as single autonomous driverless trucks. The single autonomous truck can be expected to fit most current logistics operations, such as the scheduling of logistics and operation of terminals, including scheduling of departures and arrivals. Autonomous follower convoys require space to form and break up the convoy. Additional personnel can be expected to manage the added processes, and the concept may require an adapted type of schedule as the convoy vehicles need to be bundled and scheduled together, and so will the trailers and goods. As there are identified comparable limitations in favour of the single autonomous trucks, other incentives are required for the autonomous follower convoy concept to be a viable solution.

Hypotheses

In this study five hypotheses are presented for the autonomous follower convoy concept to be a viable and competitive solution compared to single autonomous trucks.

The **first hypothesis** is that autonomous follower vehicles are less (technically) complex compared to single autonomous vehicles. This first hypothesis indicate that the autonomous follower concept is less costly and has shorter time to market compared to single autonomous vehicles. The first hypothesis also indicate that the autonomous follower concept may be a steppingstone towards single autonomous driverless trucks as the main technologies needed for autonomous followers is likely required for single autonomous vehicles as well, with the difference that single autonomous vehicles have even higher requirements.

The **second hypothesis** is that the autonomous follower convoy concept will have a different and occasionally advantageous operational design domain (ODD) compared to single autonomous vehicles for a foreseeable future. This is expected to be the case until perception and computer systems' ability to define and process a situational awareness overtake humans in all necessary contexts.

The stakeholders within the logistics ecosystem compete with price, availability, and service level. As long as there are situations where a human driver has superior perception and situational awareness, availability and service levels for the autonomous follower concept is higher. Examples of conditions include harsh weather conditions, traffic conditions, operational conditions, in all environments, road types, and road conditions. Operational conditions within logistics include the different loading and unloading procedures and related securing of goods. Another operational perspective is the capability to follow authorities' adhoc instructions (e.g., police, customs, ambulance, military), since a human driver will be present in the first vehicle.

In contrast, for these cases and conditions, additional systems and capabilities need to be added to the autonomous system for the single autonomous concept. In addition, a human driver is present to manage deviations, failures and malfunctions. Examples of such minor issues include re-securing goods, tire blow outs, and cleaning dirty and faulty diagnostics sensors without significant impact on safety. The auto follower concept has the potential to facilitate considerable savings in driver costs and to address the driver shortage challenges and the same time leverage on the human skills of perception and situational awareness.

The **third hypothesis** is that the introduction of single autonomous vehicle solutions will still require a human safety driver for some time to come. The autonomous follower concept inherently includes a safety driver as the first vehicle includes a human driver assumed to be the safety driver of the autonomous follower vehicles in the convoy.

The **fourth hypothesis** is that the legal barrier for a market introduction on public roads is lower for autonomous follower truck convoys compared to the introduction of single autonomous trucks due to the presence of a human driver.

The **fifth hypothesis** is that the concept can be integrated in logistics operations in a competitive way.

Related Work

Autonomous vehicles have been given much attention in recent years and massive investments have been made. Several self-driving truck technology startups (e.g., Aurora, Embark, TUSimple, Locomation, and Kodiak Robotics) have attracted large amounts of capital investments. However, autonomous self-driving trucks have still not reached a broad market introduction. Compared to self-driving cars, there are several practical barriers that need to be solved that are specific to trucking. Especially tasks connected to the load, e.g., loading, securing loads and unloading. Removing the driver in all trucking segments is a complex task as the role of the driver is diverse with different processes depending on goods type.

Technical concepts for platoons have been developed in a large number of projects but have thus far mainly focused on driver assist rather than driver removal. The European Automobile Manufacturers' Association (ACEA) define platooning as: "truck platooning is the linking of two or more trucks in convoy, using connectivity technology and automated driving support systems" [7]. According to ACEA definition, platooning is a driver support function and not defined as a driver removing function. Shoker, et al. [10] define truck platooning as a form of convoy cooperative driving of connected trucks assisted by a lead truck. The objective is to reduce fuel and driving costs, improve road safety, and reduce CO 2 emission [10].

The ENSEMBLE project addressed multibrand aspects of truck platooning and demonstrated interoperability gathering seven of the largest European truck manufacturers [8], [9]. The EDDI project was a platooning project that performed practical operation providing logistics services and under real traffic conditions over a relatively long period of time [11]. Of the kilometres driven during the study, 40% was in driver assisted platooning mode.

The Swedish project 'Sweden 4 platooning' produced a thorough analysis on the business case for truck platooning when the driver was still in-the-loop (i.e., all trucks in the platoon contained drivers) investigating the potential fuel saving aspects [12].

The concept "Autonomous relay convoy" by Locomation is described as a human relay guided autonomous follower truck convoy. The concept includes two trucks that are in convoy with two drivers, but where periodically only one driver is needed. In periods where only one driver is needed, the other driver can rest, overall extending the operational time for both trucks. The human-guided autonomy concept is presented as a steppingstone to full single vehicle autonomous trucks [13].

Summing up, platooning has mostly been regarded as a driver assist and not a driver removal function. There might be merit in investigating a hybrid concept such as autonomous follower truck convoys. Provided that the aforementioned technical solution for autonomous followers is possible and either hypothesis 1 or 2 is true an investigation of the legal barriers and logistics actors' interest in the autonomous follower truck convoy concept are needed to gauge the potential of pursuing this route. The contribution of this paper address this need with a market viability study of the autonomous follower truck convoy concept, where the legal framework and logistics integration aspects of the concept are presented and analysed.

Method

To gain an understanding of how the autonomous follower concept could be received in the transport sector, we pursued a number of steps involving various stakeholders.

Initially, we worked together with two heavy vehicle manufacturers over a series of workshops to collectively develop a concept and "operational design domain", that is, a description of the conditions in which an autonomous vehicle is designed to operate well and safely. This was condensed into a brief document containing easily read and understood models and descriptions.

These were then used as a basis for semi structured interviews with various stakeholders including road haulers, forwarders and harbour/terminal representatives. Respondents were asked to think about how the concept would fit into their operations. While there were questions about technical details, the researchers strived to focus the dialogue on the business impact of the concept first and foremost. During these conversations, notes were taken for later analysis and all material was compared in order to tease out a number of themes.

In parallel to the other activities, one specific step was to gauge how the concept would work in terms of current and developing regulations on autonomous driving. This included comparing insights from the development of the ODD and an analysis of the current legislative situation.

Results from all of these three stages can be found in the results section next.

Results

The first three hypotheses identified depend on the evolvement of vehicle technologies and the vehicle and convoy level concept solution. The fourth and fifth are based on factors that are external to the concept itself, focusing instead the environment where the concept is to be applied. These are the regulations and the logistics integration aspects of the concept. To further analyse the legal and logistics integration perspectives, the concept needs to be described more in detail and thus a concept of operation and a concept integration follows.

The concept of operation

The concept of operation derived in this study can be described by its three main phases: forming, active and break-up, see figure 1. The convoy forming phase is the process to set up, commission and deploy the convoy. It includes physical as well as logical formation processes. The physical formation entails vehicles brought to a specified area. The following logical process is a technical handshake of the convoy including the commissioning and hand over of responsibilities and liability of the vehicle to the lead vehicle and driver. In theory, forming can take place anywhere. For instance, a re-forming of convoys may be needed on the roadside to manage failures of individual vehicles in order to be able to continue the transport operation with any remaining vehicles.

The active phase is the state where the convoy is in operation. The driverless follower vehicles are connected to the lead vehicle and follow it as if they are connected by a virtual drawbar. A committed active convoy does not need to include a physical transport movement and it may be stationary. In its active state, the follower vehicles are assumed to autonomously handling cut-in vehicles, i.e. vehicles external to the convoy that enter the space between convoy vehicles. In addition, each follower vehicle is expected to manage vehicle failures and emergency stop individually whenever needed.

Finally, the break-up phase is the process and conditions for when the vehicles are to be moved from the convoy to resume manual operation. The forming and break-up could be done by a human operator, but also by an autonomous system. In any case a logical reversal of the preceding commissioning process of the hand-over of control, responsibilities and liability is expected to be required before the physical dissolving of vehicles can take place.

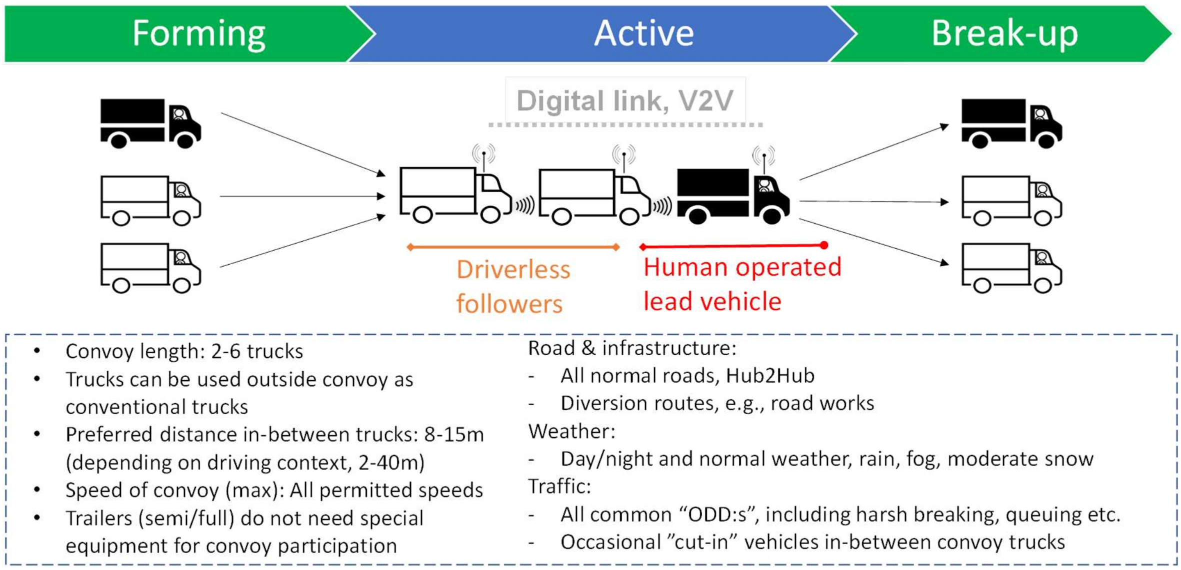

Figure 1 - Concept of operation and assumed high level ODD used in the study

Integration and expected use in logistics

As a last step, the early defining phase of the study detailed two hypothesized main methods of operation. In a logistics operation, truck combinations are used to transport goods on road. As such the loading, moving, and unloading goods are key activities. To integrate the auto follower concept in the transport process two main alternatives are identified to integrate the concept activities in the transport activities. Either loading and unloading is performed while in convoy active state or the trucks are loaded and unloaded separately and only the transport activity is in convoy active state. Figure 2 illustrate the two main concept integration options. The idea behind option 2 is that the business potential could be higher for short distance cyclic transport behaviours where a transport between two destinations is performed iteratively. Examples of such operations can be found within a wide array of processes such as mining, construction, quarry and aggregates, waste handling and container transports between nearby terminals. The benefit is that the time for forming and break-up as well as needed personnel to perform the activities are minimized and entire work shifts can be performed in an active convoy state. However, for logistics operations where trailers are loaded from the rear at docks it seems more likely that option 1 is preferred.

Industry perspective

The project relies on interviews with key informants at stakeholder organizations: 2 major forwarding companies each with 20000+ employees worldwide, a haulier, and a port. Interviews were open ended but relied on an introduction revolving around an informative set of presentation slides detailing the concept and intended ODD. The interviewees were encouraged to reflect on how the suggested concept could be used in their operations and what likely advantages or disadvantages they could foresee. Interviews lasted 1-2 hours with notes being taken by one of the researchers. Notes were then compared and corroborated between the participating researchers.

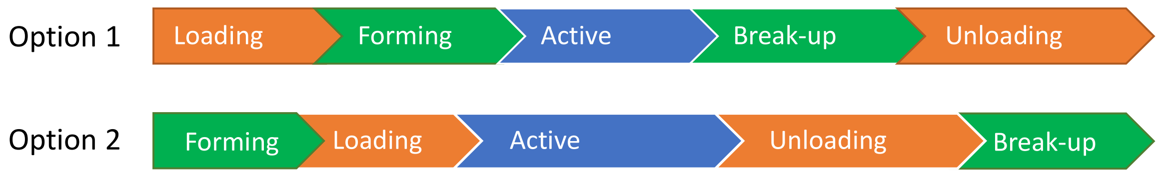

Figure 2 - The loading state for where forming and break-up can be operated

The results were compared searching for themes, and the existence or lack of common views. These are summarized in the following section.

Time to full auto: For some time, the industry has been awash with bold statements and rumours about the more or less imminent arrival of more or less fully autonomous vehicles. All forwarder and haulier respondents were quite hesitant to commit to this type of concept due to this. "Why should we invest in this when we will have fully autonomous vehicles in 2-5 years anyway?". One respondent stated that for this concept to make sense in terms of the investments required, it would have to be up and running at least 5-10 years ahead of the introduction of fully autonomous trucks.

Complex multiparty freight chains: One of our forwarder respondents pointed out what he considered a frequent misunderstanding of how their type of freight operations is organized. Few trucks drive all the way even in comparatively simple hub to hub hauls. They often stop halfway and swap trailers and then return. This is due to the local coverage and business area of hauliers (as opposed to forwarders). Hauliers prefer to have their trucks and drivers back at the end of the working day if possible. Trailers are owned by forwarders for this reason, and these are handed over to another hauliers truck and driver who then proceeds to the final location. There is already a waiting time in this process so reforming platoons does not necessarily generate an extra time cost here. However, hauliers would likely be unwilling to let competing hauliers, even within the same forwarder network, drive their trucks in a platoon necessitating a rather more complex trailer swapping process. Alternatively, the current ways of organizing such freights would have to be redesigned to cater for the concept, entailing both cost and risk.

Customer urgency dictates planning: Even in comparatively simple setups with several trucks going from one hub to another on a daily basis, the freight is segmented according to urgency according to customer needs and waiting to form a platoon is currently not an option. There is a possibility that customers could be persuaded to accept a longer waiting time in exchange for a lower price for the service, but this would have to be negotiated case by case.

Space and other resources are limited: Space was a concern among all respondents. First, space for forming platoons, second for loading platooned vehicles and finally for buffering more goods at pick up (or drop off) destinations as a result of more trucks arriving or leaving at the same time.
In the harbor case, there were excellent facilities at the terminal drop off points. Trucks still in platoon

mode could easily drive up to the storage facilities where they could be accessed from the sides by forklifts for an efficient off loading process. However, at the source site – a high capacity paper mill, storage facilities were limited. This poses two challenges for the concept. First, space is limited for buffering enough freight to fill a platoon of trucks. This could potentially be managed by expanding storage facilities, but again, space is at a premium and such a cost would have to be mitigated by the increased economic efficiency of the concept. Second, in case of breakdowns, the setup requires swift action and replacement trucks to show up very quickly. In case the entire platoon is affected by a single vehicle breakdown, even if only for a short while, this exacerbates the problems. Ultimately, to work around these challenges, the concept would have to be implemented by the operator and freight customer working much more closely together than usual sharing costs and gains.
In the case of more traditional hub to hub packet freight, space was also mostly very limited. Both in terms of actual available surfaces, but also in terms of an expected high turn-around speed for individual truck at terminals. As a rule, it was thought that the space and time required for forming platoons would rarely if ever be available without more or less significant changes to the sites and their current processes.

Finding suitable freight routes: The two respondents with the largest and most complex networks both remarked that the mere analysis of which part of this network might be suitable for the concept was a major task in itself requiring significant amounts of qualified man hours to complete. Currently there was most likely no easily accessible data useful for such an analysis and collecting, aggregating and analyzing this would require involvement from business, operations, and technology innovation departments.

Resting drivers: Hauliers saw a potential for extending the range of current setups and making longer trips possible without necessitating driver sleep overs at destinations. This was something generally seen as a major drawback to long haul operations from management and drivers alike. However, current rules for drivers resting would be a challenge for this type of setup.

Increased skillset: Whereas one of the main benefits of the concept is a reduction of driver needs, the haulier respondents pointed to a potential drawback regarding this key aspect. They were experiencing an increasing driver shortage and were worried that the likely added complexity of the platoon driving would entail expanded education and certification of drivers. Their fear was that this could even make the already challenging situation even worse as new and replacement drivers would be harder and costlier to come by.

Regulative perspective: One of the hypotheses in this study is that the legal barrier of a market introduction is lower for autonomous follower truck convoys compared to the introduction of single autonomous trucks. Early in the project we discussed which level according to the SAE scale that fit this concept best. It can be argued that the lead truck (with a driver) is not autonomous at all (SAE level 2 or 3), but the followers are autonomous in some aspects (SAE level 4) since the follower needs to have the capability to change lanes of its own due to a complex traffic environment and the length of the convoy. The follower also needs to be able to perform a safe emergency stop if the vehicles loose contact with the lead truck. To sum up, the follower needs to have the capability to make some decisions of its own and that would make the follower a level 4 vehicle. This is also how the legislator treats platooning in relation to autonomous vehicles, not as something unique of its own but as a subcategory to autonomous vehicles. There is no legal development going on aiming at making legislation for platooning only. This means that the same legislation that applies to autonomous driverless single vehicles also applies to autonomous follower convoys. For some years now it has been legal to do trials with autonomous vehicles within many EU Member States [14]. In this project we wanted to explore how close autonomous follower convoy is to a market introduction from a legal point of view. To understand the legal space for platooning and market introduction it needs to be explored within three levels: United Nations level, European Union level and national level.

United Nations has since 1958 an agreement about type approval [15]. The agreement focusses on “parts” (chapters) of a vehicle and not on the whole vehicle as such. Different committees review different parts of the vehicle regarding autonomous functions. Of particular interest to our project is the United Nation Regulation No. 157 regarding automated lane keeping system. To be able to perform autonomous follower convoy individual trucks must be able to autonomous change lanes i.e. to avoid obstacles on the road. At the moment, at the UN level, the discussion is about allowing cars and light trucks to change lane autonomously up to a speed of 60 km/hours (level 4) [16]. However heavy vehicles are at the moment not included in the discussions and are not allowed to change lanes of its own (level 4).

European Union also has legislation about type approval. European Union has recently published new legislation for type approval of autonomous vehicles SAE level 4 and 5 [17]. Unlike United Nations European Union can grant a type approval for a whole vehicle. Previously European Union used to follow the United Nations legislation about type approval but has now moved on forward on its own. It is unclear how these two legislation will related each other in the future. European Union type approval legislation for autonomous vehicles fits autonomous follower convoy (level 4). The legislation covers heavy vehicles that moves between two nodes or within an area. The legislation focusses on traffic scenarios that are relevant for the specific use case and that the manufacturer needs to prove that it is safe to use the autonomous vehicle within that specific use case with a safety case. In our concept of autonomous follower convoy, the driver in the first truck is a part of the safety case and can make risk assessment i.e. it is too foggy at the moment to go on. It therefor can be argued that safety case for an autonomous follower convoy can be less complex.

To protect drivers working environment and to protect other road users European Union has regulation about drivers resting time. According to art 8 and 9, the driver cannot rest on a moving truck whether it is a level 2 truck or a level 4 truck [18].

In our study we have worked with the concept within or between countries. European Union´s legislation about type approval of autonomous vehicles make them legal to sell, but it does not necessarily make autonomous vehicles legal to use on the road on a national level. For example, criminal law must be in place on a national level defining what is a driver and what is a driver´s rights and obligations. Germany has that kind of legislation, but Sweden has not.

Summing up, our hypothesis that the legal barrier for a market introduction is lower for autonomous follower truck convoys compared to the introduction of single autonomous trucks proved to be wrong. The legislation is currently the same. The question is if autonomous follower truck convoy would benefit having its own legislation to get more attention? One advantage with our concept compared to single autonomous vehicles is that there is always a human driver present which means that the response time, for example in the event of an accident, will be shorter. This is perhaps something that a legislator wants to reward in the future.

Conclusions

Autonomous vehicle technology is still in an early stage from an industry adoption and market penetration point of view. As with all major technological breakthroughs, the exact ways of how the dominant autonomous solutions for heavy vehicles will be designed is yet uncertain. This paper has examined a specific concept as a means of bridging the gap from current largely manual driving to autonomous vehicles in an ostensibly more evolutionary process, retaining drivers to a degree whilst reaping benefits of limited amounts of autonomous technologies. Summing up, this study has shed light on a number of factors to take into account across three dimensions: the design domain of the concept itself, the perceived advantages and challenges as seen by industry, and the how it could be affected by regulation. The concept seems to have potential, but this study also points to several clear caveats.

The viability of the concept depends on the continuous evolvement of several factors:

- Improved autonomous capabilities including controls, perception and computer based situational awareness.
- New legal framework to allow for different types of autonomous concepts.
- Logistics actors vested interest in forming joint ventures adapting current processes and infrastructure to meet the concept of operation limitations of autonomous follower truck convoys.

In innovations studies, the evolutionary is often pitted against the disruptive in the sense of making small incremental steps towards an improved product [19]. Research literature is full of numerous pitfalls and risks involved in developing a radical new technology and these can be enough to promote a measured development agenda, sometimes letting the dominant win [20]. But sometimes, also striking a balance between the two when possible.

Our concept is just such an attempt at retaining the well known whilst adding just enough innovation to better cater for the needs of customers. The hypotheses as listed above entail a less tumultuous technological development and regulative process. However, while our study indeed finds potential for the more evolutionary concept, it also makes it clear that whilst this technology could be easier to develop and implement from a technical point of view, it would require significantly larger and potentially disruptive adjustments to current business processes, physical infrastructure and ways of collaborating with others on behalf of the main operators of the concept. It is also unclear as to whether lawmakers would accept the concept more readily than single autonomous vehicles.

While the data from our study is quite clear and concordant, we do acknowledge our small sample. In theory, there will be other views held among some of the practicians that we did not have the opportunity to speak to. We do feel confident that our results are viable, but would like to point to the opportunity of an extended study including a larger population of potential stakeholders with a wider range of methods and equipment for transporting goods e.g., containers.

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References

1. Eurostat. "Freight transport statistics - modal split." https://ec.europa.eu/eurostat/ (accessed.
2. DHL. "Truck Driver Shortage in Europe." https://dhl-freight-connections.com/en/business/truck-driver-shortage-in-europe/ (accessed.
3. IRU, "Driver Shortage Global Report 2022: Summary," in "Understanding the impact of driver shortages in the industry," 2022. Available: https://www.iru.org/
4. P. Anderson and M. L. Tushman, "Technological Discontinuities and Dominant Designs: A Cyclical Model of Technological Change," Administrative Science Quarterly, vol. 35, no. 4, pp. 604-633, 1990.
5. D. Gruyer, V. Magnier, K. Hamdi, L. Claussmann, O. Orfila, and A. Rakotonirainy, "Perception, information processing and modeling: Critical stages for autonomous driving applications," Annual Reviews in Control, vol. 44, pp. 323-341, 2017/01/01/ 2017, doi: https://doi.org/10.1016/j.arcontrol.2017.09.012.
6. Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles, SAE, 2021. Available: https://doi.org/10.4271/J3016_202104
7. ACEA. "What is truck platooning?" https://www.acea.auto/fact/what-is-truck-platooning/
8. L. Konstantinopoulou, A. Coda, and F. Schmidt, "Specifications for multi-brand truck platooning," in ICWIM 8, 8th International Conference on Weigh-In-Motion, 2019, p. 8 p.
9. E. Mascalchi, A. Coda, and D. Willemsen, "Specifications for multi-brand truck platooning," 8th Transport Research arena TRA 2020 April 27–30 Helsinki, Finland, 2020.
10. A. Shoker, P. Moertl, and R. Robles, "A First Step Towards Holistic Trustworthy Platoons," in 2021 IEEE 7th World Forum on Internet of Things (WF-IoT), 14 June-31 July 2021 2021, pp. 795-800, doi: 10.1109/WF-IoT51360.2021.9595496.
11. "Project report - presentation of the results," in "EDDI, Electronic Drawbar - Digital Innovation," 2019. Available: https://www.truck.man.eu

12. J. Axelsson et al., "Truck platooning business case analysis," in "Sweden 4 platooning project," RISE Report, Sweden 4 platooning project, 2020:07.
13. "Locomation." https://locomation.ai/
14. www.show-project.eu, D3.1_legal_regulatory_institutional_frameworks_SUBMITTED.pdf.
15. Agreement Governing the Adoptation of Harmonized Technical United Nation Regulation for Wheeled Vehicles, Equipment and Parts which can be Fitted and/or be used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis of these United Nations Regulations., UNECE, 2022. Available: https://unece.org/
16. UNECE. https://unece.org/sites/default/files/2022-09/R157am3e.pdf
17. Commission Implementing Regulation (EU) 2022/1426 of 5 August 2022 laying down rules for the application of Regulation (EU) 2019/2144 of the European Parliament and of the Council as regards uniform procedures and technical specifications for the type-approval of the automated driving system (ADS) of fully automated vehicles (Text with EEA relevance), 2022.
18. REGULATION (EC) No 561/2006 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 15 March 2006 on the harmonisation of certain social legislation relating to road transport and amending Council Regulations (EEC) No 3821/85 and (EC) No 2135/98 and repealing Council Regulation (EEC) No 3820/85.
19. C. M. Christensen, The Innovator’s Dilemma: When New Technologies Cause Great Firms to Fail. Boston, MA: Harvard Business School Press, 1997.
20. M. L. Tushman and P. Anderson, "Technological Discontinuities and Organizational Environments," Administrative Science Quarterly, vol. 31, no. 3, pp. 439-465, 1986, doi: 10.2307/2392832.