Chapter 17
Discussion

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Abstract In 2017, the Connecting Austria project was internationally unique with respect to the special consideration of the infrastructure and traffic perspective as well as the special consideration of investigating an urban truck platooning use case with traffic-light-controlled intersections before and after motorway entrances. The three main target groups of the project were: (1) road operators/infrastructure providers, (2) logistics operators and (3) C-ITS industry. Especially for those target groups and policy maker faced one central question at that point in time —"How can safe truck platooning reduce CO_2-emissions and how can this help to strengthen the stakeholders' role in their market or political environment?". Cooperative, connected and automated mobility shape the future of road transport. Thereby, truck platooning represents an important application case in the transport logistics domain. In this chapter, the research and evaluation results presented in this book are discussed along the following three fundamental pillars: (1) traffic safety and legal issues, (2) sustainability and (3) truck platooning deployment. Finally, limitations and cultural blind spots experienced within international workshops and discussions in the context of the Connecting Austria project are reflected.

Keywords Traffic safety · Legislation · Sustainability · Truck platooning deployment

17.1 Traffic Safety and Legal Issues

Especially when introducing new technologies in the domain of automated driving, a close observation of a range of parameters is desirable—and even mandatory. In the case of truck platooning, this is not only referring to the automated system, but

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A. Schirrer et al. (eds.), *Energy-Efficient and Semi-automated Truck Platooning*,
Lecture Notes in Intelligent Transportation and Infrastructure,
https://doi.org/10.1007/978-3-030-88682-0_17

also to the temporarily inactive driver and the interaction with other road users. The impact on driver attention and effects of risk compensation or adverse behavioural changes of other road users in reaction to platoons, etc., cannot be ruled out yet. Either way, systematic collection of a wide range of safety-relevant indicators within a cross-border longitudinal field test will be key for truck platooning and the safety of all road users involved. Quite a lot of safety-related material have been collected in various European research projects and even industry-driven studies in the USA. Overall, truck platooning seems to be an enabler for increasing traffic safety on public roads. However, in advance, a major issue needs to be solved—the harmonisation of European law with regard to truck platooning, e.g. for regulating minimum distances between trucks, labour law or technical preconditions for building a platoon.

Although road safety might not be the primary motivation for proponents of platooning, it is worth discussing potential safety benefits. Human errors are a leading cause of road accidents; e.g. in Austria, inattention and distraction alone accounted for 51% of HGV crashes on Austrian motor and expressways between 2014 and 2018. Thus, relevant potentials to reduce truck accidents exist. However, one unknown factor in the equation is the reliability of systems that control the connected/automated driving function as well as the assumed penetration rate.

In order to enable safe, high-performance and efficient truck platooning control concepts, the global properties (surrounding traffic, infrastructure, platoon dynamics, road properties and route) must be appropriately considered in the planning and optimisation of platoon trajectories. For the effective realisation of these movement patterns in vehicle control, the distributed or locally acting control on the individual vehicle level must be combined with the essential information from the broader, global context in a suitably prepared form. Cooperative platoon control strategies make use of provided information from vehicle-to-everything (V2X) communication to reduce energy or fuel consumption, increase traffic flow and improve traffic safety. Thereby, local information and predictions can be shared with the entire platoon, thus improving the effectiveness of the distributed control actions.

Within Connecting Austria, a distributed control concept for cooperative platooning was developed that combines trajectory optimisation and local model-predictive control of each vehicle. The presented control architecture ensures collision safety by design, platoon efficiency and situational awareness with the option of exploiting V2X communication. The resulting platoon control performance was tested and validated in a realistic setting by utilising a co-simulation-based validation framework with detailed vehicle dynamics.

In the Connecting Austria project, the urban truck platooning use case considering intersections has been the most complex one with respect to possible C-ITS, traffic and vehicle control actions. For this use case, platoon control concepts and innovative means to monitor and assess real-time traffic have been developed. Recent progress in video-based vehicle sensors allow for a detailed observation of road users on intersections in urban areas. By combining the measured real-life traffic situation with thorough traffic simulations, a cooperative system design for the dynamic management of traffic flow including vehicle platoons is possible. A video-based traffic flow estimation system was developed and tested at a three-way intersection in the small city of Hallein, Austria. The installed system is able to collect comprehensive information about the traffic situation in near real time. This information can be used to estimate traffic density as well as traffic flows of cars and trucks with high precision. Furthermore, it allows inform cooperative platooning control strategies and support situational awareness.

The comprehensive scenario-based approach taken in Connecting Austria allowed for an effective and efficient development as well as the validation of complex, cooperative control functions in connected and automated driving. The conducted studies do not yield a single result, but instead depend on many parameters (such as platoon spacing/gap policy, surrounding traffic density and speed and many more) and are investigated in terms of the results' sensitivities on these parameters. This approach allows to draw meaningful conclusions despite the inherent uncertainty and spread of the influencing parameters. By using representative conditions, the resulting key performance indicator distributions may be evaluated and interpreted. Under certain circumstances, platooning may lead to extra risks with respect to safety. One such issue are vehicle cut-ins, e.g. in case of a highway exit. For passenger cars, which have to exit the highway, it would be beneficial not to overtake a platoon just before the aimed exit, in order to avoid wriggling through narrowly driving trucks of the platoon. However, what precisely does "just before" mean? The answer depends on the length of the platoon, the speed difference, the deceleration capabilities of the cars, the cooperative behaviour of the single trucks, etc. For such special situations, characteristic diagrams are suitable and have been developed. They allow the estimation of necessary distances before an exit and help specifying adequate distances before special locations and conditions, respectively. Additionally, they are useful in case of danger zones, which demand for the dissolution of platoons or for temporal/spatial increase/decrease of intra-platoon distances.

A further question within the platooning discourse is the ideal distance between the trucks of a platoon. Alongside economic and environmental considerations, this is an important road safety question. Not only in terms of potential malfunction of the used technical equipment but also for the perception of car drivers who for example have to decide at which gap sizes between trucks, they would merge onto the rightmost lane for the purpose of exiting the motorway or merge into traffic coming from an on-ramp. To gain knowledge about the drivers' decision making regarding the acceptance of different gap sizes between trucks, an on-road driving study was conducted in summer 2020. However, in this contribution, only a basic outline of the study design was given, since the data analyses were still ongoing.

17.2 Sustainability

Sustainability is one of the main topics discussed globally right now—and it is necessary to do so. Typically, sustainability is discussed along the pillars (1) economic-, (2) social- and environmental sustainability. Truck platooning may contribute to each of these pillars. The results from Connecting Austria and other research projects confirm that truck platooning allows reducing fuel consumption. As such, truck platooning may contribute to reduce fuel costs (cf. economic sustainability) and CO_2 emissions (cf. environmental sustainability). To this regard, the book presented a fuel assessment methodology and its application. Thereby, the methodological approach covered three main aspects: (1) the assessment of the road infrastructure in terms of the suitability of road segments for truck platooning, (2) the assessment of driving behaviour and strategies for truck platoon formation and dissolution and (3) the assessment of efficiency in terms fuel savings for certain routes. Within an initial method application, a route analysis for an Austrian fleet operator was performed including the assessment of feasible and economic viable routes and scenarios. Furthermore, potential fuel consumption savings and CO_2 emission savings were discussed within the given case.

When analysing a typical route (Origin: Pasching— Destination: Guntramsdorf) of an Austrian fleet operator with respect to the feasibility of platooning and the economic viability of platooning segments, the results indicate a wide range of feasible segments (from 65% up to 92%). The highest share of economic viable road segments is gained when applying a medium formation and dissolution strategy for truck platoons. However, dynamic C-ITS-based truck platoon regulations may even more increase the savings. Overall, the saving potential may be increased via dynamic C-ITS-based truck platoon regulations, instead of statically defined, too restrictive regulations.

Subsequent to the assessment of the feasibility and economic viability of road segments, an analysis of potential costs and emission savings was conducted. This analysis confirmed that in most instances the medium formation/dissolution strategy for a 3 truck platoon driving at an intra-platoon distance between 1 and 1.5 s at a speed of 80km/h is suitable. For the route "Pasching -> Guntramsdorf", the maximum achievable fuel saving is 4.83% for all three trucks in a platoon driving from Linz to Vienna. The minimum saving when applying the fast formation/dissolution strategy at an intra-platoon distance of 1 s leads to fuel savings of 2.53%. The analysis of the fuel reduction also provides a basis for assessing potential savings in CO_2 emissions. Based on the consumption values and a factor for translating fuel consumption in emissions, one may illustrate potential CO_2 savings. Maximum potential CO_2 savings for a three-truck platoon are up to 25kg CO_2 savings (Well-To-Wheel).

The given fuel efficiency assessment results rely on a fuel reduction model for truck platoons. With regard to related work, the range of fuel savings reported is quite high for average savings in a platoon of three trucks at a distance of 15 m (about 2% in the Companion project up to 11% measured within Japan ITS Energy 2016). In the Connecting Austria project, a fuel reduction model for truck platoons has been developed taking into account related work, CFD simulations as well as the validation of measures on a test track.

In addition to economic and environmental sustainability aspects, truck platooning may also affect social sustainability. In this regard, the book summarised related work with respect to technology acceptance of truck platooning. Related work indicated that truck platooning could decrease workload for truck drivers and support safe driving. However, adequate user-centred implementation processes within organisations and awareness building will be crucial for successfully deploying truck platooning.

17.3 Truck Platooning Deployment

What are the next truck platooning-related deployment steps internationally and especially in Europe for the next years? Some years ago, automotive industry pushed the topic with European initiatives and projects like the truck platoon challenge or the up-and-running project ENSEMBLE. Currently, press releases of global automotive industry player pushes more higher automation levels of trucks on closed areas. In parallel, start-ups in the USA show first implementation of truck platooning over long distances on highways. The reasons for this more hesitative attitude of some industry players in Europe could be based on missing legal conditions to maintain platooning in Europe. This ends up in a non-existing market need and seen from a business-perspective a logic strategic change. Some automotive industry players argued that potential savings of platoons are not relevant for customers and therefore officially decided to stop working on that. However, as we claimed above. It is not just a matter of energy savings and cost savings for the trucks. It is a matter of future necessity to reduce emissions to survive the international competition in logistics. Logistics operators need to increase drivers' safety, to even increase the attractiveness of truck driving and finally yet importantly, to reduce costs based on avoided crashes.

Besides the discussion from an industry perspective outlined in the previous paragraph, some more questions need to be addressed when talking about deployment. Taking a business-related perspective and mirroring the typical Austrian and even European situation of quite a lot of small medium enterprises in the logistics domain, the following questions arises. How should they implement new technology in their traditional logistics provider's processes—especially when not yet implemented digital processes or just maintaining a small number of trucks? This question is closely interconnected with the not yet defined truck platooning service business model. Right now, there are some ideas on how to organise truck platoons ad hoc on the road with different brands and companies. However, how long does it take to set-up a player to takeover that service provider role is yet unclear.

With ASFINAG's roll-out of C-ITS stations at 2,000 highway kilometres in November 2020, the C-ITS deployment started in Austria, and the foundation for Day-1 and Day-2 C-ITS services like cooperative platooning was established. Even if the initial investment in Austria took already place, viable business models for the operation, maintenance, and the enhancement of C-ITS services are still an open issue. Examples in existing publications propose as revenue streams taxes/tolls, reduced road maintenance costs or earnings from data provision services. However, when developing/deploying new C-ITS services, viable business models should be investigated to support road operators and technology providers in taking informed decisions and sustainably deploying C-ITS services.

C-ITS and platooning-related research and innovation will continuously face new questions and white spots in our knowledge. There has been significant knowledge spillover into road operator spheres, digitalisation ecosystems for Europe's future, advanced traffic management, logistics and air quality management.

Dynamically evolving customer expectations into home delivery, just-in-time delivery and other newly emerging transport services together with newly emerging technologies and smart take up we will see interesting decades to come. Digital road infrastructure has the potential to significantly leverage the way we will organise road-based freight transport systems in Europe. However, it has the potential for more than that. A European innovation system is made of ecosystems and key stakeholders thinking and conceiving their activities also in terms of joint absorptive capacity. However, the future will be open. Unleash entrepreneurial innovation is anticipated to rank high. Moreover, the digital capacity building together with innovation brings the opportunity to attract some of the finest talents in this field of road-based freight transport systems and innovation.

17.4 Some Limitations and Cultural Blind Spots

When you prepare a large-scale flagship project, probably all key players accept the challenge to contribute to a better world and a better future for Europe. This involves also citizens living in Europe and more specifically in a kind of transit country with challenging alpine topography—like Austria. However, our concepts of what a better world and future would look like have also evolved rather dynamically.

Looking back, we see significant progress as well as entirely new challenges and questions. Here, we will reflect on some of the results towards this overall challenge as well as on selected limitations and blind spots. One guiding frame can be seen in any innovation, or any newness is kind of an intermediate transition. Counterintuitively, this transition can be validly framed rather not a transition between two stable situations, but an ongoing transition in itself.

Connecting Austria was designed to cooperate with all existing activities and to try to cross-fertilise towards specific aspects of a transit country with innovative ITS infrastructure to mitigate unintended consequences from platooning technologies. Coming to some limitations and blind spots in the public discourse on truck platooning and the future of truck platooning: several European stakeholders wonder why the USA is rather readily implementing truck platooning at rather high average truck speeds, when far higher gains in fuel consumption could be made by reducing the maximum speed to European standard levels of 80 km/h. For stakeholders in the USA, this is not even considered a valid proposal. The superficial diagnosis would look into lack of climate-related ambitious commitments in the USA. A more elaborated diagnosis would look into road-freight systems that have been kind of optimised for local bottlenecks. At lower speeds, truck drivers would not make it back home—something that is less obvious for truck operations in Europe; and with increasing transport volumes, hardly anybody would like to increase the number of trucks to make lower speeds feasible under a climate-related agenda. One kind of elephant in the discussion room seems to be climate-related impacts: we often hear 8 per cent or 15 per cent or 35 per cent improvement is not enough. With increasing volumes of goods transported, it is not efficiency but rather effectiveness—across multiple transport modes. Several initiatives have looked into feasibility of modal shift in European freight transport (e.g. ALICE) and have quickly reached practical limitations and cultural bottlenecks. A study group with a Swiss rail operator estimates efficiency gains in the road-based freight transport sector in the order of 35 per cent until 2030. This is anticipated to foster innovation in the rail sector—otherwise it would significantly loose share in the modal split. Requests to limit innovation in the road-based freight sector remain.

Some countries have defined their future-proof road network as part of their innovation system or at least as enabler for sustainable future wealth creation. Stakeholders in Finland currently are studying how a roll out of longer truck platoons will impact infrastructure design at borders, harbours, highway intersections and ramps and entire resting areas and parking lots. This can be partly attributed to a strong forestry industry and a strategic importance of 24-hour global delivery requirements for Scandinavian fish shipped to customers in Japan and South East Asia. As a consequence, in Finland, several stakeholders are preparing for higher levels of truck platooning—even without commercially available offers on the market yet for even lower SAE-Levels in Europe. Europe-wide, several leading fleet operators and logistic operators have already reached higher levels of automation within their logistic hubs. They have expressed that they would immediately adopt automated hub-to-hub truck transport including truck platooning as soon as legal regulations would make this feasible.

In other countries, automation has been perceived as unnecessary risk or detrimental for social inclusion: some stakeholders have explicitly expressed they would define any legal requests into innovative forms of road-based traffic, in a way to kind of prevent the commercially valid roll-out of any automated driving technology—be it in trucks or individual transport. Another elephant in the discussion room is the actual following distance between trucks on European highways. Several anecdotal evidence stories in large printed media have indicated that the actual following distance in 2017 has been significantly lower than what has been demonstrated in electronically coupled high-tech trucks within EDDI in Germany, Drive-Sweden or in the USA. Significant cohorts of truck drivers have a rather high work ethic and maintain this professional mind-set when using assistive systems (validated and confirmed in EDDI). On the other hand, during the 2020 COVID-19 impact phase, driver availability has dynamically evolved. With longer waiting times at national and even regional borders and significant shortages with the most experienced drivers, there is an increasing share of less experienced truck drivers adding momentum. In combination with some of the other mentioned elephants, the value perception of assistive systems and electronically coupled trucks might quickly see significant changes in public discourse.

Digitalisation and steps towards using digital twins for entirely new forms of decision making at road operators have the potential to open up the opportunity space for simulation-based quick responses to the way road-based freight transport is accepted on highways. The CEDR working group on CAD as well as C-ITS groups at ASFINAG have proactively addressed several of these opportunities. Results from Connecting Austria were taken up within CEDR's automation study project MANTRA. Three road authorities in Germany, Switzerland and Austria have committed to a detailed study into integrated digital twins for purposes of traffic management and especially ODD-aware forms of traffic management or complex traffic scenarios.

The Connecting Austria team's knowledge generation would not have been possible without the support from several workshops with Richard Bishop and some fellow truck platooning projects (EDDI; Sweden4Platooning). Michael Nikowitz has successfully supported the flagship project within the dynamically evolving complexities in different ministerial High Administrations since 2017. Connecting Austria has opened European awareness on infrastructure-based views and on specific needs for ambitious climate agendas in topographically challenging regions. Several projects now have taken up validation exercises and the concept of infrastructure-based information services to accompany the next wave of digitalisation, automation and future mobility. And, it is steadily evolving how this nourishes our commitment to contributing to a more nuanced answer for Europe's share in a global challenge to effectively cooperate with the USA and Asia in a highly competitive environment of innovation.

Walter Aigner has been a kind of boundary-spanning individual [between pioneering users, public administration, research and various industries] since the early 1990ies. As managing director at HiTec he prepared several national and European innovation and technology programmes and serves as an independent expert on evaluation and impact assessment. His focus is on key individuals in the European innovation system and how they nourish our commitment to contributing to a more nuanced answer for Europe's share in a global challenge to effectively cooperate with the US and Asia in a highly competitive environment of innovation, digitalisation and automation.

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