Truck Platooning: Towards Future Business Models

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Abstract. Automated driving trucks promise significant improvements with regards to traffic, logistic costs and emissions. Platooning can be seen as the next technological step in this direction. While the body of literature reflects the engineering perspective of platooning extensively, an Information Systems discussions about user-centered business models are rare. Our paper aims to strengthen the Information Systems perspective on platooning and its inherent business models. Up to the current state of our project, we found that intra-fleet platooning can be understood as an amortization issue, while inter-fleet platooning requires complex matching algorithms, motivational incentives for drivers and fleets and easy plus fast payment solutions. We built a Monte Carlo simulation for an inter-fleet platooning app and present preliminary results.

Keywords: Platooning, Autonomous Driving, Logistic Research, Logistics, Vehicle2Vehicle Communication

1 Introduction

1.1 Problem Relevance and Research Questions

Platooning can be defined as "(…) coupling two or more vehicles without a physical link to form a train" [14]. Public challenges with wireless connected trucks took already place in California, Japan and Europe; across national borders and under real traffic conditions [16]. The primary motivation for engineers to develop platooning was for sure the fuel-saving potential. It is a scalable factor for transportation companies even with little savings because fuel equals one-third of the operating costs of a heavy duty vehicles (HDV) [10]. Platooning of long-haul trucks is moving more and more from a science-fiction to a real-life technology. However, while technological confidence is evolving, research rarely covers the economic aspects of platooning, as pointed out in [3]: "One of the greatest neglects in the literature is how platooning will be developed and operated in practice." and further "It must also be understood that there will form a business ecosystem around platooning, with many different actors cooperating and competing with each other, and this raises important issues related to safety, due to interoperability requirements and shared responsibilities".

What makes platooning very interesting for researchers, is the multi-perspective challenge of it [15]. Thus, an Information System (IS) view can support the research initiatives in this field to set impulses into a user-centric added value of this new

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technology and business opportunity. For the latter one, some basic ideas can be found in the literature, for instance [17] sees tremendous opportunities for truck fleets in the mining industry, but also opens up the wide field for the entire logistics branch. As the amount of potential savings will matter, linking as many trucks as possible might be a good choice. In [10], up to 200 trucks get connected, which brings up the important question, how platooning partners will find their matches; may it be within their own fleet and transport company or may it be in the open market. We summarize the described aspects with the following research questions: **RQ1.** Which basic business models can be described for intra-fleet and inter-fleet platooning? **RQ2.** How could a market for inter-fleet platooning look like, based on the current data available?

The paper is structured as follows: In the next section, we take a brief look at related articles and – in the context of this paper – relevant platooning technologies. Based on that, we create a concept of a business model for platooning in section 2. Then, a simulation of our business model will be conducted, using Monte Carlo. In section 3, we wrap up this research in progress paper, anticipating learnings of the simulation and sharing an outlook onto the future research and project scope.

1.2 Related Work

The literature research will form the baseline for section 2, where we aim to build a realistic market scenario for platooning. We conduct the review in common databases, including SCOPUS, ScienceDirect, AISEL and Google Scholar. To ensure proper quality, we limit the search to articles from peer-reviewed journals and conferences.

Synapsis. While automated driving in the passenger car segment came up already in the 1950s, experiments with autonomous trucks started only in the 1990s [16]. Practical tests proved already in 1995 the possibility of visual-based platooning. But even in such an early stage of research in the 90s, researchers were aware of the fact which impact platooning will have on the way to fully autonomous driving in technological and its' economic perspectives [7]. General benefits of platooning are fuel saving and a variety of other advantages: [1] analyzed, that 72% of greenhouse gas emissions has been caused by road transportation; in [16] safety and drivers' comfort are reflected, of course under the assumption, that the long-term strategy of automated trucks is driverless.

Fuel saving potential. It is common sense that shortening the distance between trucks reduces the air drag, which reduces the fuel consumption. A study with 1,800 heavy-duty trucks driving through Europe, conducted in [11], shows that spontaneous, *manual* platoons were formed in 1.2% of all routes by the drivers, simply by reducing the safety clearance to the max. However, such a non-optimized and non-coordinated approach only let to 0.07% fuel savings overall. Thus, a technological platooning solution is obviously desirable. Early research of truck platooning predicted potential savings in the range from 30 to 40 percent. In [2], a fuel reduction between 4.7 and 7.7% has been achieved, taking driving two identical loaded trucks at 70 km/h. But fuel savings vary based on the individual circumstances, for instance [12] was able to confirm a 7% fuel reduction for a 350km trip driving with 80km/h. In contrast to this, [4] achieved in their experiments a saving potential from 12.1 to 19.8%, driving at a speed of 60.1 km/h. Theoretical savings for the non-leading vehicle up to 20% are also described in [10], but the authors identified the speed of the platoon, and the distance between the trucks as critical factors. Thus, a realistic saving range from 9-10% could be achieved, if all trucks start at the same node of a route. [2] has also shown, that the load weight and the time gap between the trucks determine the fuel saving.

Economic scenarios and use cases. Scania and Volvo built industry-ready solutions for well-defined scenarios, like mining, logistics or industry. Thus, productivity could be increased, as well as safety for other vehicles and the truck drivers, especially in dangerous mining or tunnel situations. But logistics and industry solutions in general also describe a huge potential for platooning [17].

An unsolved question is an incentivization model. Why should a truck driver offer platooning (and thus, fuel saving potential) to following trucks, instead of joining an existing platoon chain? In [6] a game-theoretic approach focusing on road traffic can be found, where platoons get incentivized but face a trade-off concerning road traffic, time and so forth.

2 Towards a Business Model for a Truck Platooning Platform

2.1 Business Model Conception

Intra-fleet platooning. Seeking for future business models which can utilize this technology, our approach follows two steps: Based on the literature research presented, intra-fleet platooning and inter-fleet platooning can be clustered; both may inherent own business models. To answer the research question, we strive for mathematical or statistical evidence. We analyze intra-fleet platooning first by seeking for a mathematical expression. The economic potential can be seen as the geographical area between the original cost function and the new cost function with platooning:

$$p_{savings} \int_a^b [c(x) - c_p(x)]\, dx \qquad (1)$$

where c(x) is the cost function without, cp(x) with platooning and they simply differentiate in the fact that platooning vehicles will have a reduced diesel consumption rate (which will not be further elaborated here). Thus, the area between the original and the new cost graph geometrically symbolize the saving potential of platooning within, for instance, a mining fleet. Typically, this potential will follow the bandwidth of 7-9%, as discussed in section 1.2. As [16] has shown, the cost for platooning technology will consist of the cost of the Adaptive Cruise Control (ACC) and the V2V communication system. But even taking labor costs into account, it remains an amortization issue. In other words, to give the first answer to our research question:

Intra-fleet platooning is a cost-saving business opportunity, but not a new business model on its' own.

Further, an intra-fleet platoon might be organized by the fleet company itself, without the need of further IT-infrastructure: Drivers or dispatchers can match schedules and routes to achieve a maximal platooning-based efficiency inside the company. Out of scope for this paper but a crucial factor in the daily routine of logistics companies might become the driver rating of the digital tachograph or fleet optimization software like Fleetboard. While the driver rating of all following drivers will increase, based on the reduced diesel consumption, any solution and benefit for the leading driver must be created to prevent penalties.

Inter-fleet platooning. Therefore, we continue to a second perspective, the inter-fleet platooning to evaluate this business model in terms of cost and revenue streams. As nothing comparable is existing in the presented body of literature we have to come up with a platooning ecosystem, following the analogy of car sharing providers [8]: We build the hypothesis, that there will be a business model for the platform which brings the different platooning partners together. This asset should solve the problem of needed starting nodes in a highway nets, as discussed in [10]. In the following, we are going to describe the players in that market more in detail.

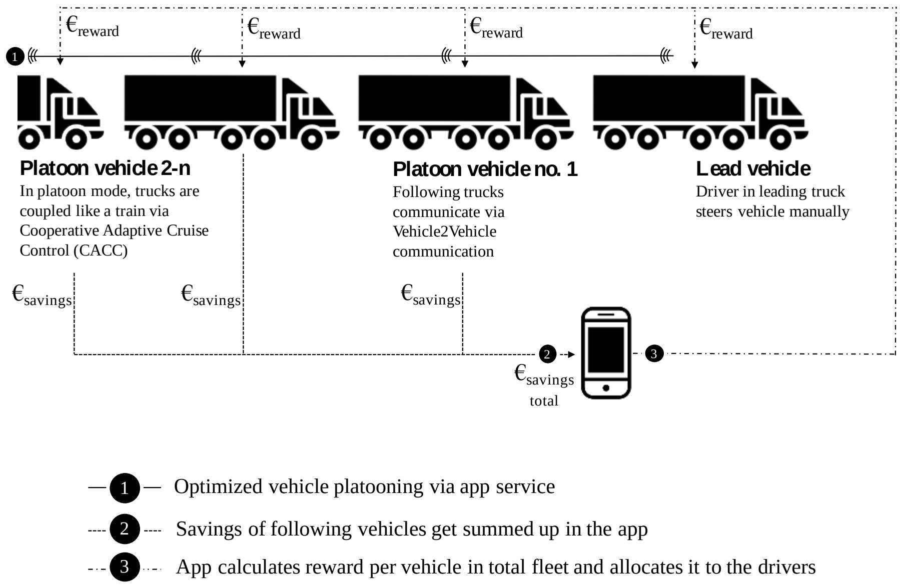

Figure 1: Scheme of a platooning app business model, matching trucks in a platoon virtually to share the diesel savings belong all participants in the platoon

Fig. 1 describes our business model, where we see one central app provider as matchmaker between potential platooning partners. The app would detect route parameters, geo-positions and weight/speed indicators from the truck onboard system, which allows a precise and vehicle-individual computation of fuel savings. In some cases, this might happen via the Fleet Management Systems Interface (FMS) or an existing OEM telematics unit with a third-party access API, like Fleetboard (Daimler) or Rio (MAN). When the app computes a positive platooning matching chance, both trucks have to accept. An important assumption here is, that a truck can also decline a platooning offer and can't be forced to platoon, for instance by law, OEM technology or any other reason. Assuming that a platoon activation follows a positive match, the app extracts the savings of all following vehicles from the trucks' telematics system, as described above. All needed parameters to do so are already part of today's FMS interface,[1] therefor the app would always be delivered together with a small hardware dongle which the trucker can attach easily to his/her truck. For our simulation, we iterate different business logics first, to find a good way to sum up and allocate savings to the group of a platoon. One idea could be to pay directly via e-wallets or blockchain technology to the truck in front. We skip that idea because it is not route-based and makes it hard to include the entire platoon with different weights (and therefore fuel savings, as earlier discussed based on the results of [12]). To tackle this problem and to grant maximum (financial) motivation to the truckers – to include the learnings of [6] – we decide to calculate the truck-individual diesel savings on the fly. The virtual saving amount will be transmitted to the app's backend, where all savings of the entire platoon for the time it exists in a specific constellation will be captured. When a platoon formation ends, the rewards will be calculated and virtually transferred to the in-app account of all trucks. For the reward calculation, we take the weighted portion of savings generated by a truck, relative to the entire platoon (important: including the lead vehicle, which won't generate savings but should participate in the total savings). By doing so, we motivate any potential leading truck starting a platoon.

2.2 Simulation

Simulations are a valid source of statistical evidence to cover those aspects of platooning, which can't be evaluated in real-life situation, such as the optimal distance for the case of emergency breaks of the leading platoon vehicle [13] or business opportunities and models for a market to come, as proposed in this paper.

Market parameters. The basic input value for our simulation is the amount of new truck registrations per year, which is around 200,000 trucks in Germany [9]. We assume 10% market share of platooning hardware within the newly sold trucks for our scenarios, which equals in total 19,961 platooning-ready trucks. This is based on the assumption, that platooning equipment will become a cost-intensive feature, and only early adopters will purchase the technology after the market launch. Next, we calculate the expected maximum distance of platoons for all platooning-ready trucks in Germany. Given a yearly mileage between 100,000 and 120,000 km for a regular fleet truck [5], the total potential distance for truck platooning would end up (taking the average of

[1] See also the official FMS web page http://www.fms-standard.com/ (accessed: 9/26/17)

110,000 km mileage per year) at 2,195,743,000 km. Reducing this number to a more realistic level, we considered the expected overlap of trucking routes with respect to time schedules, starting points, destinations and delivery stops. Thus, we see 5% (109,787,150 km) as the total platooning potential per year (for all trucks combined, having platooning equipment installed).

Finally, the business model of our platooning app is based on a small fee, which all truckers have to pay, who benefit from the platoon. This fee should be relative to the total platoon savings; we chose a range from 0.5 to 5% to have an appropriate and – from a user point of view – acceptable price and good statistical data to find to conduct further analytics on the price impact. At this point of research, we focus on fuel savings purely (and not driver efficiency etc.), which can be understood as a limitation in our paper. However, fuel savings can be calculated and simulated already today, without field data. Future research projects might allow the research community to enhance this.

Computation. The entire simulation algorithm, including every single truck, all routes and market conditions is implemented in Python 3.0.[2] Running the entire simulation took 15:36:25 hours on a MacBook Air with an Intel Core i7 processor running at 2.20 GHz, in total, more than 250 GB of platooning data has been created.

3 Conclusion and Outlook

In total, we ran the simulation 1,000 times with an average app fee of 2.69€ (standard deviation: 1.29), which led to an average app revenue per simulation of 5,654,936.01€ (standard deviation: 4,462,360.50€). The broad spread in the total app revenue is based on the mileage bandwidth, which was 54,778,745.14km in average (standard deviation: 31,708,886.03km). These first results underline the potential of a Monte Carlo simulation in our context. As the input and output parameters face such a huge bandwidth, we can start now selecting worst-, best- and most-likely cases out of the generated data and build a sensitivity analysis. We expect to get a clear understanding of minimum revenue, such an app would achieve, even under worst-case conditions. With that, a holistic concept for platooning business solutions, including the utilization of blockchain and smart contract technology, can follow. With this research in progress paper, we aim to communicate the current state of our project and to gather feedback from the research community.

[2] We also considered using VISSIM for our simulation, as well as UNITY (where also a platooning package exists), MATLAB and Python. Experimenting with these tools showed us, that we could neglect visual output for our simulation (which reduced our tests to MATLAB and Python). Due to personal preference of the authors, we finally chose Python 3.0 for the simulation itself and SPSS for the interpretation of the data.

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