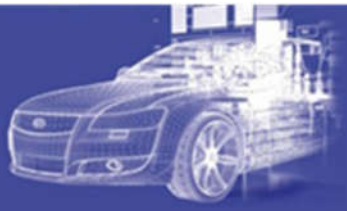
2nd IAVSD Workshop on Dynamics of Road Vehicles
March 29 - 31, 2017
Berlin / Germany



MOTORWAY SHARING BETWEEN AUTOMATED SINGLE PASSENGER CARS AND LARGER TRUCK PLATOONS

Werner Schiehlen
University of Stuttgart
Germany

ABSTRACT

In road vehicle dynamics car automation and autonomous control are hot research topics. Among the anticipated benefits of automated cars is the reduction in traffic collisions caused by human-driver errors, such as delayed reaction time. Additional advantages could include higher speed limits, smoother rides and increased roadway capacity with minimized traffic congestion due to decreased need for safety distance, and higher speeds. Reduced traffic congestion and the improvements in traffic flow by widespread use of autonomous cars will also translate into better fuel efficiency and less fuel consumption, reduced air pollution and a lower carbon footprint from road travel. In particular, trucks in a platoon are able to drive very close together reducing aerodynamic drag in a big way and bringing fuel-efficiency of as much as 20% depending on depending on the test conditions used. The smaller the distance between vehicles, the better the fuel economy. Furthermore, the traffic control for sharing the extremely busy motorways, e.g. in central Europe, between cars and trucks will be discussed at the 2nd IAVSD Workshop on Dynamics of Road Vehicles in detail.

INTRODUCTION

In this paper some of the major research projects on autonomous cars and truck platoons.will be reviewed. Then, different options for the traffic control by rules of sharing the motorways between cars and platoons are considered. After some conclusions the references are added.

REVIEW OF PLATOONING PROJECTS

Major research activities on autonomous started about thirty ago. The Eureka **PROMETHEUS** Project (**PRO**gra**M**me for a **E**uropean **T**raffic of **H**ighest **E**fficiency and **U**nprecedented **S**afety, 1987-1995) was a large project in the field of driverless cars. From German universities Dickmanns [1] was the scientific leader and his research group dealt with dynamic vision resulting in the seeing passenger car 'VaMoRs-P' which drove 1995 without human interaction from Munich in Bavaria to Copenhagen in Denmark and return, Figure 1.
At the same time, in 1986 the California **PATH** Program (**P**artners for **A**dvanced **T**ransportation **T**echnology) was established, still known as PATH Berkeley, Shladover [2]. The partnership was a platooning pioneer, Figure 2. In 1994 it showed an Automated Highway System that used automated longitudinal control of a four-car platoon and they ramped that up to an eight-car platoon in 1997.
A smaller project dealt 1996 to 2001 with the platooning of two BMW passenger cars [3] using multibody system dynamics and nonlinear control for simulation and experiments at the University of Stuttgart, Figure 3.

The **SARTRE** Project (**S**afe **R**oad **Tr**ains for the **E**nvironment, 2009-2012), funded by the European Commission under the Framework 7 Programme, aims to develop strategies and technologies to allow vehicle platoons to operate on normal public highways with significant environmental, safety and comfort benefits. Figure 4 shows a platoon with a leading truck which has a responsible driver, and five cars with mechatronic drawbars. SARTRE is led by Ricardo UK Ltd [4] and comprises a collaboration between companies in UK, Spain, Germany and Sweden. In 2012 a road train comprising a Volvo XC60, a Volvo V60 and a Volvo S60 plus one truck drove automatically in convoy behind a lead vehicle operating on a public motorway among other road users. The historic test in Spain was highly successful.

European Truck Platooning

Finally, the European Truck Platooning Challenge 2016 has to be mentioned, a Dutch initiative for smart mobility. This initiative is documented in a booklet [5] with a cover of three trucks platooning, Figure 5.

Worldwide, the European truck industry leads the field in terms of smart driving. To this end, EU member states are now asked to:

- grant permission for truck platooning through their national road authorities,
- implement innovations that improve safety, efficiency and the environment,
- enable this boost to the position of the European truck industry,
- which could create new jobs and economic growth in the traffic and transport sector,
- enable the market introduction of automated trucks through a coordinated approach.

The European Truck Platooning Challenge 2016 aims to combine as many forces as to creat a European partnership between truck manufacturers, logistics service providers, research institutes and governments – and by sharing knowledge and experience around truck platooning.

Right across Europe there were contacted and briefed the directorates of relevant ministries, road managers and vehicle authorities on the European Truck Platooning Challenge 2016 – and the intention to go ahead together with the development of innovative mobility.

All European truck manufacturers strongly support the European Truck Platooning Challenge 2016. This is a unique opportunity to accelerate the implementation process both in the medium and long-terms. Bringing together member states and the industry to provide safe platooning, on open roads and cross borders, is unique.

Truck Platoons Rally 2016 to Rotterdam

The semi-autonomous moving trucks from six manufacturers have met after a multi-day rally throughout the EU in Rotterdam. Full autonomous driving was legally not possible at the time being.

After a few days of driving through five European countries six convoys of semi-automatic trucks reach their destination in Rotterdam on April 6, 2016. The so-called Smart Trucks were networked via wireless communication and drove partially automatically. The Dutch Minister for Transport Melanie Schultz van Haegen said on the technology of the future: “Freight transport will be safer, cleaner and more economical”.

The so-called “Truck platooning” can save fuel for trucks, and the CO2 emissions are reduced. This first transnational rally of Smart Trucks was a project of the Netherlands during its 2016 EU presidency.

The trucks had come from Germany, Denmark, Sweden, Belgium and the Netherlands to the port of Rotterdam. The vehicles communicated via radar, GPS and Wi-Fi, and can thereby automatically keep track and distance. At the rally, the truck manufacturer MAN, Scania, DAF, Iveco, Volvo and Daimler were involved, see e.g. Figure 6.

According to the manufacturers, the concept could be used industrially in Europe until 2020th “We have made it clear that it is possible,” said the Dutch minister. The Association of European Car Manufacturers (ACEA) said that prior to the introduction of European laws there is a need to be harmonized.

SHARING THE MOTORWAYS

An open question remains how the very busy motorways in central Europe, see e.g. Figure 7, could be shared between automated single passenger cars and larger truck platoons. Options discussed today are to use the most right lane or the most left lane for truck platoons, respectively. In any case, good motion control is most essential. For the dynamical modelling of the trucks the longitudinal

motions including the energy saving aerodynamics and the vertical motions featuring the tire – road contact have to be considered.

In addition to standard trucks with 18 m length, in Germany EuroCombi trucks or gigaliners, respectively, with 25 m length and 80 km/h speed are registered since 2017. For comparison, the length of the passenger cars is 5 m, the speed may very between 120 and 180 km/h. The safety distance in m is speed dependent and it is for all vehicles legally half of speed counted in km/h.

Today's standard lane utilization is depicted in Figure 8A where the red double arrows indicate the safety distance. Even for fast cars there isn't any problem for exiting or entering a motorway. However, in a platoon the trucks don't need, due to the common vehicle dynamics control, any safety distance, they should drive as closely as possible for a maximum reduction of the air resistance and the related fuel consumption. That means a platoon is like a moving wall, and for a car it may be difficult or even dangerous to enter or exit the motorway for both, cars and platoons, see Figure 8B and 8C.

To overcome these problems there will be several options discussed: 1) New roads for platoons, 2) Same speed limits for cars and platoons, 3) Adaptive cruise control between all vehicles, cars and platoons, depending on their final destination. Most attractive is the third option which is depicted in Figure 2. Moreover, the vehicles could be charged for the route using the motorway, too. Such systems of demand dependent customer prices are very successfully applied by airlines and railways. Late bookings get more and more expensive. Finally, by a complete management of the space on the motorway, traffic jams could be strongly reduced.

CONCLUSIONS

Research activities in Europe and the US have been reviewed. Even if the dream of autonomous driving is not new in the public discussion, the increasing number of vehicles on the one hand and the restricted space on roads on the other hand, due to limited environmental resources, requires new initiatives. One of them is truck platooning for smart mobility. Then, a related open question is the sharing of motorways by different kinds of vehicles.

In this paper three options are discussed where a complete management of the space on motorways is most attractive. The accessory research topics to be initiated includes vehicle dynamics and control, computer science and changes in the infrastructure.

REFERENCES

[1] Dickmanns, E. 2007. "Dynamic Vision for Perception and Control of Motion." Springer, Berlin.
[2] Shladover, A. 2006. "PATH at 20 – History and Major Milestones. www.path.berkeley.edu.about.
[3] Fritz, A. and W. Schiehlen. 2001. "Nonlinear ACC Simualtion and Measurement." Vehicle System Dynamics 36 : 159-177
[4] SARTRE. 2012. www.sartre-project.eu
[5] European Truck Platooning Challenge 2016. 2016. www.eutruckplatooning.com
[6] PROMETHEUS.1994. https://de.wikipedia.org/wiki/Prometheus
[7] http://blog.mercedes-benz-passion.com/2016/04/european-truck-platooning-challenge-daimler-mit-3-actros-mit-highway-pilot-connect-am-start/

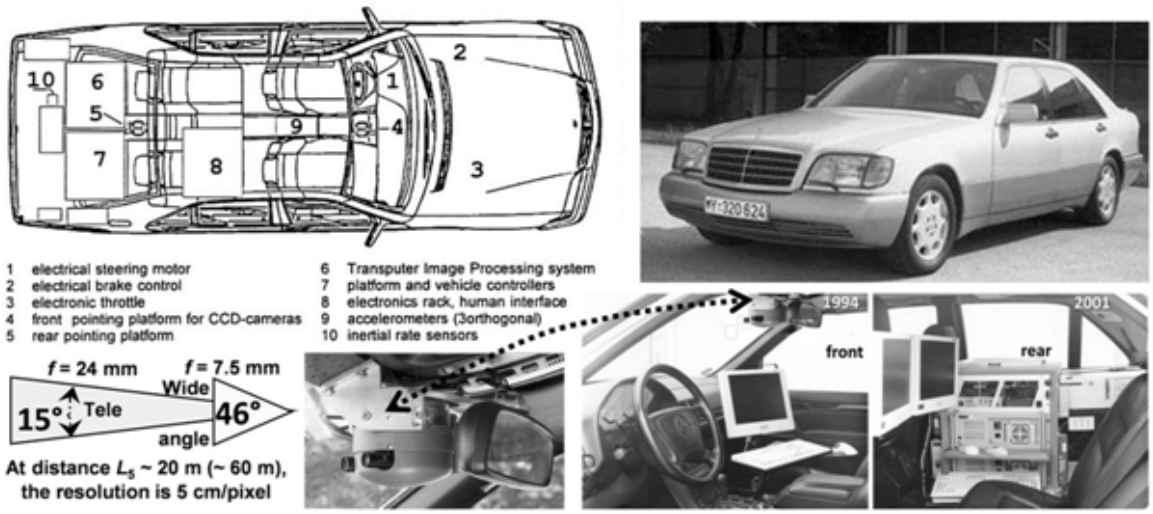


Figure 1. PROMETHEUS vehicle VaMoRs-P [6]

Figure 2. Automated and connected vehicles: Advancing technologies that connect vehicles to surrounding infrastructure and other vehicles or automates vehicle processes. [2]

Figure 3: Platooning project with nonlinear distance control at University of Stuttgart, Germany (1997)

Figure 4. SARTRE simulation of a platoon with one responsible driver in the leading truck [4]

A fresh perspective on mobility and logistics

European Truck Platooning Challenge 2016

Figure 5: European Truck Platooning Challenge 2016 [5]

Figure 6. Daimler Truck on their rally 2016 from Stuttgart to Rotterdam [7]

Figure 7: On busy motorways platoons create a moving wall on the right lane [7]

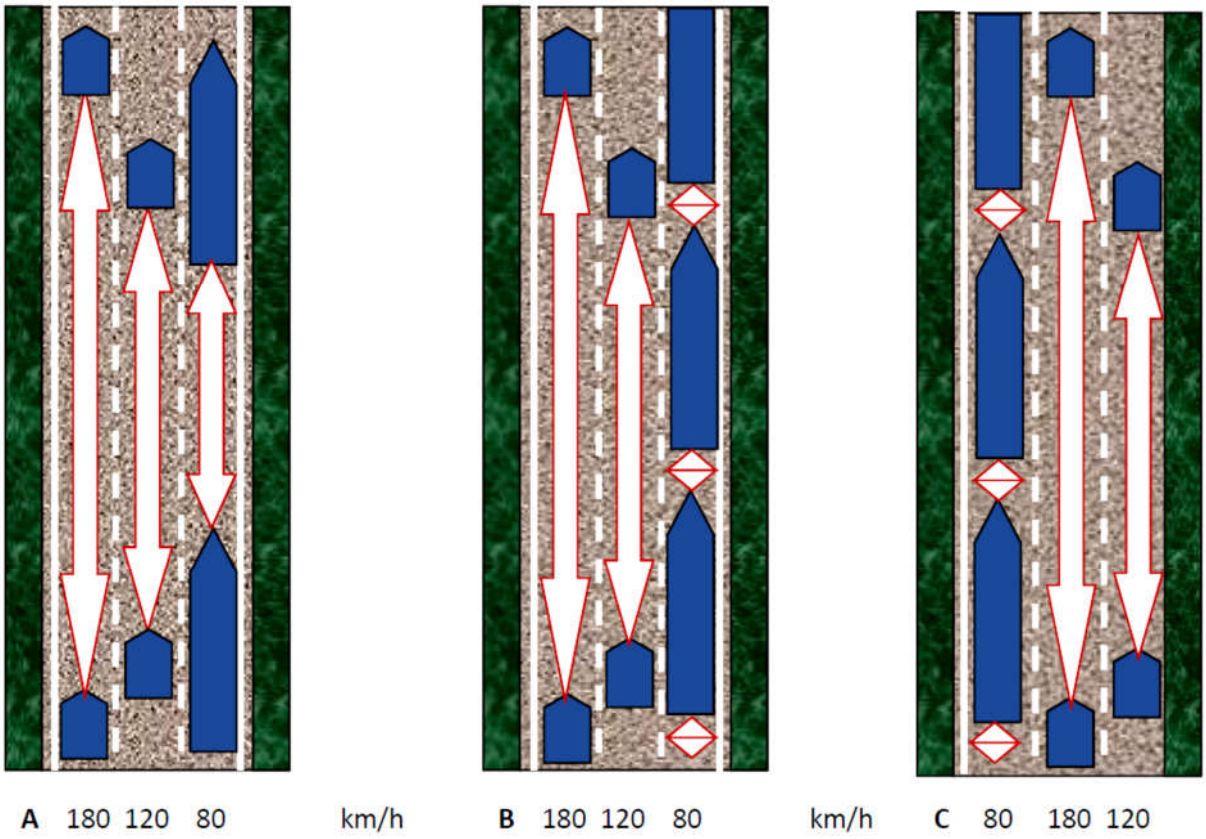


Figure 8: Lane utilization by passenger cars and platoons