MOTORWAY SHARING BETWEEN AUTOMATED SINGLE PASSENGER CARS AND LARGER TRUCK PLATOONS

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In road vehicle dynamics are car automation and autonomous driving 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 will include smoother rides and increased roadway capacity due to decreased need for safety distance, and higher speeds.
1 Introduction

The widespread use of autonomous cars will also translate into reduced traffic congestions and improvements in traffic flow.

Better fuel efficiency results in 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 strongly aerodynamic drag and increasing the fuel efficiency of as much as 20% depending on the test conditions used.

Furthermore, the traffic control for sharing extremely busy motorways between cars and truck platoons, is an open problem.

This is especially true in central Europe, and in particular, around Stuttgart.
2 REVIEW OF PLATOONING PROJECTS

❖ PROMETHEUS
❖ PATH
❖ University Project
❖ SARTRE
❖ European Truck Platooning
❖ Rally to Rotterdam 2016

Major research activities on autonomous cars started about thirty years ago. The Eureka PROMETHEUS Project (PROgramme for a European Traffic of Highest Efficiency and Unprecedented Safety, 1987-1995) was a large European project in the field of driverless cars.

The word PROMETHEUS means a futuristic thinker in Greek mythology.

From German universities Ernst Dickmanns 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.
VaMoRs-P is the German abbreviation of „Versuchsfahrzeug für autonome Mobilität und Rechnersehen – Personenwagen“
At the same time, in 1986 the California PATH Program (California Partners for Advanced Transit and Highways) was established, still known as PATH Berkeley.

On the occasion of the twentieth anniversary documented Steven Shladover the history and milestones by a paper “PATH at 20”.

The partnership was a platooning pioneer. 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.

Automated and connected vehicles: Advancing technologies that connect vehicles to surrounding infrastructure and other vehicles or automates vehicle processes.
A smaller project dealt 1996 to 2001 with the platooning of two BMW passenger cars using multibody system dynamics and nonlinear control for simulation and experiments at the University of Stuttgart.

This project was treated by Axel Fritz and documented in his PhD thesis entitled “ACC of Two Mechatronically Coupled Vehicles”.

Testing the automated steering of the second vehicle.
The SARTRE Project (Safe Road Trains for the Environment) was funded 2009-2012 by the European Commission under the Framework 7 Programme.

SARTRE aims to develop strategies and technologies to allow vehicle platoons to operate on normal public highways with significant environmental, safety and comfort benefits.

SARTRE was led by the engineering consultancy Ricardo UK Ltd, and comprises a collaboration between companies in UK, Spain, Germany and Sweden.

In 2012 a road train comprising three Volvo trucks 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.
Finally, the European Truck Platooning Challenge 2016 has to be mentioned, a Dutch initiative for smart mobility.

The European Truck Platooning Challenge 2016 aims to combine many forces to create a European partnership between truck manufacturers, logistics service providers, research institutes and governments by sharing knowledge and experience around truck platooning.
The **EU member states** are now asked to:

- grant **permission** for truck platooning,
- improve safety, **efficiency** and the environment,
- boost the position of the European **truck industry**,
- create economic **growth** in traffic and transport,
- introduce **automated trucks** by a coordinated approach.
On April 6, 2016 after a few days of driving through five European countries six convoys of semi-automatic trucks reach their destination in Rotterdam. 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. The first transnational rally of Smart Trucks was a project of the Netherlands during its 2016 EU presidency.

The trucks did drive from Germany, Denmark, Sweden, Belgium and the Netherlands to the port of Rotterdam.

The vehicles communicated via radar, GPS and Wi-Fi, and could thereby automatically keep track and distance. At the rally, the truck manufacturer MAN, Scania, DAF, Iveco, Volvo and Daimler were involved.
3 Sharing the Motorway

An open question remains, however, how the very busy motorways in central Europe could be shared between automated single passenger cars and larger truck platoons.

Options discussed today are the use of only one lane for truck platoons. In any case, good motion control is most essential.

For the dynamical modelling of the trucks their 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, are registered since 2017 with 25 m length and 80 km/h speed.

For comparison, the length of the passenger cars is 5 m, the speed may vary 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 on the left where the red double arrows indicate the safety distance. Even for fast cars there isn’t any problem for exiting or entering a motorway.

In a platoon the trucks don’t need any safety distance, they should drive as closely as possible for a maximum reduction of the air resistance and the related fuel consumption.

Due a connected common vehicle dynamics control of the whole platoon, the safety of the longitudinal relative motion of all trucks can be readily achieved. Such a kind of control is also denoted as mechatronic drawbar.

That means a platoon is like a moving wall on the right, and for a car it may be difficult or even dangerous to enter or exit the motorway for both, cars and platoons.
3 Sharing the Motorway

If the platoons drive **on the left**, then the passenger cars don’t have any problem.

But for the platoons it may be more difficult or even dangerous to enter or exit the motorway for both, cars and platoons. The result may be additional traffic jams.

To overcome these problems there may 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, however, requires communication between all vehicles. At the being this is not state of the art.
3 Sharing the Motorway

All vehicle communicate with each other and the environment via huge traffic control centers.

3 Sharing the Motorway

A central traffic control center could also be used to charge the vehicles for the route driving on a motorway system.

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.
Research activities in Europe and the US have been reviewed.

The increasing number of vehicles on the one hand and the restricted space on roads on the other hand, require 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.

Three options may be discussed where a complete management of the space on motorways is most attractive. The related research topics to be initiated includes vehicle dynamics and control, computer science and changes in the infrastructure.