Implications of Cooperative Adaptive Cruise Control for the Traffic Flow

A Simulation Based Analysis

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German Aerospace Center (DLR) at a Glance

- 5,100 employees working in 27 research institutes and facilities
  - at 8 sites
  - in 7 field offices.
- Offices in Brussels, Paris and Washington

Program Directorates
- Aeronautics
- Space
- Transport
- Energy
Research at the DLR Institute of Transport Research

- analysis of the **Transport Demand** in private and commercial transport
- **Model-Based Analysis** of the impacts of technical, organisational and political transport related measures
- development and assessment of **Future Scenarios**
Agenda

Motivation

Introduction
Cooperative Adaptive Cruise Control (CACC)

Methodology
Simulation based assessment

Results
Impact of CACC on Traffic Flow

Discussion
**Motivation**

Goods Transport on the road is attractive...

...when the roads are not congested

<table>
<thead>
<tr>
<th>Capacity improvements</th>
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<tr>
<td><strong>Infrastructure</strong></td>
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<tr>
<td>• new lanes</td>
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<td><strong>Vehicles</strong></td>
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<td>• eg. Gigaliner</td>
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<tr>
<td><strong>Traffic Management</strong></td>
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<tr>
<td>• Avoid traffic</td>
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<tr>
<td>• Shift traffic</td>
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<tr>
<td>• Modal shift, shift in time, shift in space</td>
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<tr>
<td>• Control traffic</td>
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<tr>
<td>• eg. ITS (\rightarrow) eg. CACC</td>
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Cooperation Adaptive Cruise Control (CACC)
Generell Mode of Operation of CACC

- Trucks driving connected in a platoon
- Leading vehicle is driven manually, followers are steered fully automated
- Up to 7 vehicles can be coupled
Research on CACC

- **USA**
  - California PATH

- **Europe**
  - PROMOTE CHAUFFEUR I/II 1996-2003
  - Demonstration of Technical Feasibility
  - SARTRE (Safe Road Trains for Environment) 2009-2012

- **Germany**
  - KONVOI 2005-2008
  - field tests in real traffic flow
Research on CACC – Viability

- Technology
  - works

- Legal aspects
  - are recognised

- Acceptance
  - first results

- Practice readiness
  - successful field tests
Research on CACC – Impacts

- Fuel savings: mixed results, but positive; field-test: up to 20%

Research on CACC – Impacts

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- **Safety**
  - Qualitative studies: rear end collisions reduced

- **Operation in traffic flow**
  - coupling and decoupling, maximum number of linked trucks, …
Research on CACC – Impacts

- **fuel savings**
  - mixed results, but positive; field-test: up to 20%

- **safety**
  - Qualitative studies: rear end collisions reduced

- **operation in traffic flow**
  - coupling and decoupling, maximum number of linked trucks, …

- **What about the capacity of motorways?**
Impact of CACC on the capacity

Methodology
Outline

- **Question:** Impact of linked road trains on the capacity in relation to penetration rate, number of trucks etc.?

- **Microscopic traffic flow simulation (VISSIM)** without and with equipped trucks

- **Szenarios**
  - motorway, no intersections, three lanes, one-way, slope of 1 %
  - varying...
    - traffic volume
    - number of trucks
    - share of CACC-equipped trucks
Special View on implemented CACC-Trucks

- Length distribution of trucks based on real data
- Only Trailer-Trucks and Drawbar Combination Trucks are equipped (~80% of all trucks on motorway)
- Number of trucks in platoon uniformly distributed

- A very long truck simulates the platoon
- Distance between vehicles \(dx = 10m\)
Calibration of VISSIM

- Fitting of q-v-curves (no trucks, 20% trucks, 10% trucks)
- benchmark: HBS (German HCM)
- subsequent model tuning by driver behavior (many parameters)
Calibration Process: No trucks
Calibration Process: 20% trucks
Calibration Process: 10% trucks for validation
Impact of CACC on the capacity
Results
Results of the simulation

- Effects on Traffic Flow with 50 % CACC-equipped Trucks
  - CACC has a significant effect on traffic flow

10 % trucks (50 % CACC)

20 % trucks (50 % CACC)
Results in Detail

- up to 6 % higher capacity (traffic volume at breakdown speed)
- insignificant effects for low penetration rate
Discussion
Conclusion

- Positive impact on capacity quantified
  (~5 % for 50 % penetration rate)
  based on realistic vehicle mix

- high penetration rate of CACC required
  for significant overall impact on capacity

- To the positive effects of CACC
  - Fuel Saving
  - Safety
  we can add
  - Capacity
Outlook

- quantitative results can be used to calibrate (macroscopic) models
- effect of coupling and decoupling yet to be incorporated
- extension to different vehicle types (passenger cars) possible
Thank You Very Much For Your Attention!

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