Implications of Cooperative Adaptive Cruise Control for the Traffic Flow

A Simulation Based Analysis

Axel Wolfermann, Stephan Müller
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>Infrastructure</td>
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<tr>
<td>• new lanes</td>
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<td>Vehicles</td>
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<td>• eg. Gigaliner</td>
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<tr>
<td>Traffic Management</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

- **fuel savings**
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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

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- **safety**
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- **operation in traffic flow**
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- **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 \( dx = 10 \text{m} \)
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

Implications of CACC on Traffic Flow: Müller, Wolfermann > 4th ECITL, Thessaloniki > 13th October 2011
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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