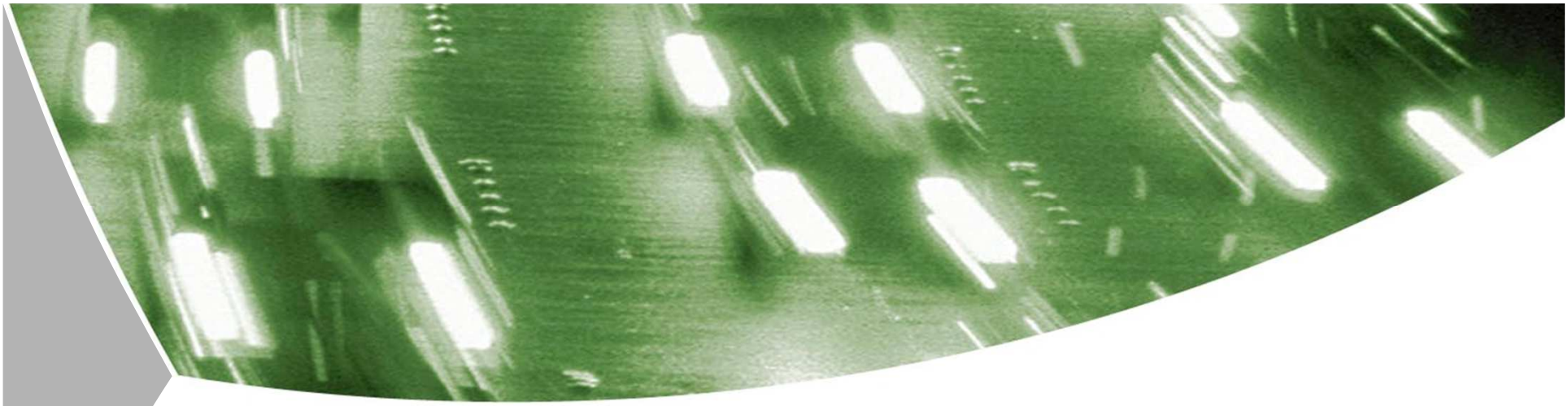


Implications of Cooperative Adaptive Cruise Control for the Traffic Flow

A Simulation Based Analysis

Axel Wolfermann, Stephan Müller

Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

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

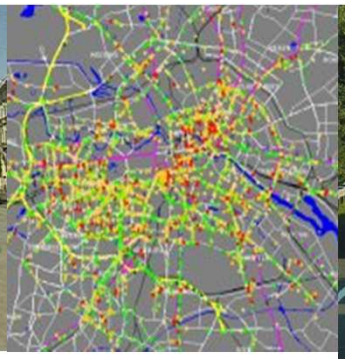
Program Directorates

- 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

Capacity improvements

Infrastructure

- new lanes

Vehicles

- eg. Gigaliner

Traffic Management

- Avoid traffic
- Shift traffic
  - Modal shift, shift in time, shift in space
- Control traffic
  - eg. ITS → eg. CACC


Source: ATZonline

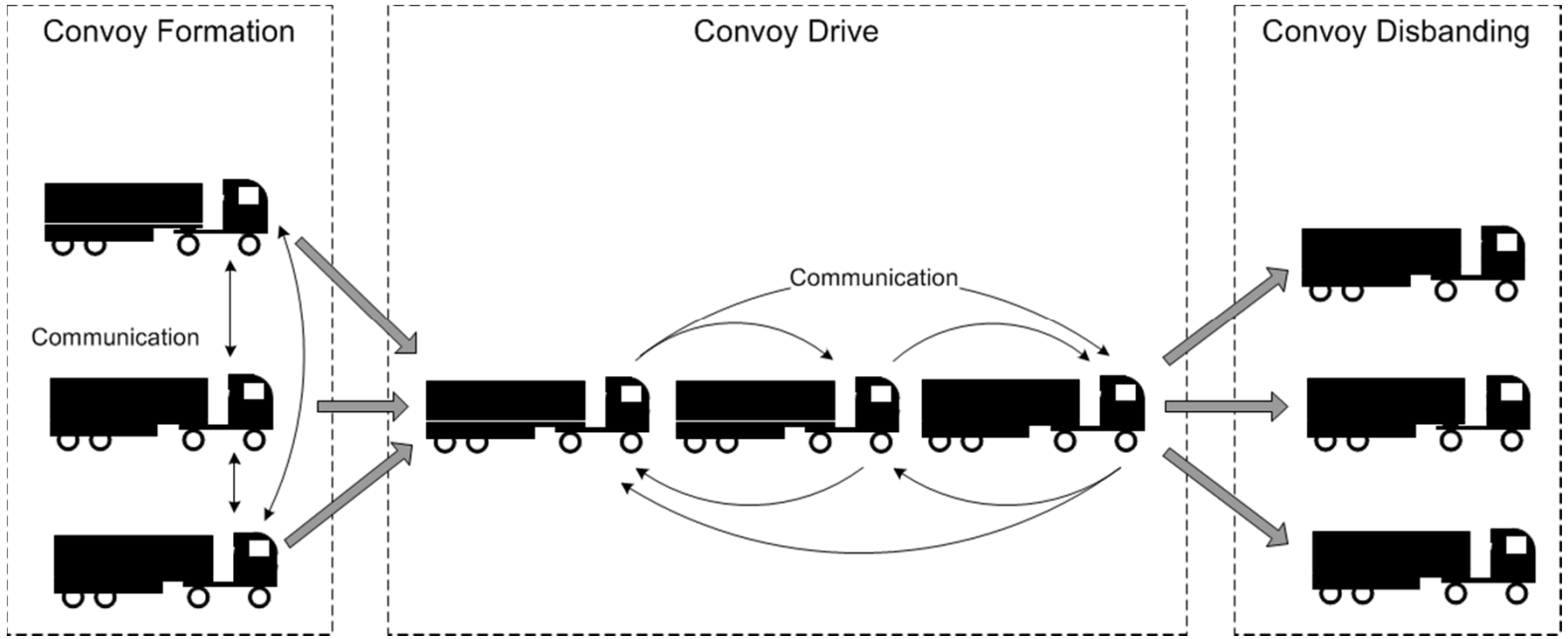

Source: Promote Chauffeur

Source: Promote Chauffeur

Cooperation Adaptive Cruise Control (CACC)

Generell Mode of Operation of CACC

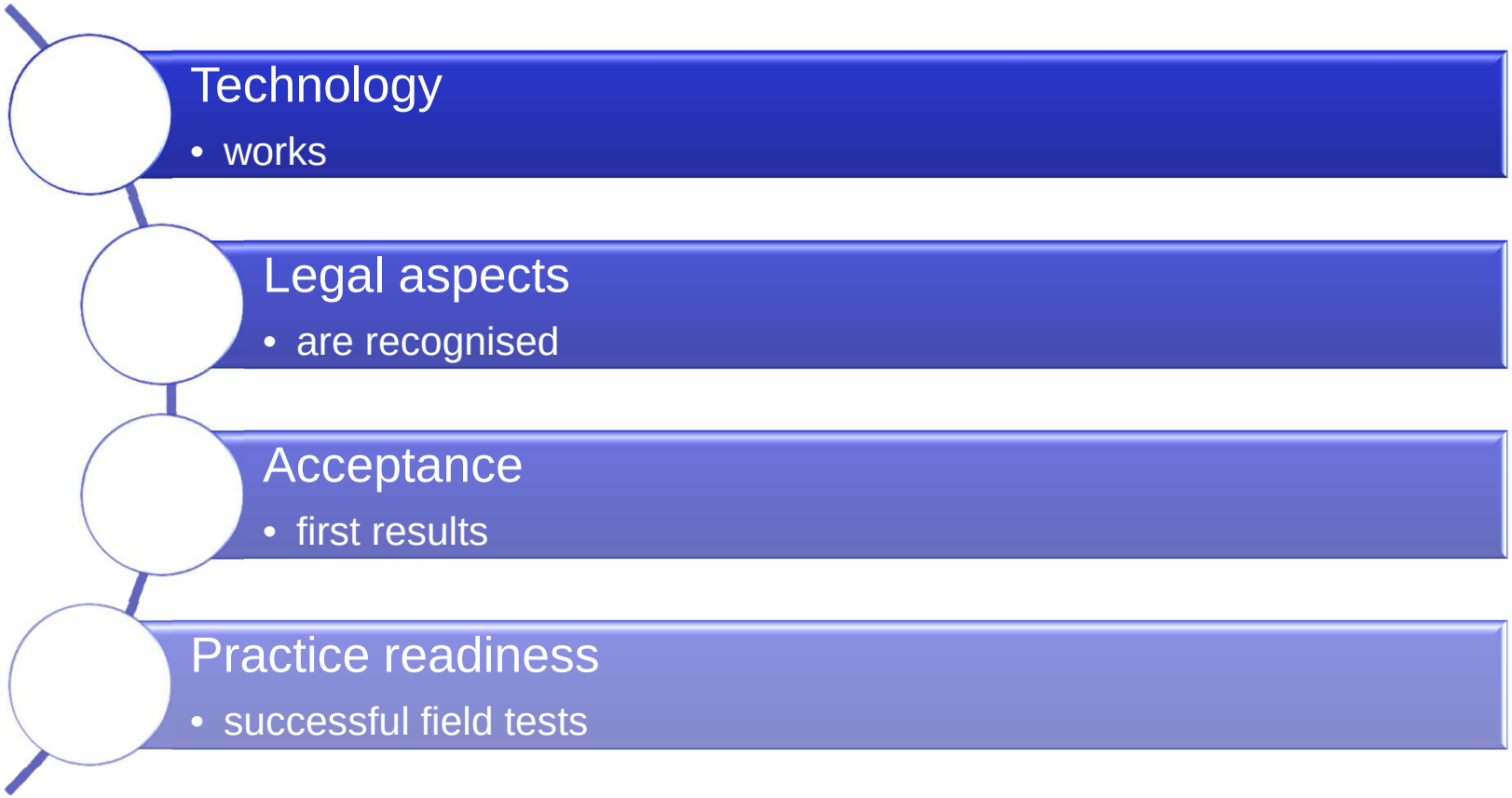
- Trucks driving connected in a platoon
- Leading vehicle is driven manually, followers are steered fully automated
- Up to 7 vehicles can be coupled



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
  - EFAS (Szenarios of Deployment of Driver Assistance Systems in Goods Traffic) 2001-2002
  - MFG (Preparing Measures for practical Deployment of Driver Assistance Systems in Goods Traffic) 2003-2004
  - KONVOI 2005-2008
    - field tests in real traffic flow

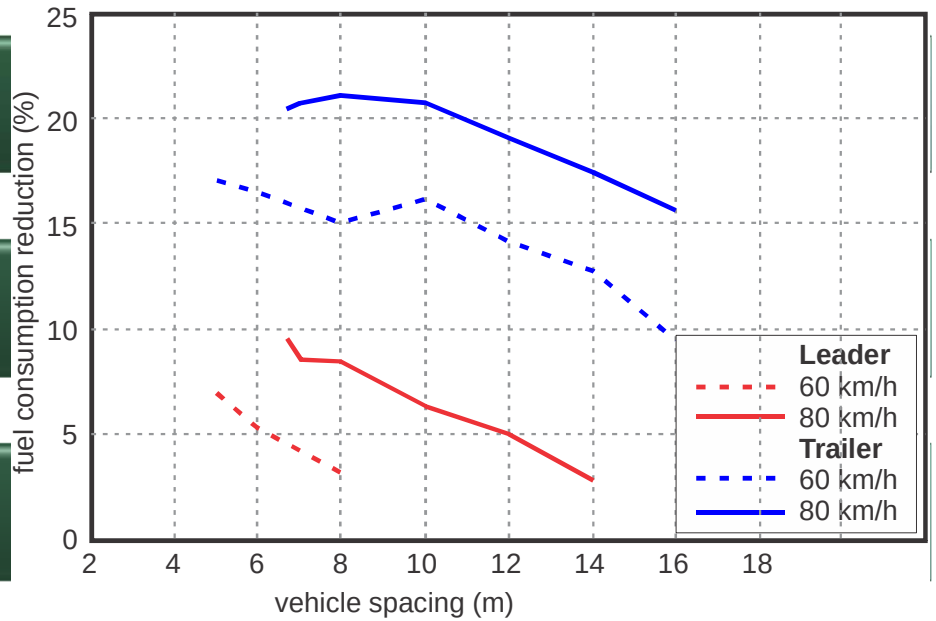
Research on CACC – Viability



Research on CACC – Impacts

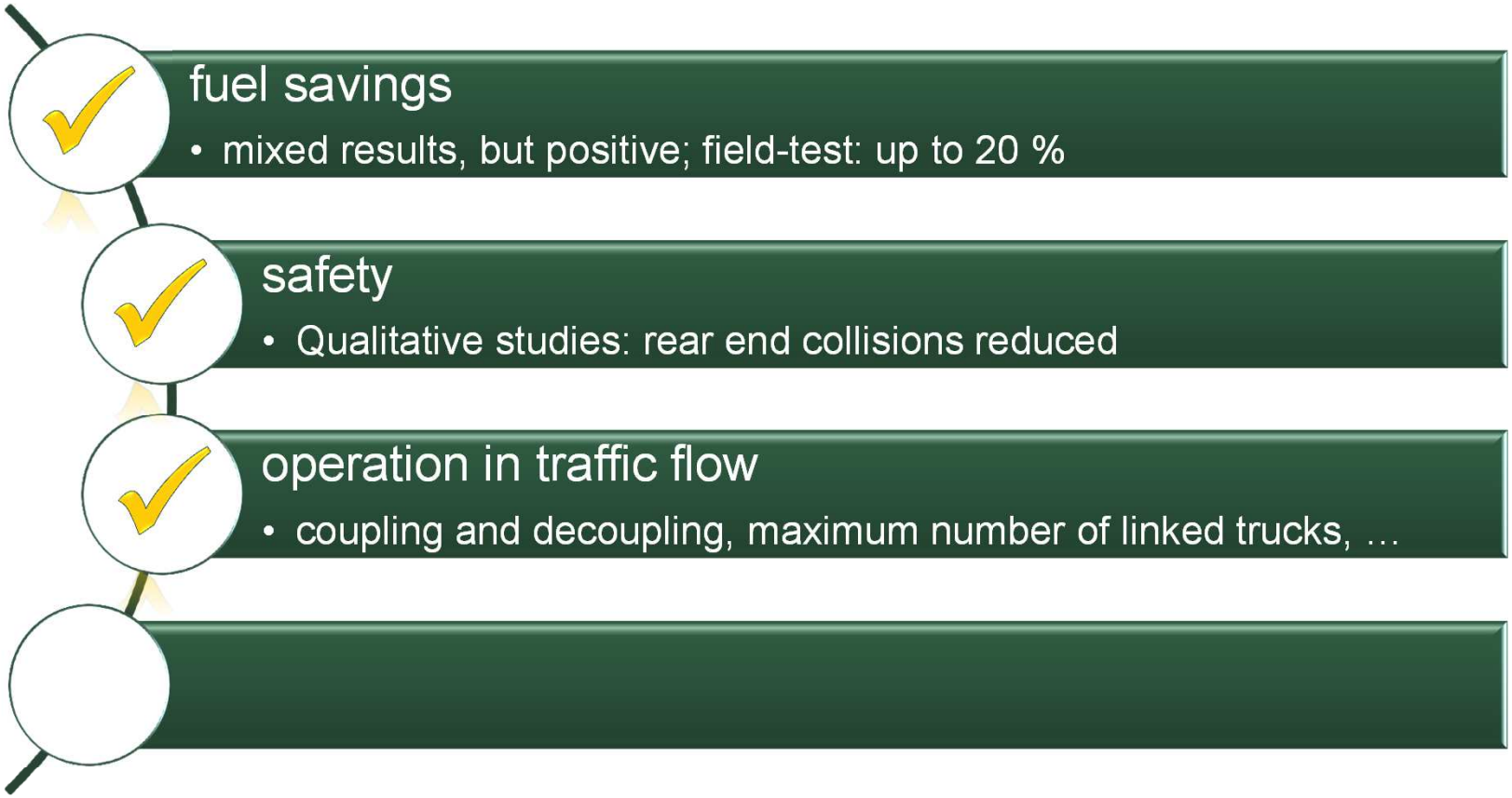
fuel savings

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

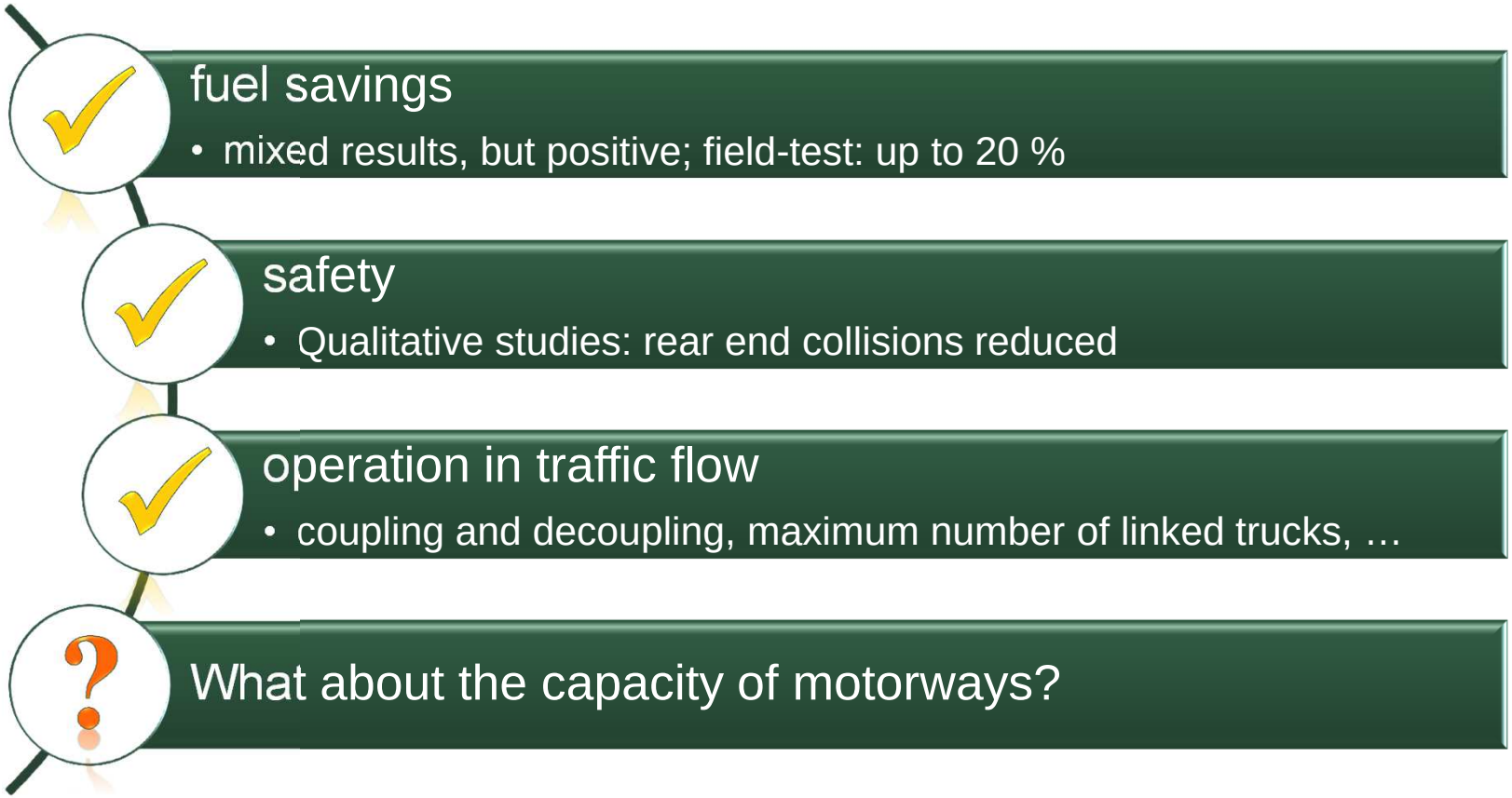


Source: Bonnet, Chr. ; Fritz, H.:
Fuel Consumption Reduction Experienced by Two PROMOTE-CHAUFFEUR Trucks in Electronic Towbar Operation.
In: *7th World Congress Conference on ITS*, 2000

Research on CACC – Impacts



Research on CACC – Impacts



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.?

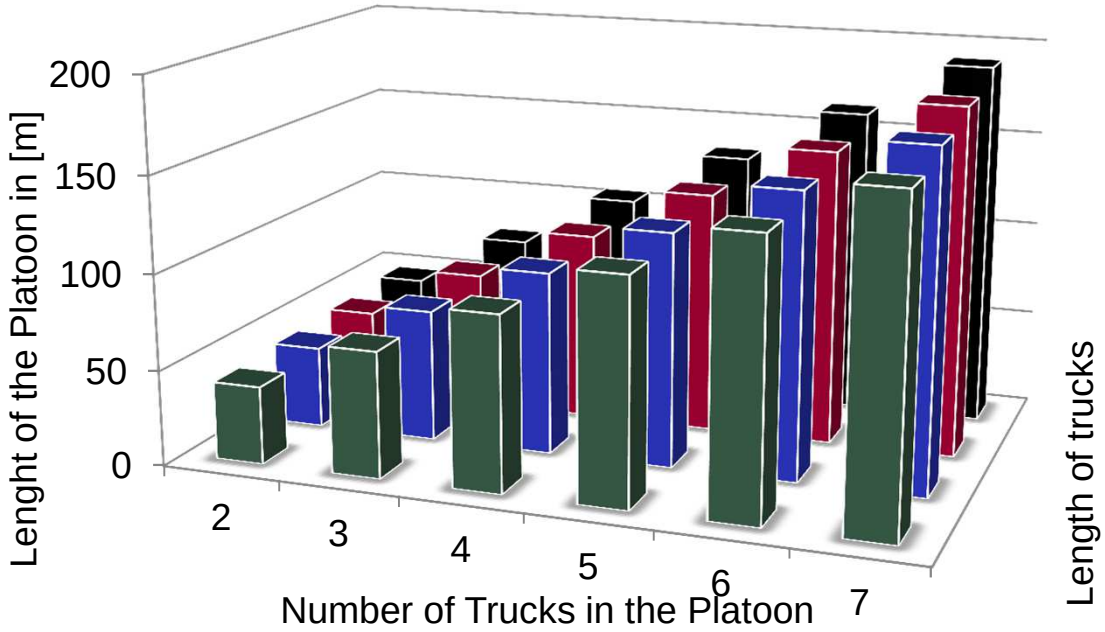
- **Microscopic traffic flow simulation** (VISSIM)
  without and with equipped trucks

- **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

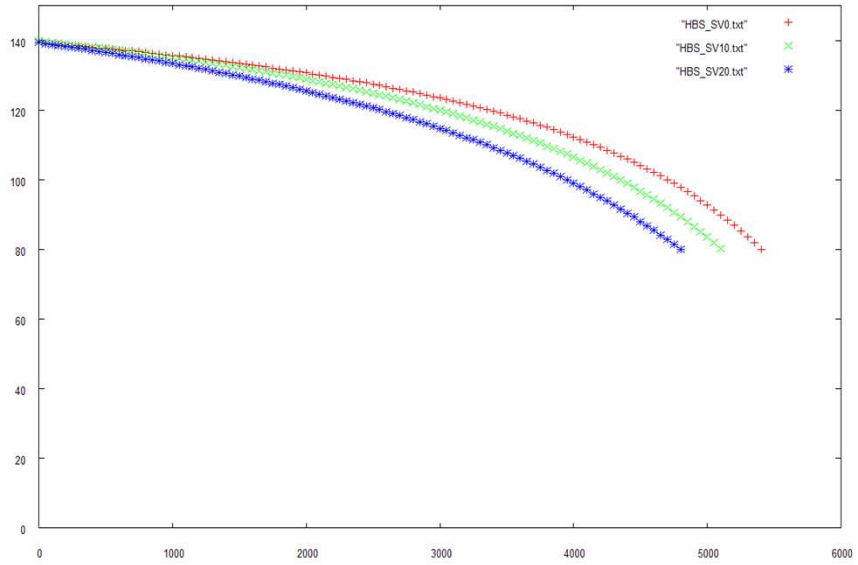
- Lenght distribution of trucks **based on real data**
- Only Trailer-Trucks and Drawbar Combination Trucks are equipped (~80 % of all trucks on motorway)
- Number of trucks in platoon uniformly distributed

- A very long truck simulates the platoon
- Distance between vehicles **dx = 10m**

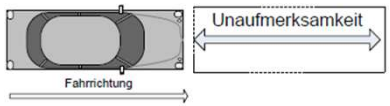


Calibration of VISSIM

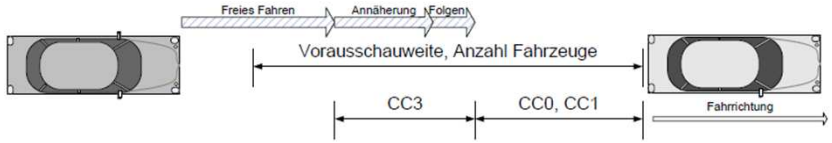
- Fitting of q-v-curves (no trucks, 20 % trucks, 10 % trucks)
- benchmark: HBS (German HCM)
- subsequent model tuning by driver behavior (many parameters)



Parameter of free riding

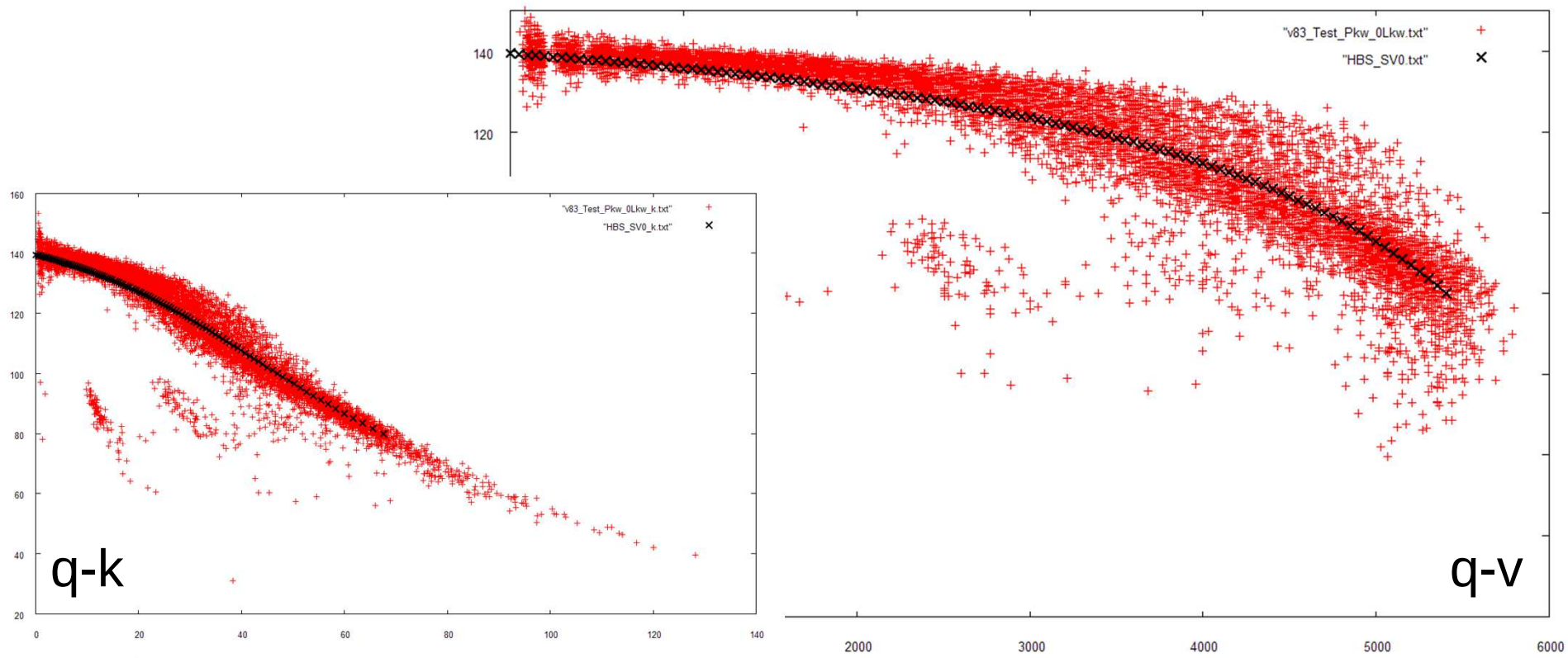


Parameter of approximation

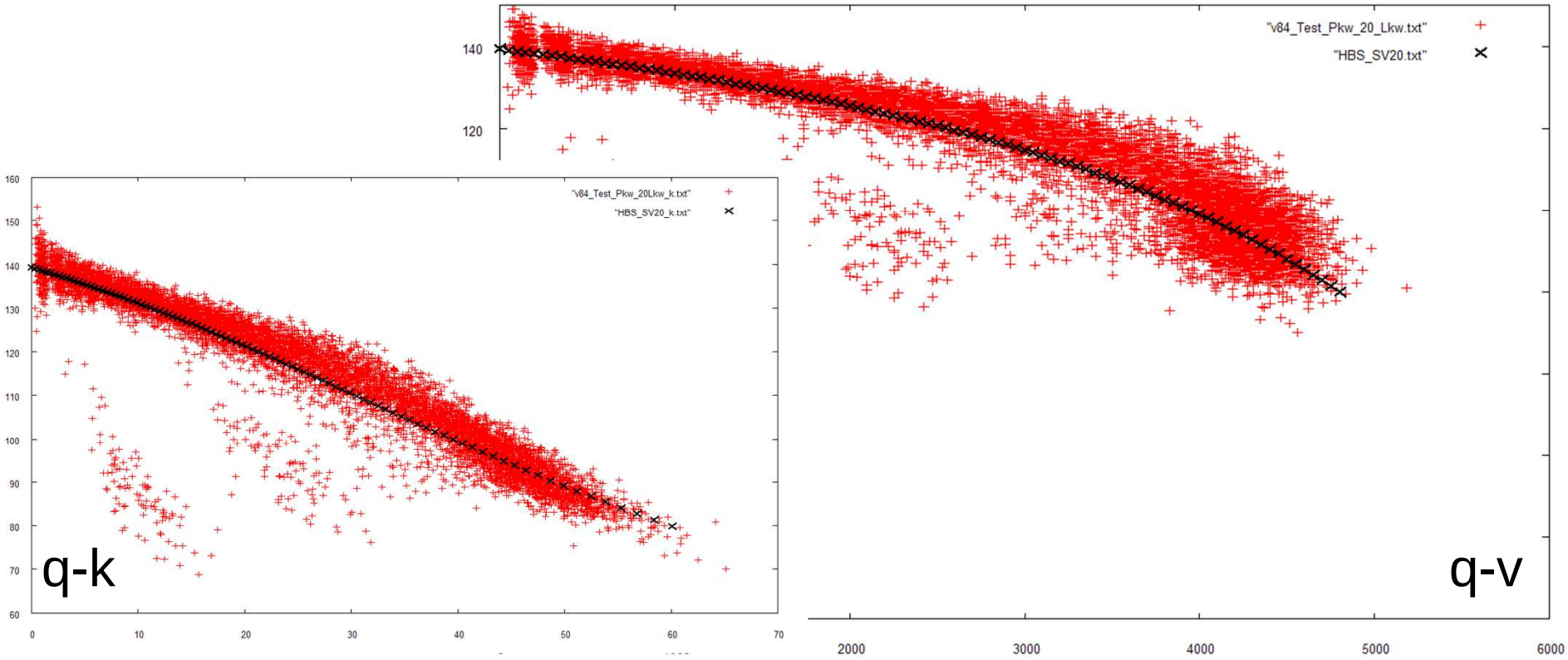


Parameter of following

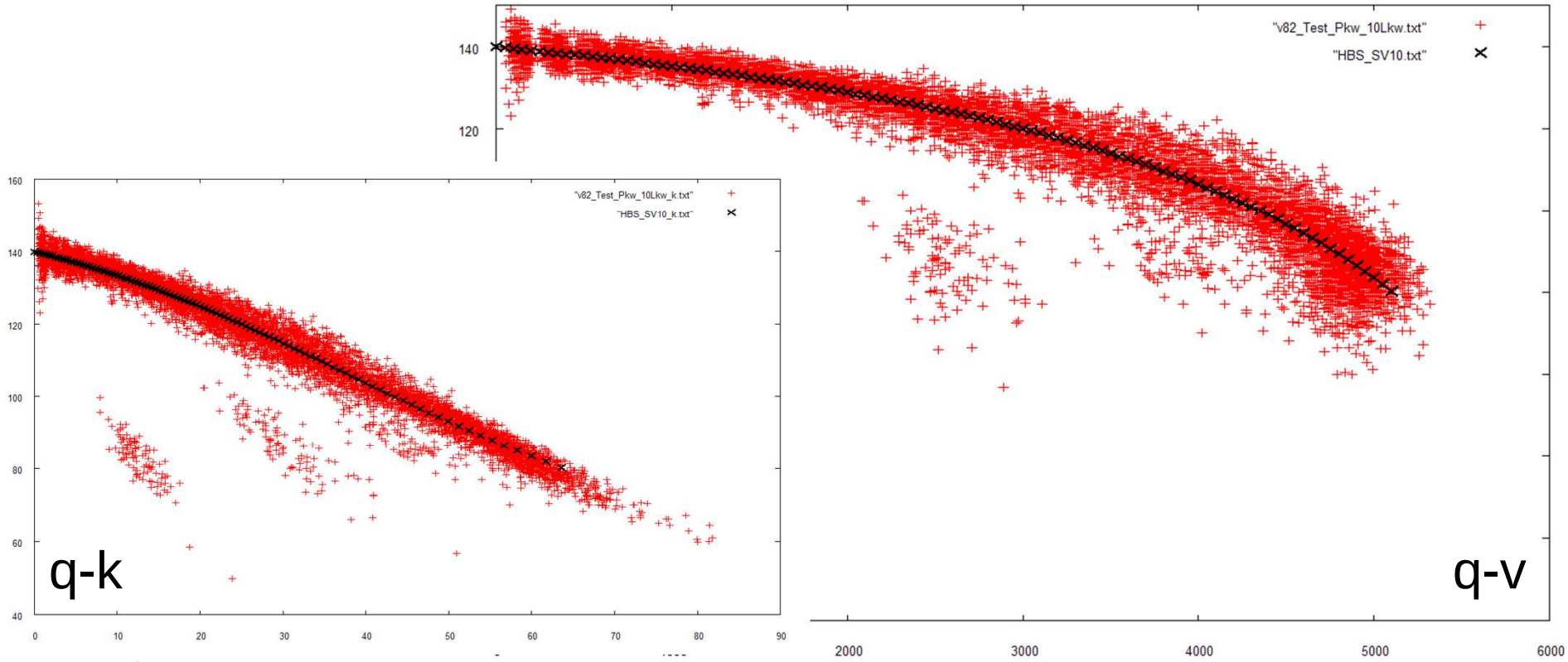
Calibration Process: No trucks



Calibration Process: 20% trucks



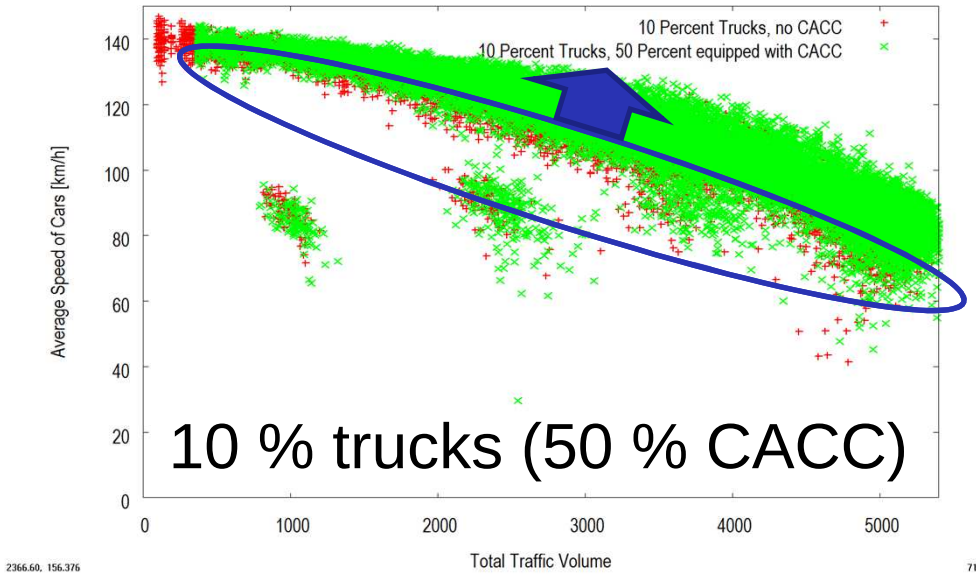
Calibration Process: 10 % trucks for validation

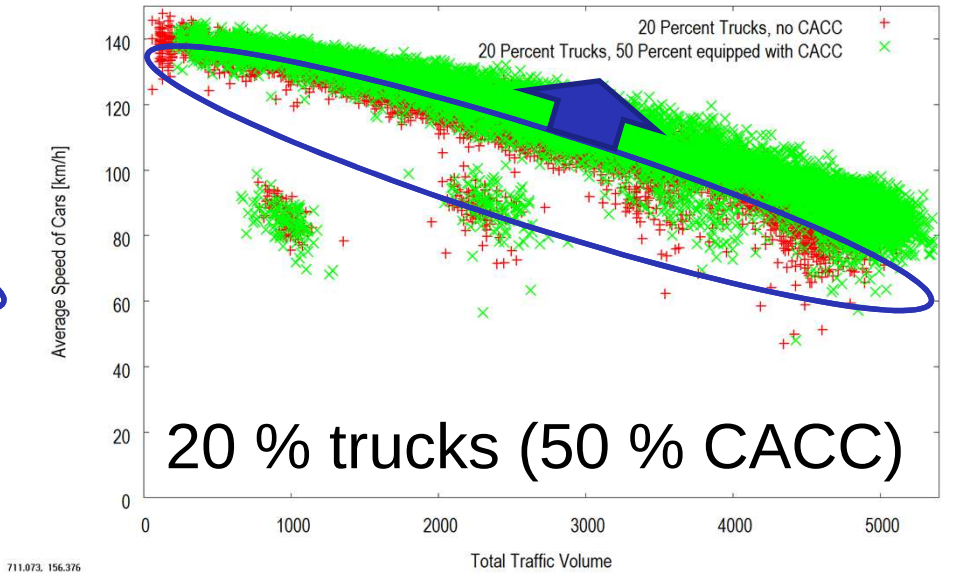


Impact of CACC on the capacity
Results

Results of the simulation

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

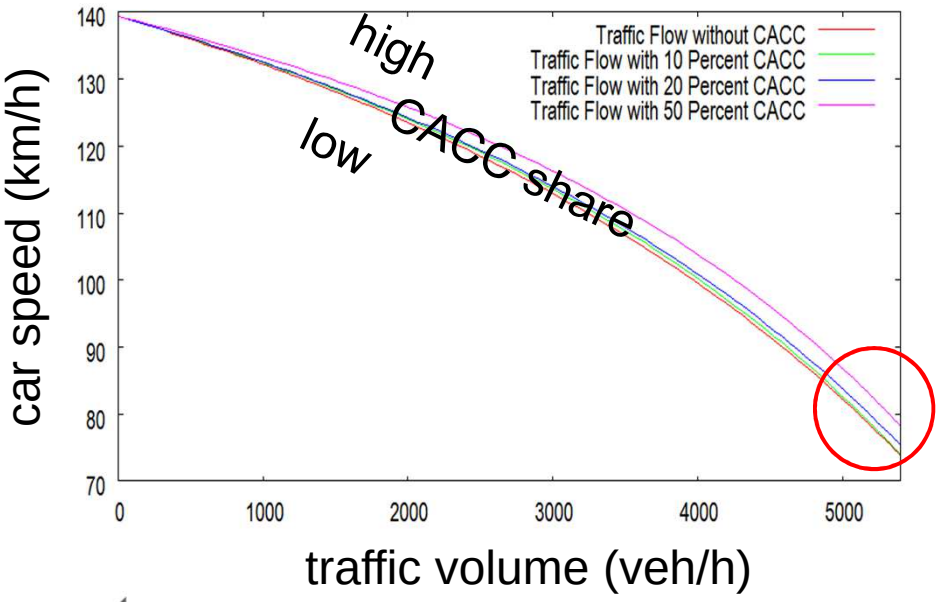




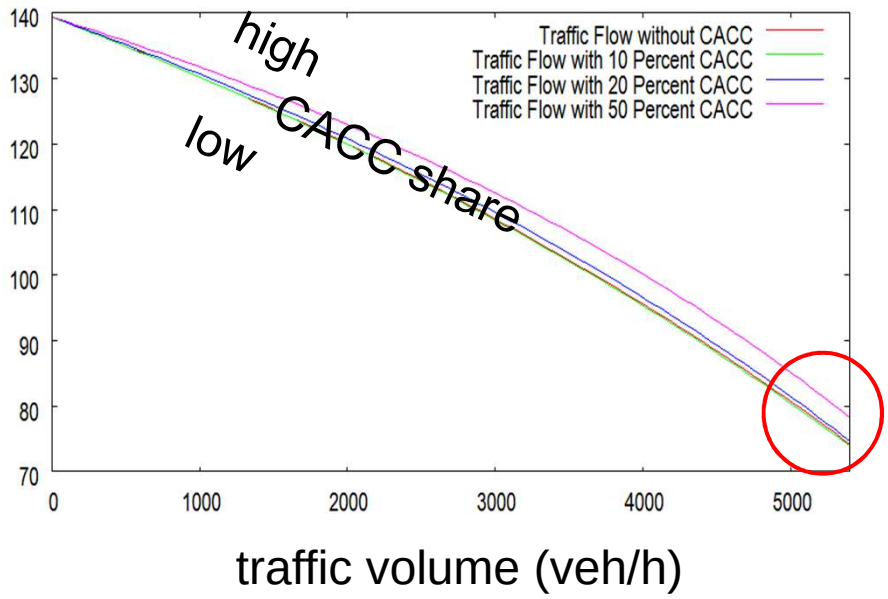
Results in Detail

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

10 % trucks



20 % trucks



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!

Dipl.-Ing. Stephan Müller
Dr.-Ing. Axel Wolfermann

German Aerospace Center (DLR)
stephan.mueller@dlr.de
axel.wolfermann@dlr.de