

# 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

## 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

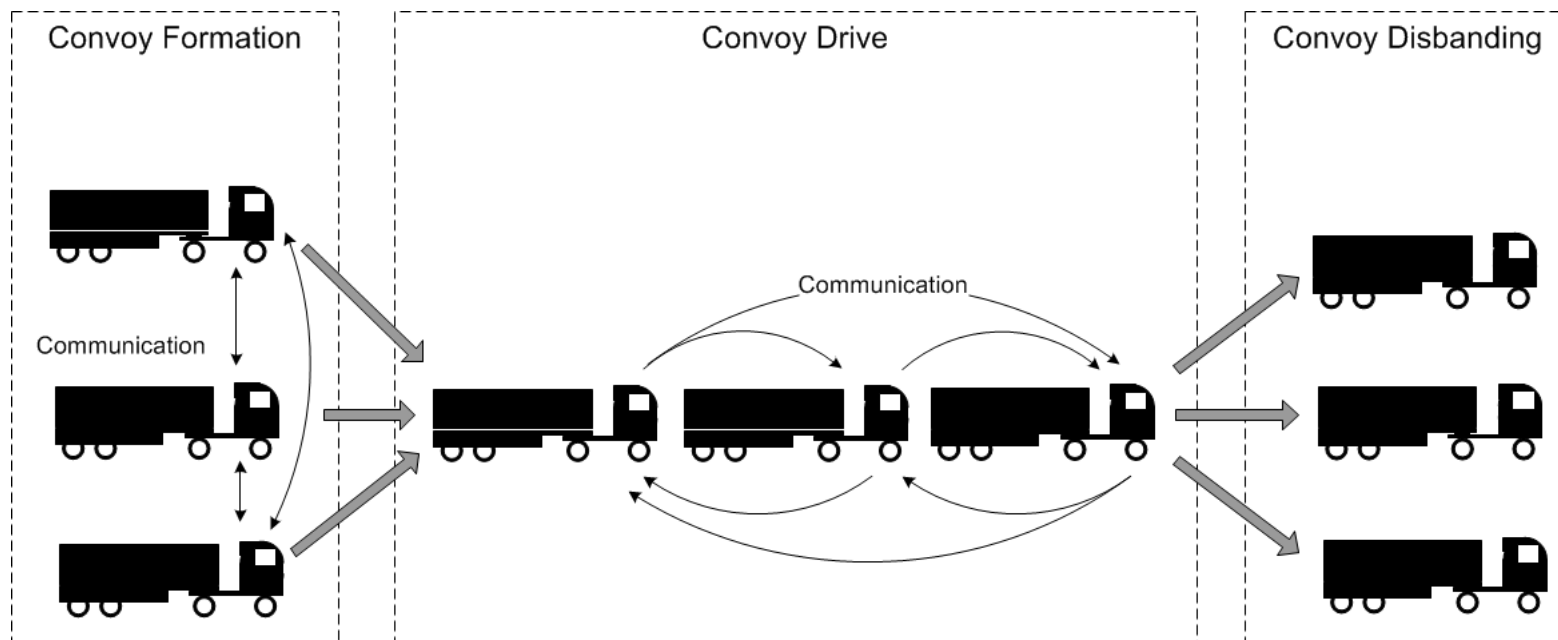




## Cooperation Adaptive Cruise Control (CACC)

## 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

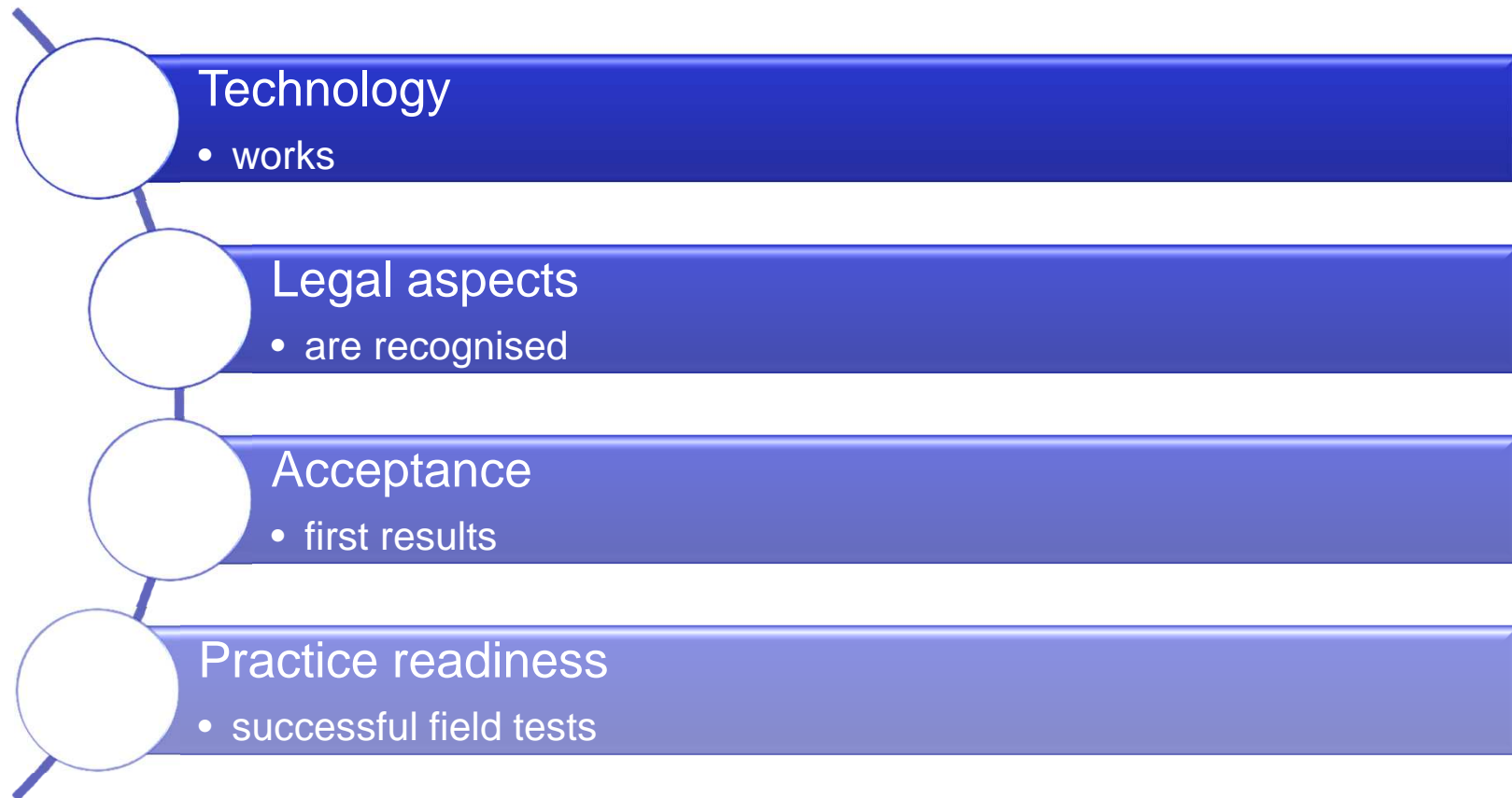
➤ KONVOI 2005-2008

➤ field tests in real traffic flow



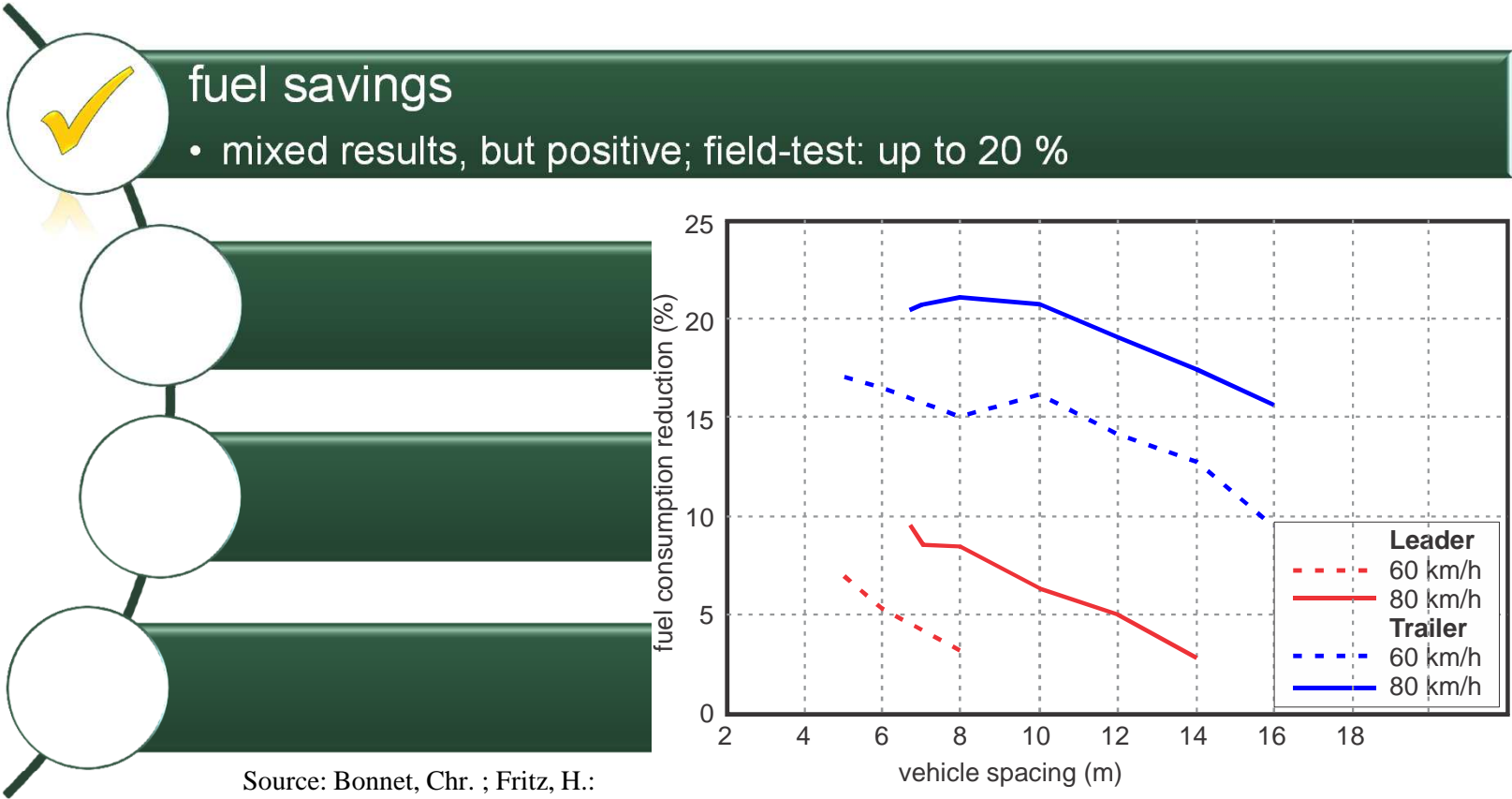


## Research on CACC – Viability





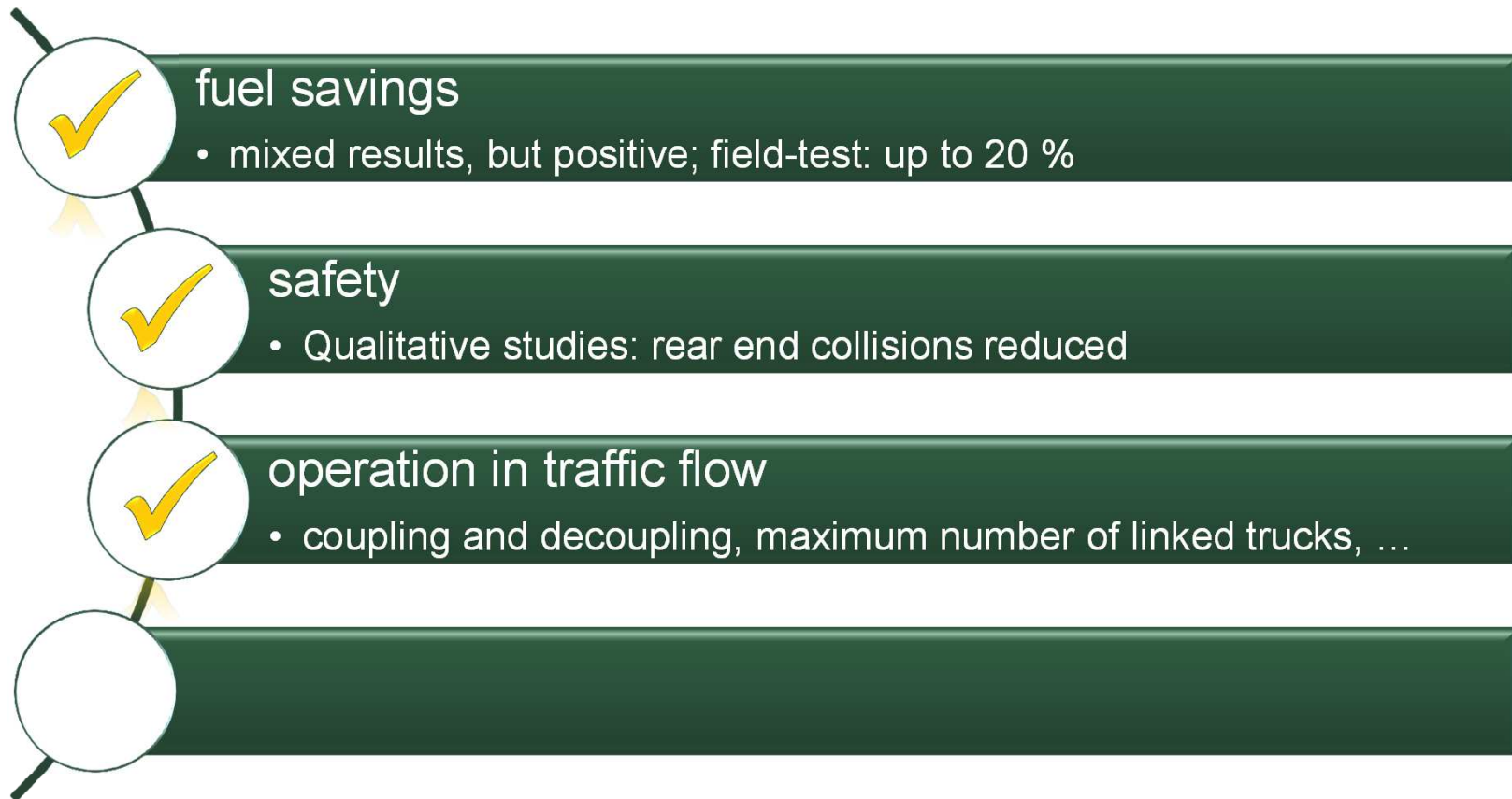
# Research on CACC – Impacts



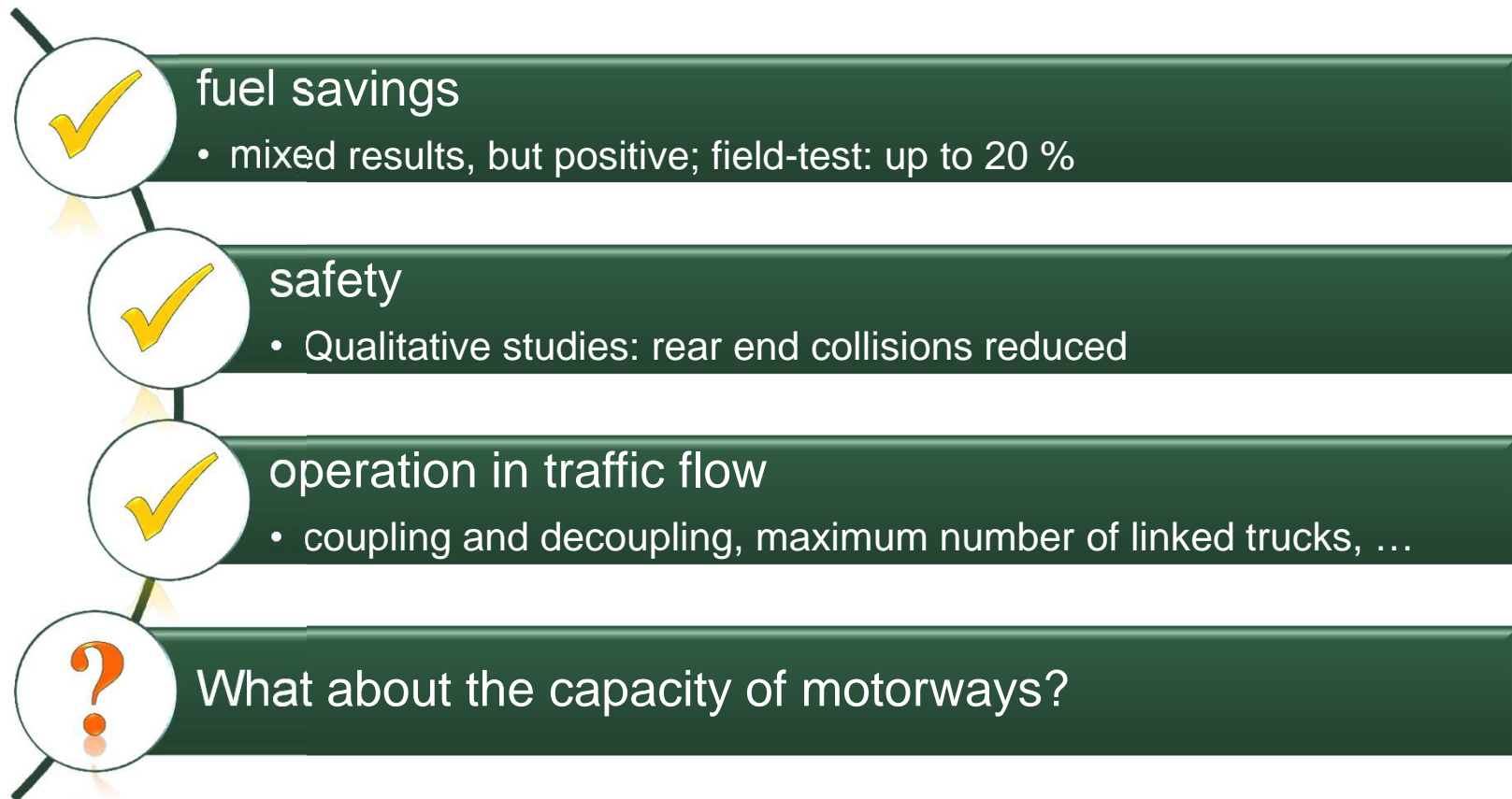
Source: Bonnet, Chr. ; Fritz, H.:  
Fuel Consumption Reduction Experienced by Two PROMOTE-CHAUFFEUR Trucks in Electronic Towbar Operation.  
In: 7th World Congress Conference on ITS, 2000



## Research on CACC – Impacts



## Research on CACC – Impacts





# Impact of CACC on the capacity **Methodology**





## Outline

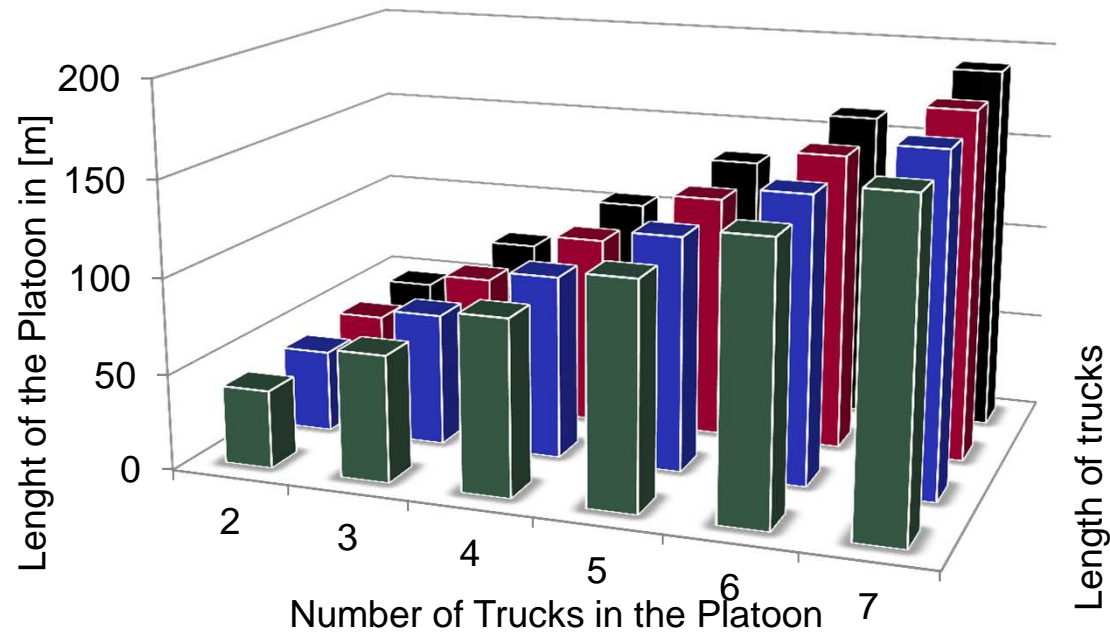
- **Question:**  
Impact of linked road trains on the capacity in relation to penetration rate, number of trucks etc.?
  
- **Microscopic traffic flow simulation (VISSIM)**  
without and with equipped trucks
  
- **Szenarios**
  - motorway, no intersections, three lanes, one-way, slope of 1 %
  - varying...
    - traffic volume
    - number of trucks
    - share of CACC-equipped trucks



## Special View on implemented CACC-Trucks

- 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

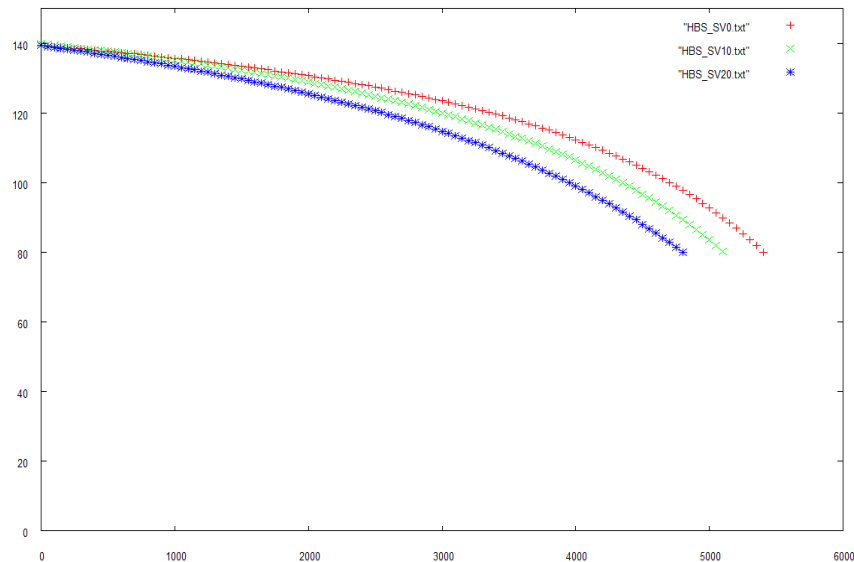
- A very long truck simulates the platoon
- Distance between vehicles  **$dx = 10m$**



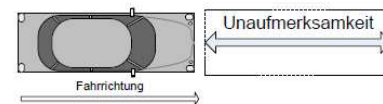


# Calibration of VISSIM

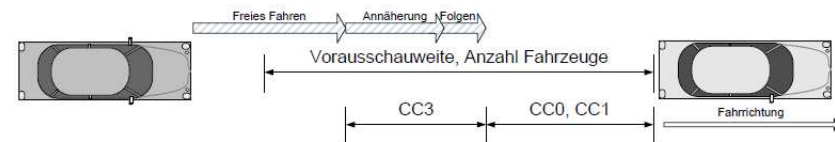
- Fitting of q-v-curves (no trucks, 20 % trucks, 10 % trucks)
- benchmark: HBS (German HCM)
- subsequent model tuning by driver behavior (many parameters)



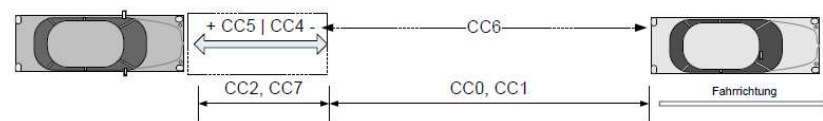
## Parameter of free riding



## Parameter of approximation

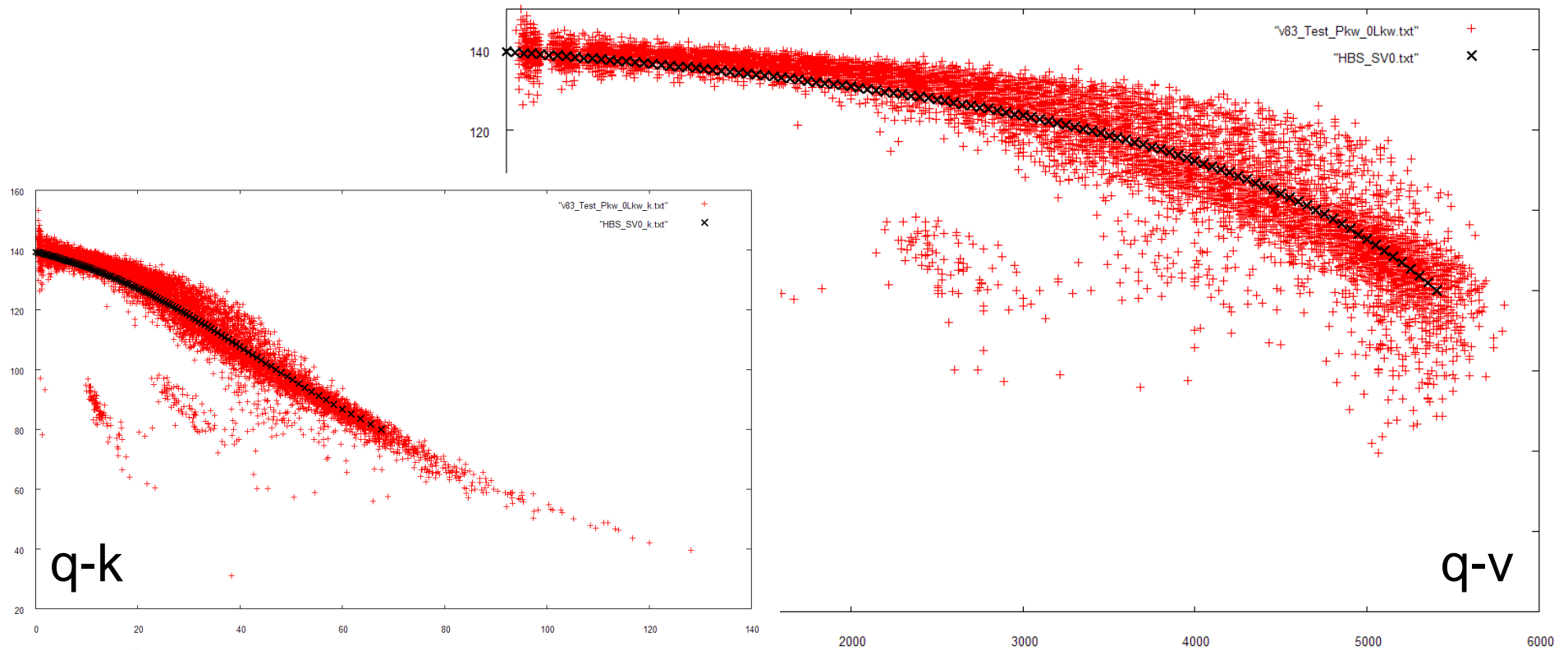


## Parameter of following



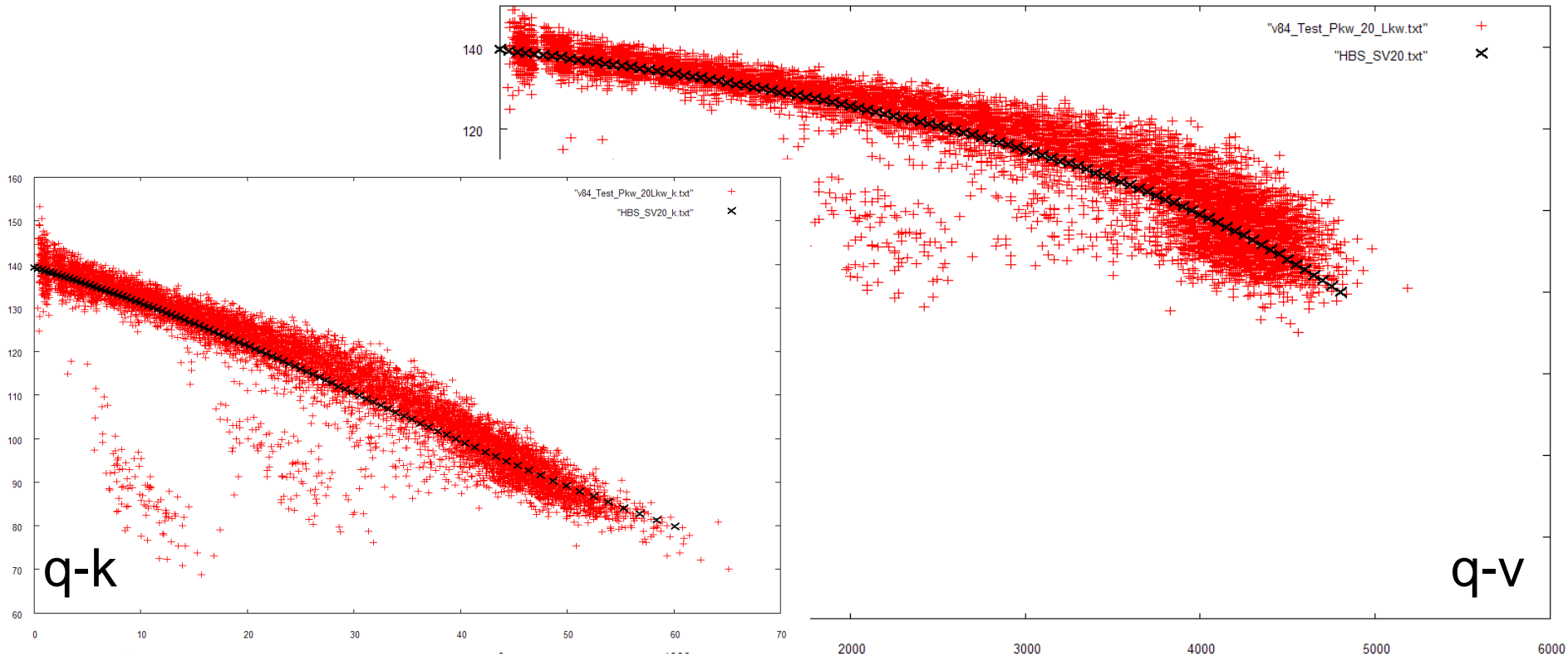


# Calibration Process: No trucks





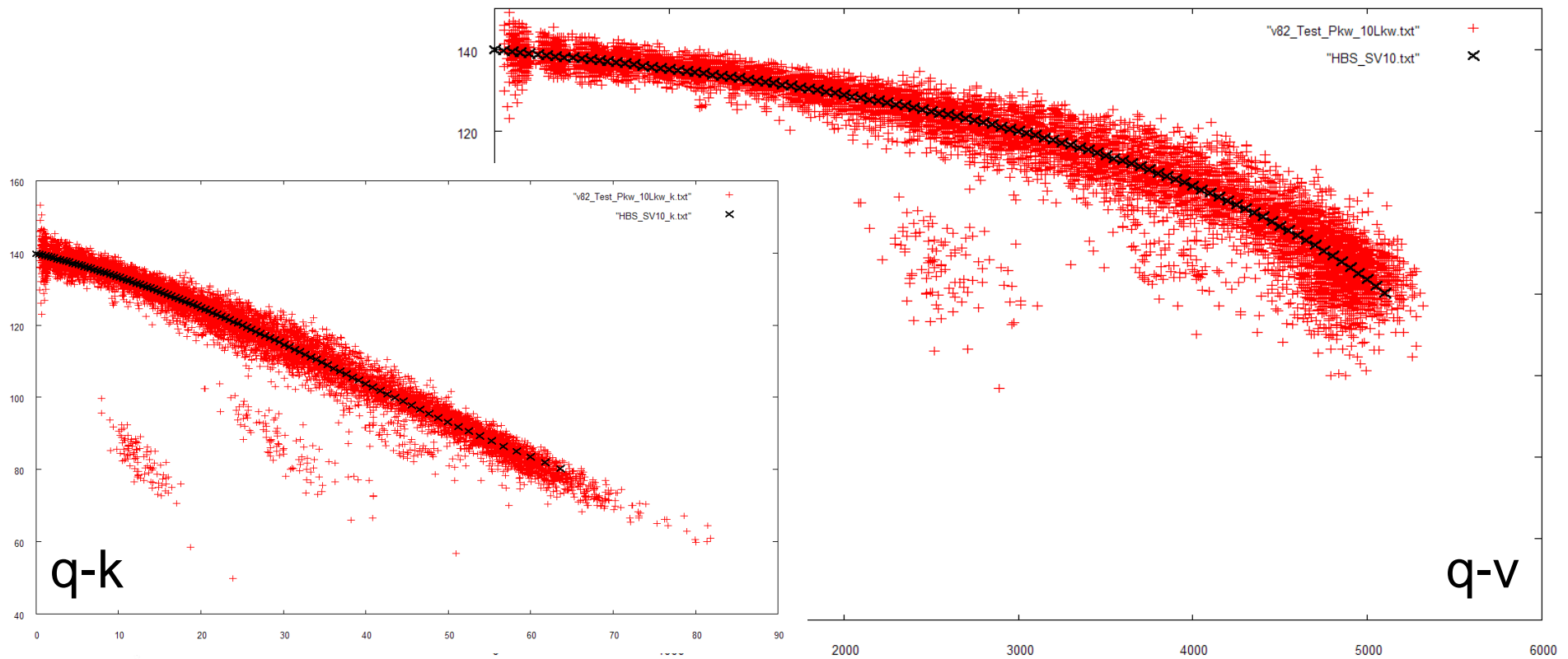
# Calibration Process: 20% trucks







# Calibration Process: 10 % trucks for validation





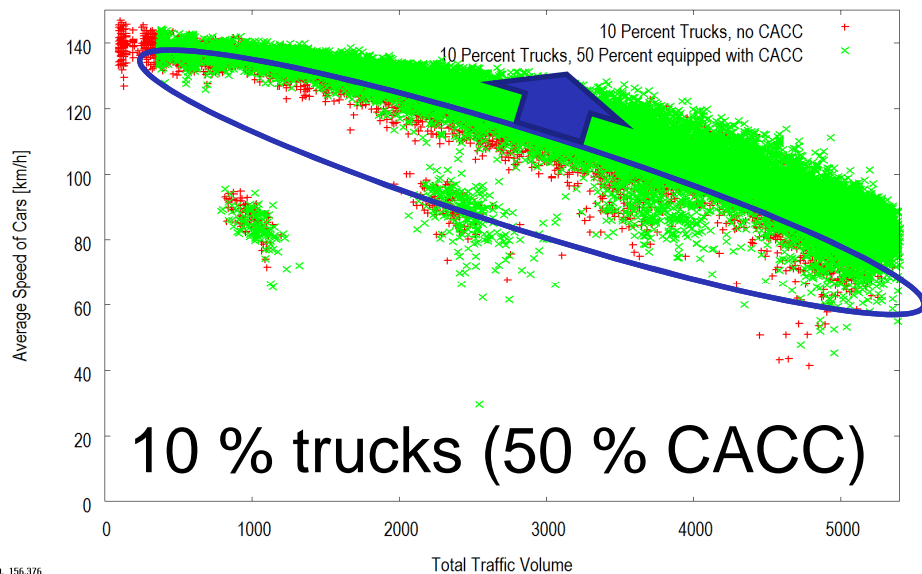
# Impact of CACC on the capacity **Results**



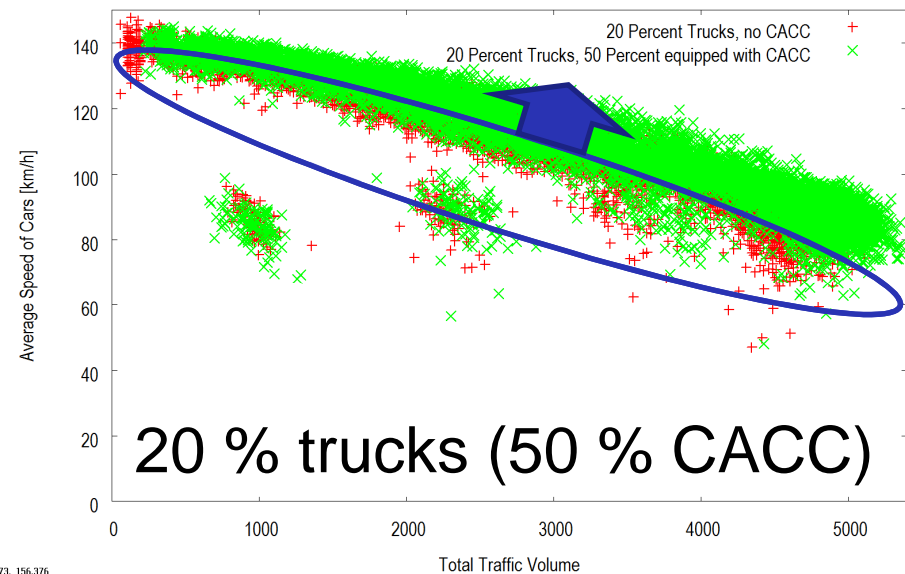
## Results of the simulation

➤ Effects on Traffic Flow with 50 % CACC-equipped Trucks

➡ *CACC has a significant effect on traffic flow*



2366.60, 156.376

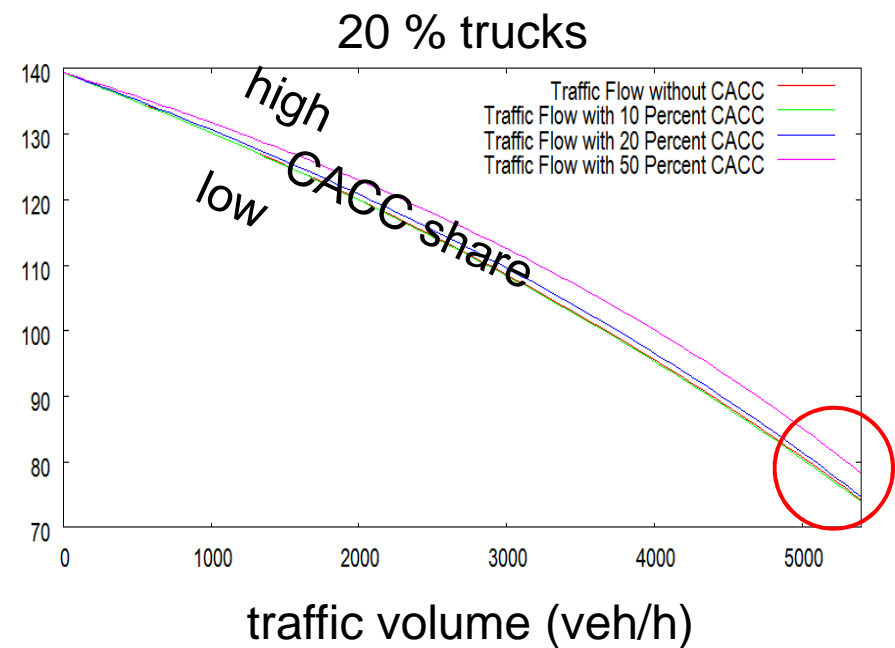
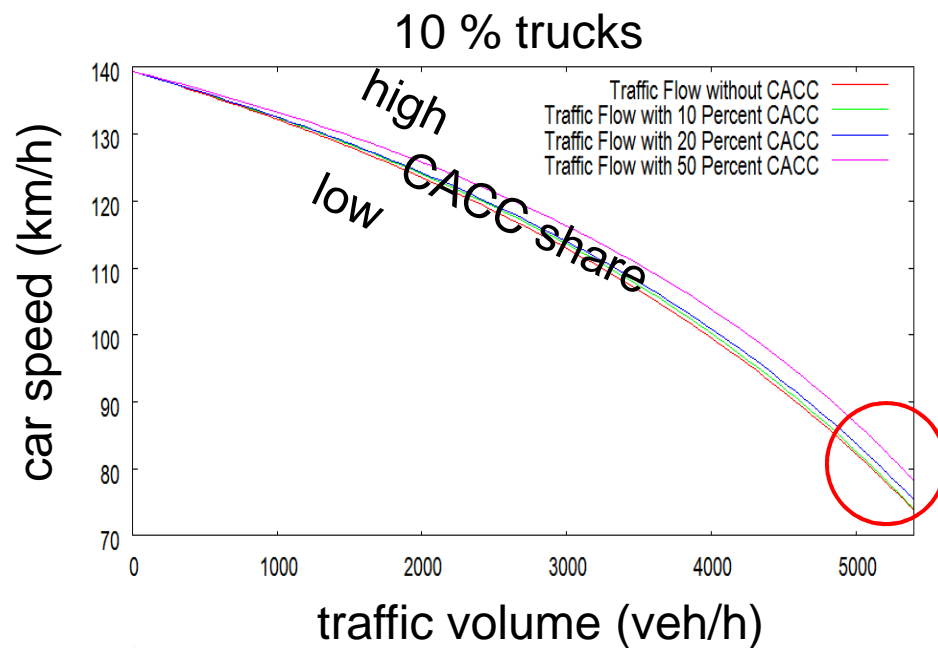


711.073, 156.376



## 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
  - Safetywe 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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