

# 2012 Road Vehicle Automation Workshop

## KONVOI and interactive *Truck Platooning and Crash Avoidance*

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# Agenda

- Motivation
- KONVOI project
- Results of the KONVOI project
- interactive project
- Summary

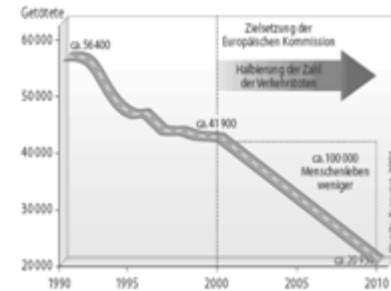
# Motivation

## Safety and Efficiency become “Mega Trends”

- New EU white paper to halve persons killed in traffic until 2020 after the goal for 2010 was not achieved
- New overall-rating of EURO-NCAP includes active safety criteria
- Conventional passive safety measures are in contrast to light weight design and CO<sub>2</sub> reduction
- Energy costs are expected to rise in the middle term
- Fuel consumption and emissions are facing further regulations and also monetary fees
- Sustainability and protection of the environment are highly important topics for politics and society
- Emissions gain crucial importance on mobility

### ▶ Regulation (EC) No 443/2009

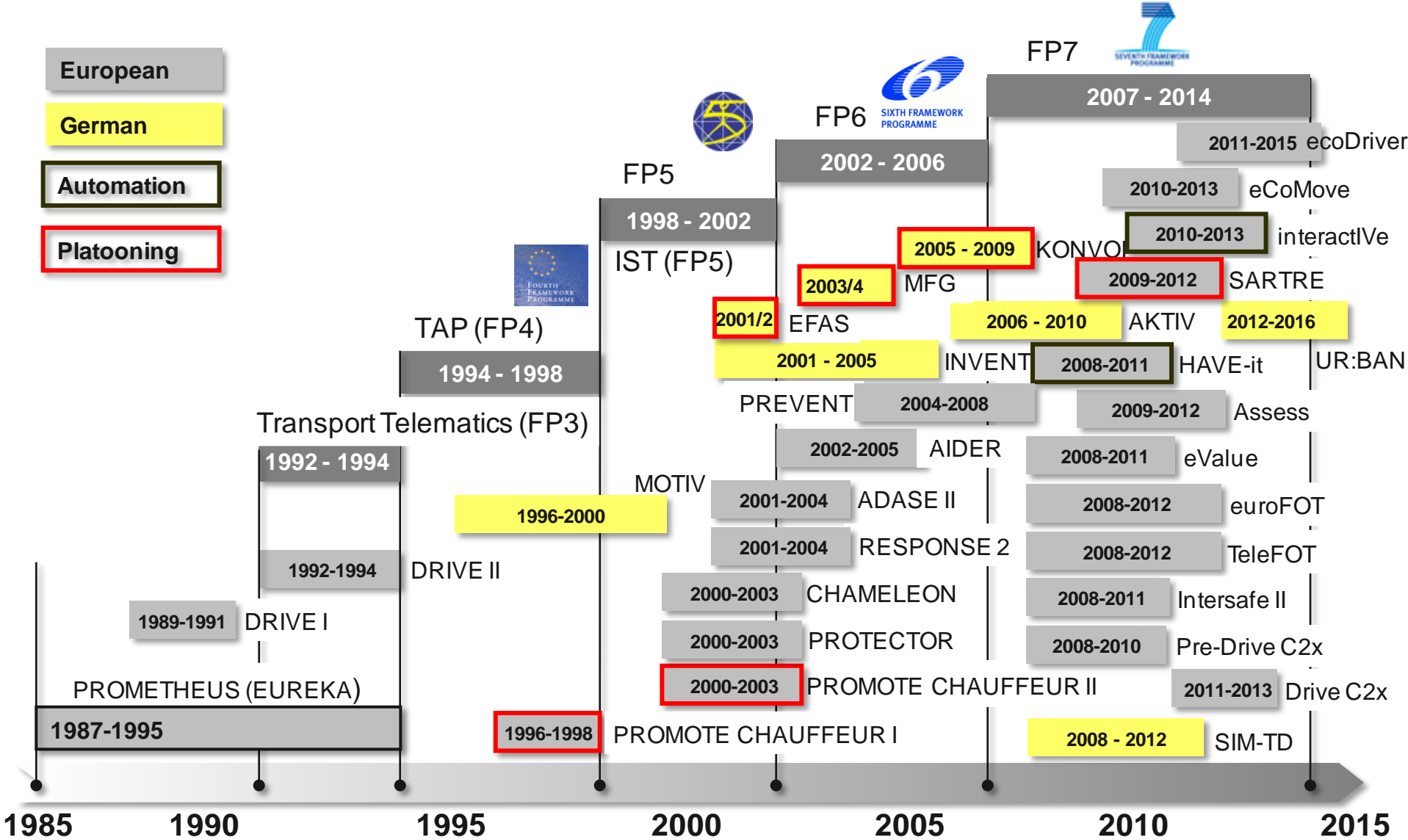
- 130 g/km CO<sub>2</sub>-Emission at 65 % of new vehicles until 2012
- 130 g/km CO<sub>2</sub>-Emission at 100 % of new vehicles until 2015
- 95 g/km CO<sub>2</sub>-Emission at 100 % of new vehicles until 2020
- ECO-Innovations can be considered with up to 7 g/km



# Motivation

## Selected EU Research on Safety and Efficiency

- European
- German
- Automation
- Platooning



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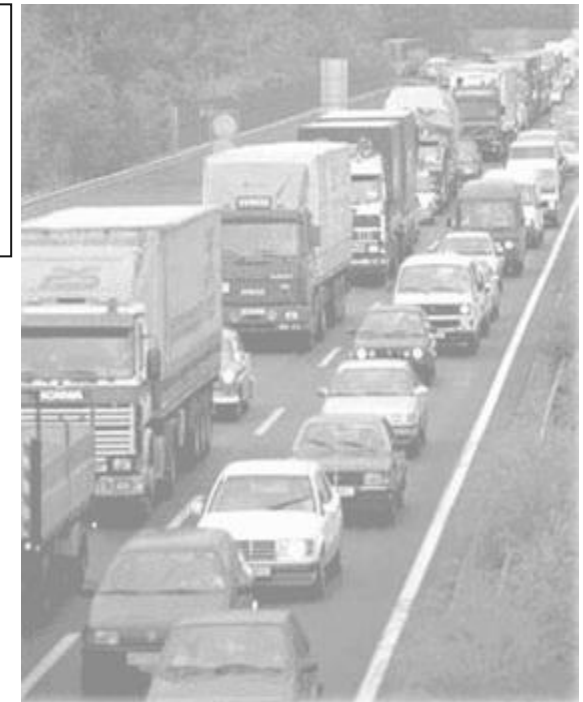
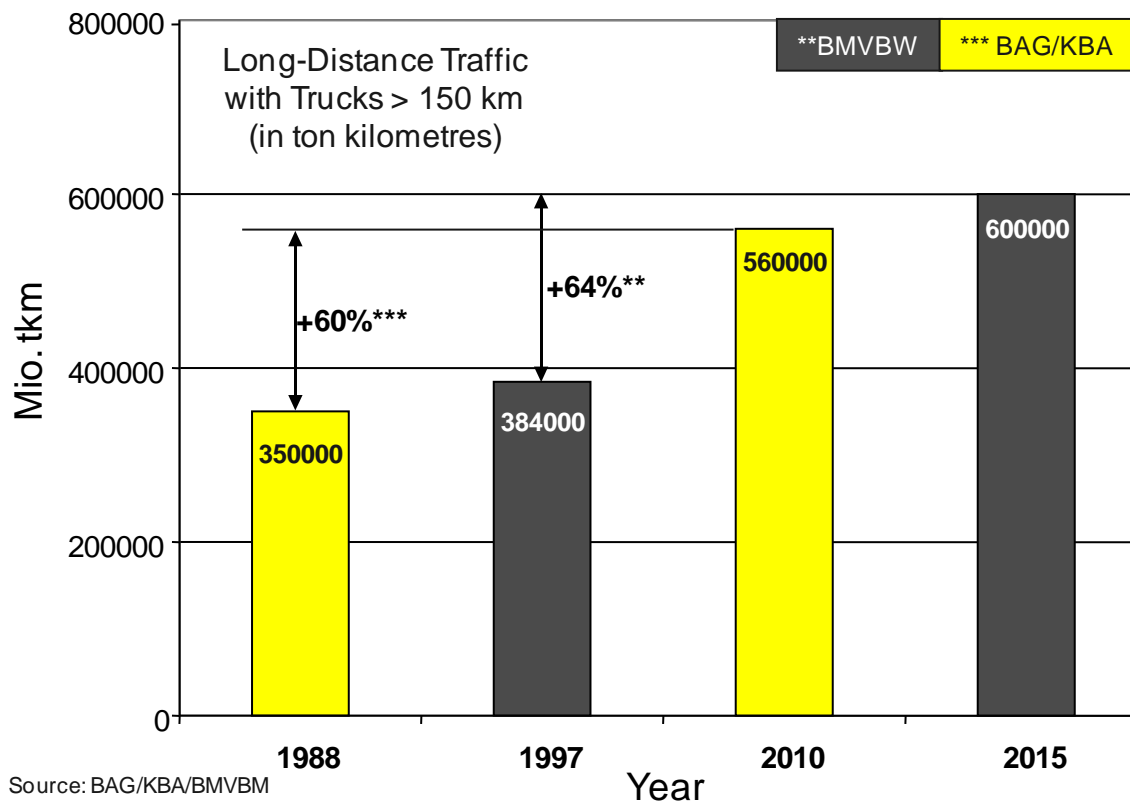
# KONVOI

## Traffic Situation in Germany

Traffic Report 2000 (BMVBM)\*

\*(Forecast until 2015, Basis 1997)

- Individual traffic increases about 20%
- Goods traffic increases about 64% up to 600 billion tkm



### ▶ Conclusion

Appropriate solutions  
needs to be developed  
in order to prevent a  
traffic collapse

# KONVOI

## Goals and General Framework



### ► Goal

Practical usage of truck platoons in road freight transport for verification of prognosticated effects (economy of road space, reduction of fuel consumption, ...)

### ► General framework

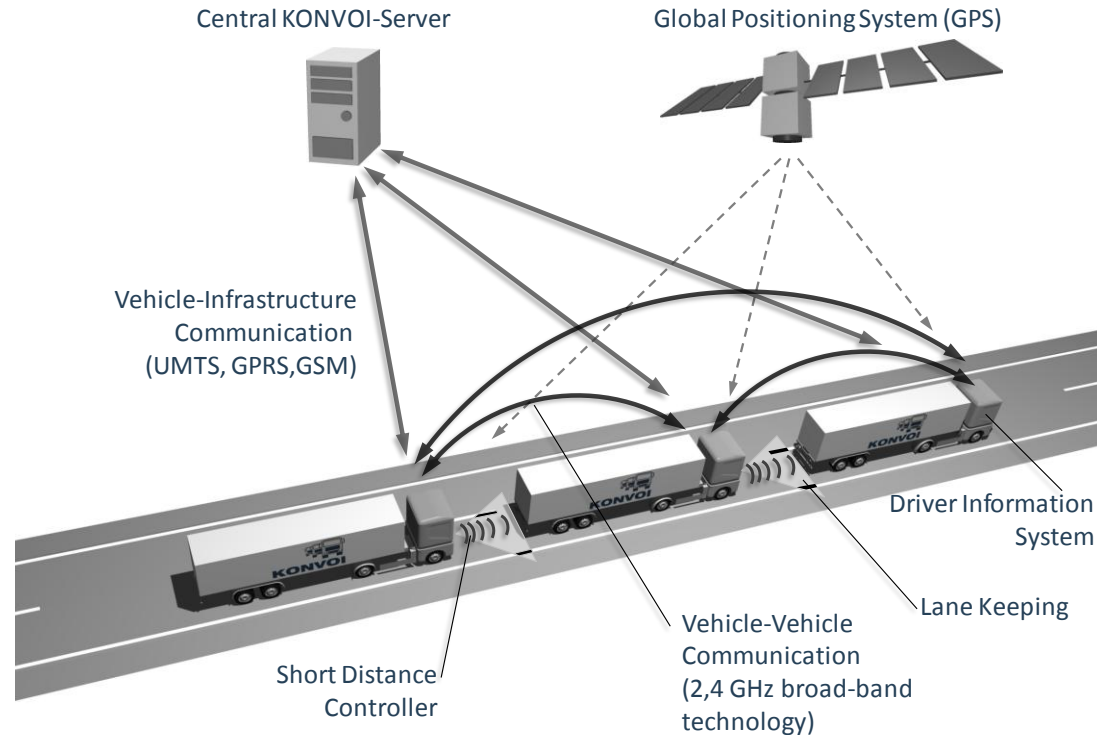
- Duration: 01.05.2005 - 31.05.2009
- Setup of 4 test trucks (1 x MAN, 1 x Wabco, 2 x ika)
- Consortium
  - Institutes of RWTH Aachen University
  - Vehicle manufacturers and suppliers
  - Highway patrol, district government of Cologne
  - Forwarding agencies as prototypical user

### Funded by



# KONVOI

## The KONVOI System



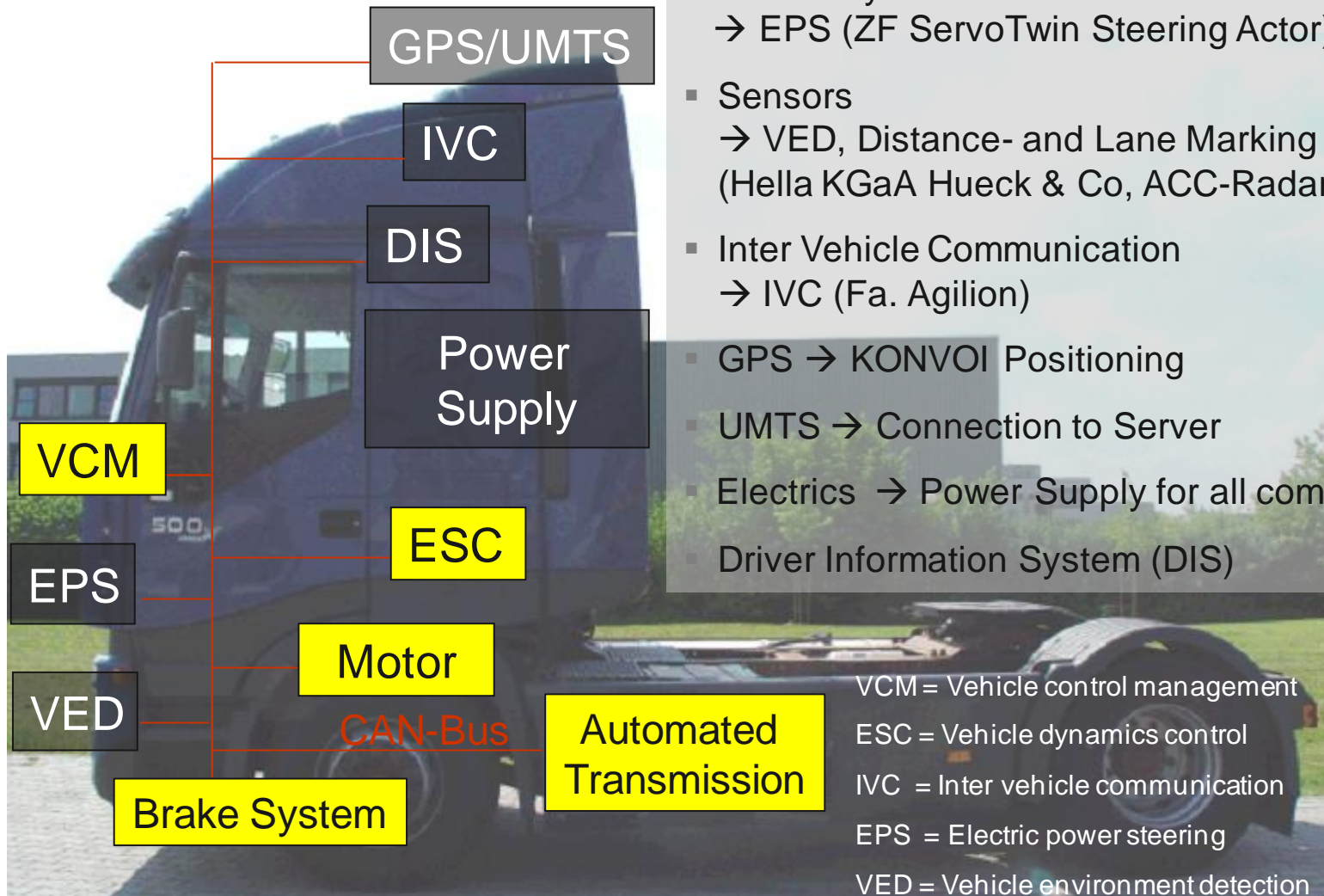
### ► Concept

- Electric platooning of up to 4 trucks with 10 m desired distance between trucks
- First truck in platoon driven manually (driver is supported by ACC and LDW)
- KONVOI system for longitudinal / lateral control for all following vehicles



# Necessary Vehicle Adaptation

## ika's Test Vehicles IVECO Stralis



- Lateral Dynamics  
→ EPS (ZF ServoTwin Steering Actor)
- Sensors  
→ VED, Distance- and Lane Marking Detection (Hella KGaA Hueck & Co, ACC-Radar Sensor)
- Inter Vehicle Communication  
→ IVC (Fa. Agilion)
- GPS → KONVOI Positioning
- UMTS → Connection to Server
- Electrics → Power Supply for all components
- Driver Information System (DIS)

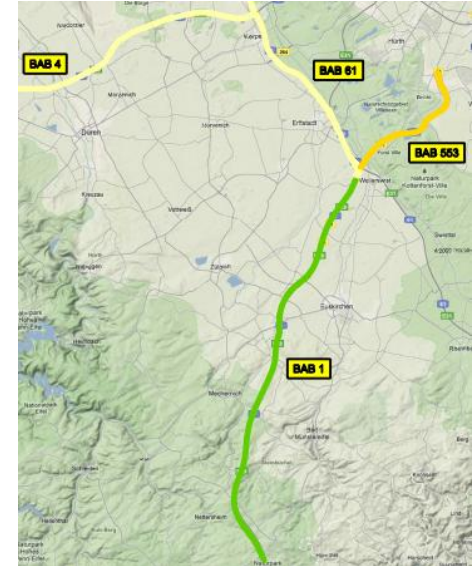
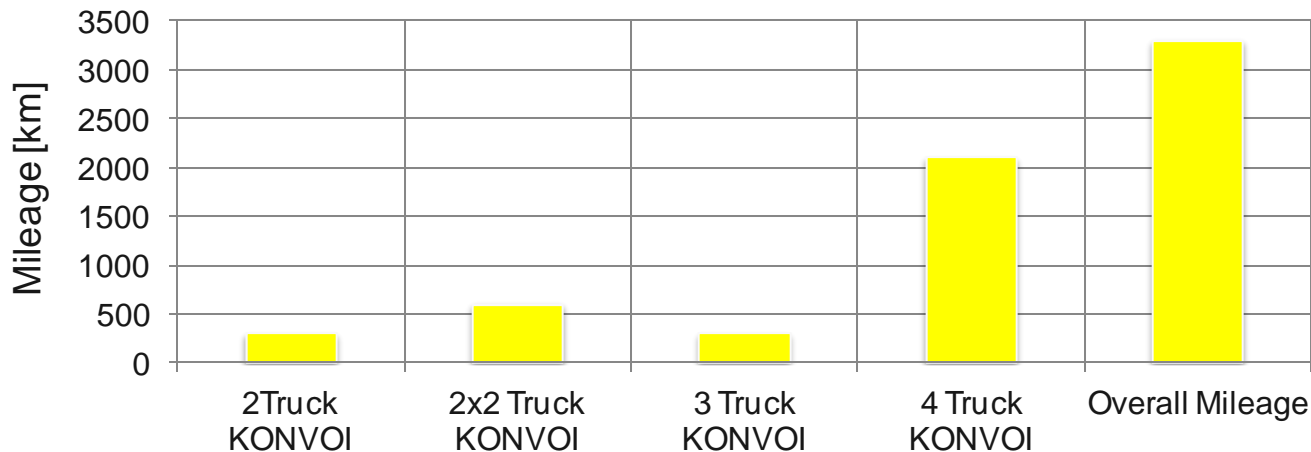
VCM = Vehicle control management  
 ESC = Vehicle dynamics control  
 IVC = Inter vehicle communication  
 EPS = Electric power steering  
 VED = Vehicle environment detection

# Real World Tests

## German Motorway



- System development and preliminary testing on closed test tracks and closed motorways under construction
- Final Tests on motorway BAB 1 in real world traffic
- Safety measures:
  - Vehicle driving 1 km before KONVOI platoon
  - Vehicle driving behind KONVOI platoon informing other vehicles of 100 m platoon length
  - Additional vehicle of motorway police following



# Maneuver Tests

## Video



clip26\_2.avi

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# KONVOI Results

## Longitudinal and Lateral Control



Driving maneuver:

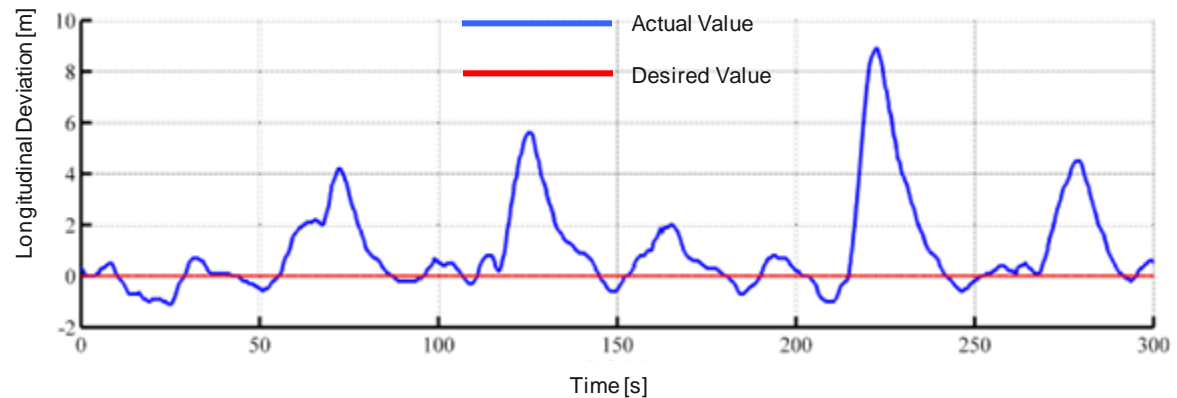
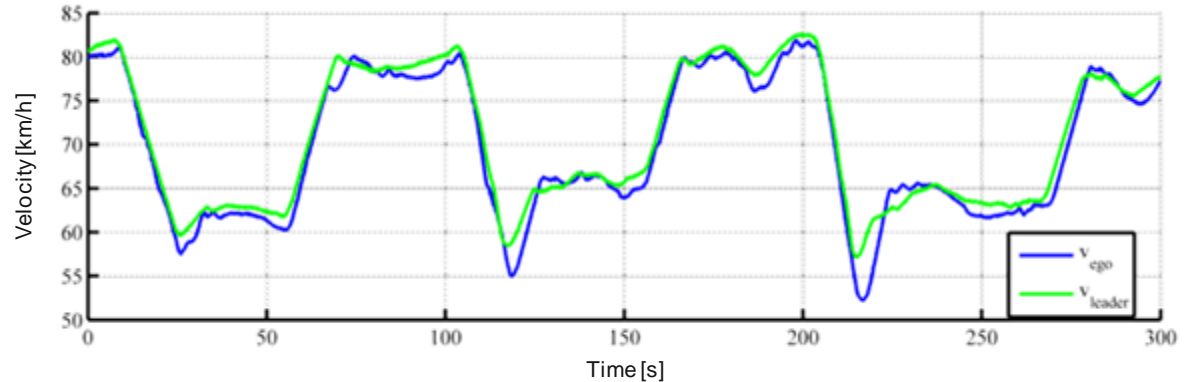
- Velocity changes of leading vehicle in platoon

Longitudinal Control

- Increase of distance at high accelerations by means of conservative control
- Increase of performance with next generation vehicle hardware possible

Lateral Control

- Lateral deviation up to 40 cm in curves



► Results

- Comfortable and safe driving in platoon
- No amplification of minor interference

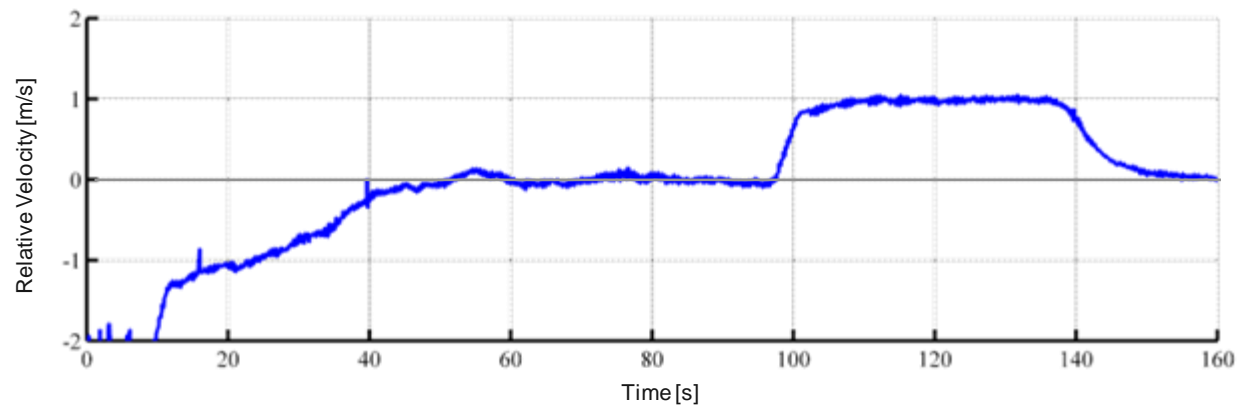
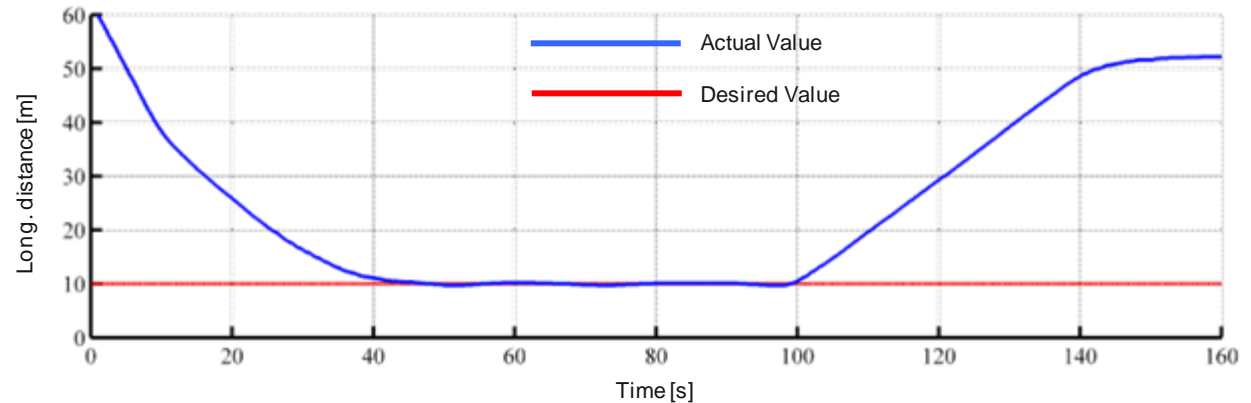
# KONVOI Results

## Platooning Control



Driving maneuver:

- Coupling
- Following
- De-Coupling



### ▶ Results

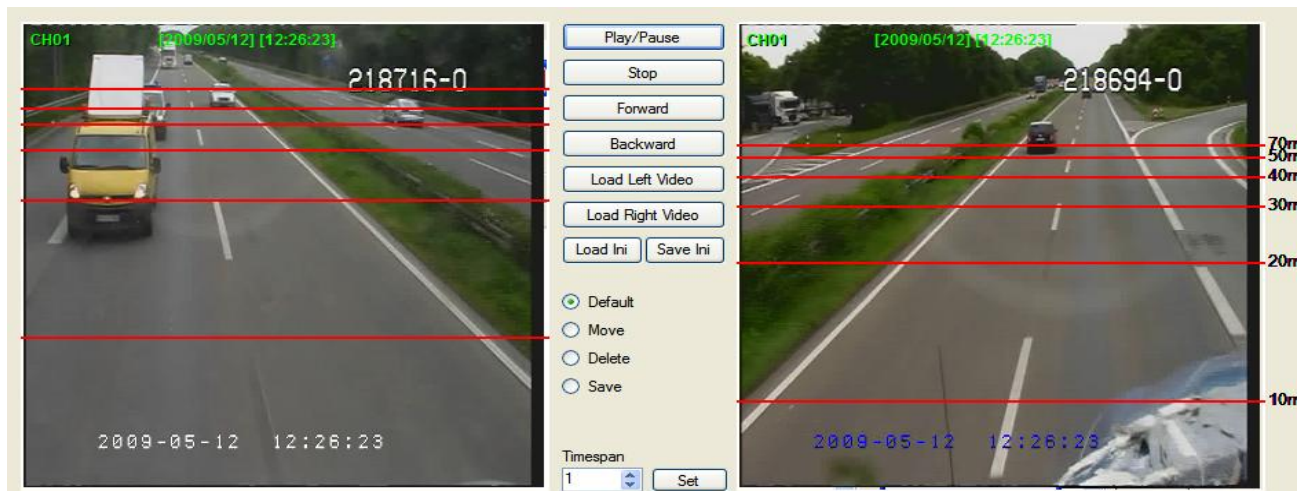
- Comfortable and safe driving in platoon
- No amplification of minor interference

# KONVOI Results

## Impact Assessment on Traffic



- Results based on test drives in real world traffic on German motorway
- Analysis and assessment of video data of all tests and comparison to reference scenarios without KONVOI system
  - Analysis of relative velocity between KONVOI and surrounding traffic
  - Analysis of up to 2400 overtaking maneuvers



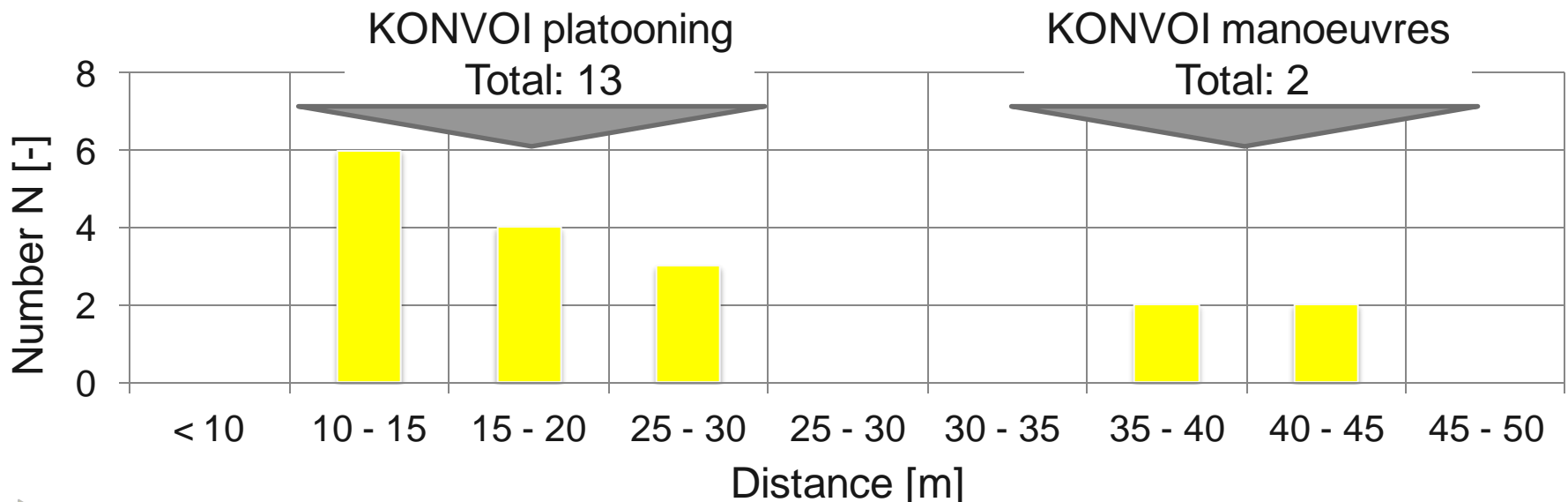
### Results

- No significant influence on surrounding traffic!

# KONVOI Results

## Impact Assessment on Traffic

- During KONVOI platooning a total of 13 other vehicles entered between KONVOI trucks at junction (distance of 10 to 25 m)
- During coupling and decoupling manoeuvres 2 other vehicles entered between KONVOI trucks at junction (distance of 35 to 45 m)



### Results

- Especially other truck driver expect friendly behaviour! KONVOI is not designed for this behaviour. "Platoon" signs not sufficient for general understanding.



# KONVOI Results

## Lessons Learned 1/2



- Acceptance
  - Population needs to be informed about KONVOI/Platoons
  - Clear platoon indication necessary
  - Positive results on questionnaires after system explanation
  - Most named advantage: efficient usage of motorway space
- Operation demand for driver
  - Simulator studies have proven that test persons are capable to drive in platoon
  - Driving distances are lower after 2 hours of platooning  
→ support in distance keeping recommended after platoon driving
  - No influence on lateral driving behavior
- Impact on Traffic
  - No significant influence on other traffic participants
  - Clear markings for junctions of advantage
  - Significant reduction of necessary space (e.g. for 4 truck KONVOI from 150 m to 100 m)
- Technology
  - Longitudinal and lateral control possible with available technology
  - Coupling and decoupling possible with available technology

# KONVOI Results

## Lessons Learned 2/2



- Legislation
  - KONVOI is in conflict with the Vienna Convention
  - KONVOI is not aligned with the German rules of the road
  - KONVOI is not aligned with German liability law
- Cost Benefit Analysis
  - Fuel consumption not focus of KONVOI project
  - Longitudinal control optimized for comfort and safety
  - Test drives on OEM test track in Dudenhofen/Rodgau with CC in first vehicle
  - Positive results for constant driving at a velocity of 80 km/h with 10 m distances
- Final comment from German motorway police
  - *“Insgesamt stellt sich das System dem Verkehrsteilnehmer als unspektakulär dar. Das Verkehrsverhalten ändert sich durch das System KONVOI aus Sicht der Begleitfahrzeuge nicht.”* (POK Thomas Fiala, Autobahnpolizei Köln)
  - *“Overall, the road user understands the system as unspectacular. The traffic behavior does not change by means of the KONVOI system from the perspective of the escort vehicles.”* (POK Thomas Fiala, Autobahnpolizei Köln)

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# interactIve Objectives

System intelligence

Low cost segment

Full collision  
avoidance | mitigation

More scenarios covered

Objectives interactIve

Sensor platform

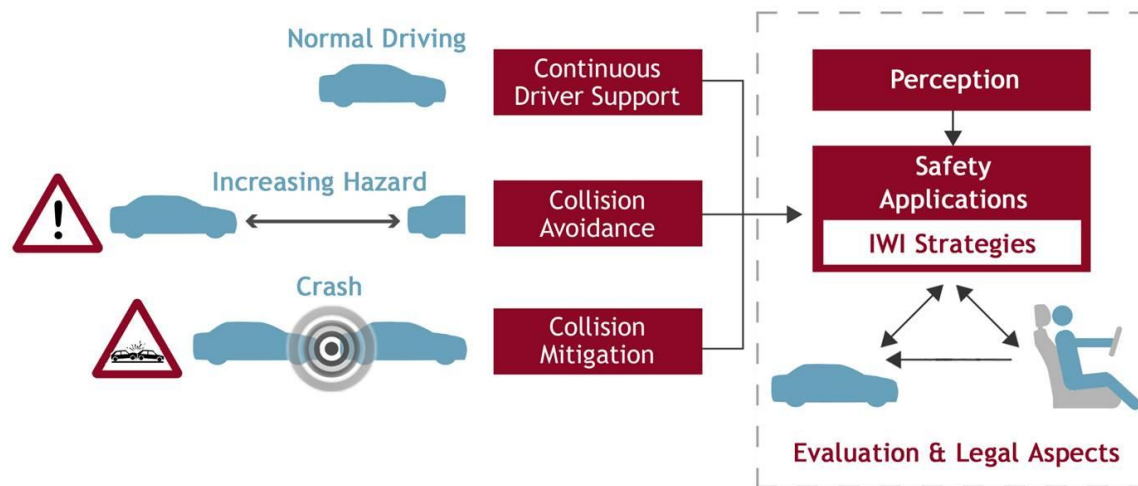
Decision strategies

Active interventions

Integration of functions

### The interactIVe vision: Accident-free traffic and active safety systems in all vehicles





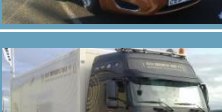


- **interactIVe**  facts:
  - Duration: 47 months (January 2010 – November 2013)
  - 29 partners of 10 countries
  - Budget: 30 Million € (Founding by the European Commission: 17 Million €)



# interactIve

## Demonstrators and Functions



Demonstrator vehicle		Continuous Support	Collision Avoidance	Collision Mitigation
BMW		enhanced Dynamic Pass Predictor		
Fiat		Continuous Support with focus on haptic HMI		
Ford		Continuous Support and automated driving	Collision avoidance (for rear-end, blind spot & run-off road conflicts)	
Volvo Car		Continuous Support and Safe Cruise	Collision avoidance (for lane change and run-off road conflicts)	
Volvo Truck			Collision avoidance (for rear-end, blind-spot & run-off road conflicts stability considerations for trucks)	
VW				Collision mitigation with focus on cost-efficient sensors and algorithm
Continental				Emergency steering assistance

# interactiVe

## Automation in interactiVe

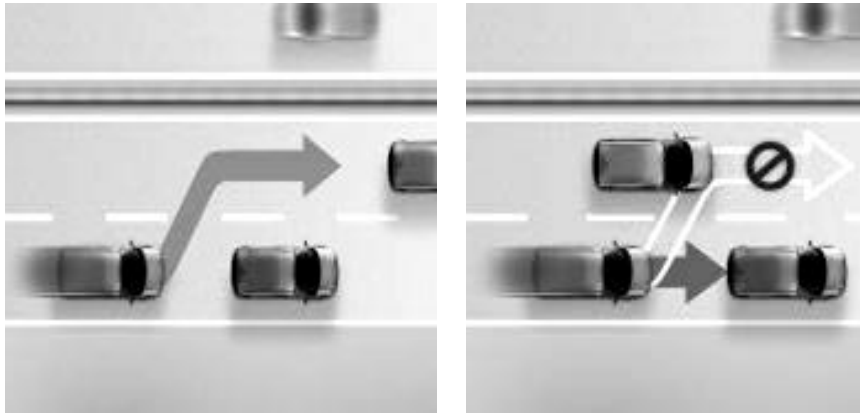
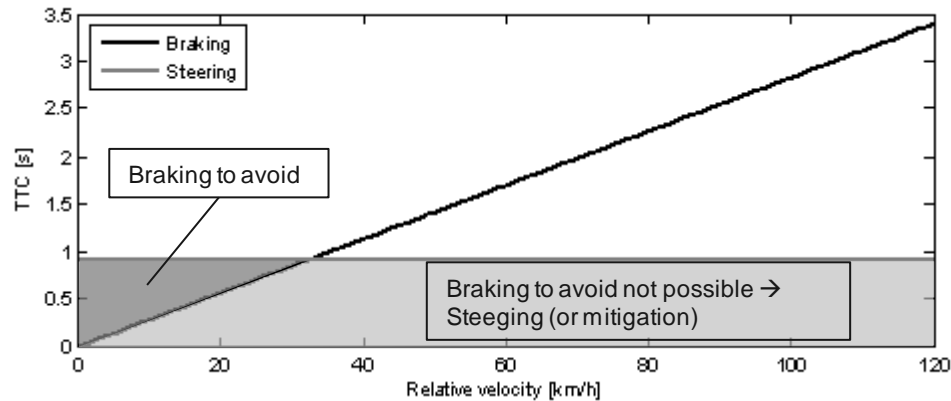
- Normal driving:
- Safe Cruise:
  - Autonomous following of front vehicle by means of longitudinal and lateral control
  - Possible to activate in vehicle speeds up to 130 km/h in extra urban traffic
  - Driver is observed in order to ensure his/her situational awareness



Source: motorvision.de

# interactIve

## Automation in interactIve



Emergency situations:

- RECA (Rear-end Collision Avoidance):
  - Collision avoidance by means of braking and steering depending on situation
  - Avoidance by Steering
    - Steering is more efficient is more efficient for higher velocities
    - Precondition must be fulfilled  
→ Check of driving direction of adjacent lane as well as other vehicles
  - Driver can overrule the function  
(→ Braking in order to mitigate)



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# Summary

- Road safety and vehicle efficiency become design dictum based on legislation, political development and consumer awareness
- Sensor and actuator technology for automated driving support is becoming available in modern vehicle
- Close to market research tries to provide continuous driver support
- Autonomous driving systems take over driving task in critical situations
- Complete autonomous driving in platoon is technical possible, but there are still issues to be solved
  - Legislation
  - Human Factors
  - Acceptance
- Research in these fields still necessary!



# Contact

Thank you  
for your attention!

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