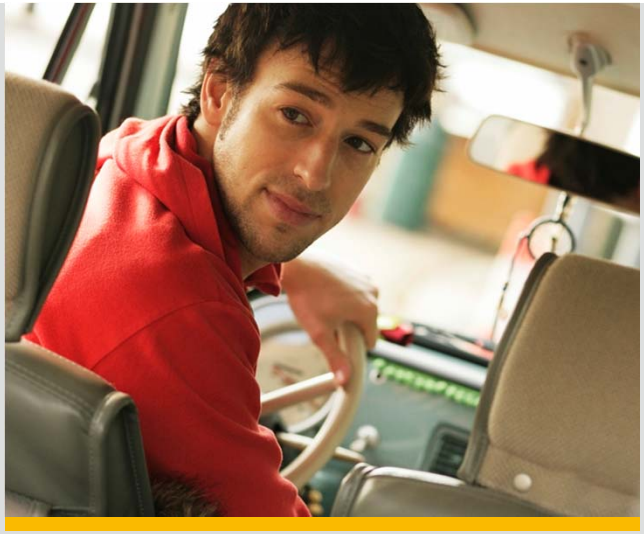
Traffic Management | Active Safety | Cooperative Cars



Measure, Adapt, and Manage – the AKTIV Approach on Driver Attention

Dietrich Manstetten (Robert Bosch GmbH)

Contributing Authors

Klaus-Peter Kuhn – Andreas Proettel – Ann Sokoll – Peter Frank (Daimler AG)

Stefan Mayer – Michael Schadeck (Audi Electronics Venture GmbH)

Daniel Heyes – Walter Schwertberger – Gunnar Tigges (MAN Nutzfahrzeuge AG)

Harald Berninger – Thomas Schramm (Adam Opel AG)

Stefan Lüke – Waldemar Schrinner (Continental Teves AG & Co. OHG)

Michael Dambier – Wolfgang Krautter (Robert Bosch GmbH)

Agenda

1. The research initiative AKTIV
2. Measuring the driver's attention –
   Driving parameters, operating behavior and interior cameras
3. Using the information on the driver's attention in prototypes –
   Adapting driver assistance systems and managing driver's attention
4. Outlook and summary

Agenda

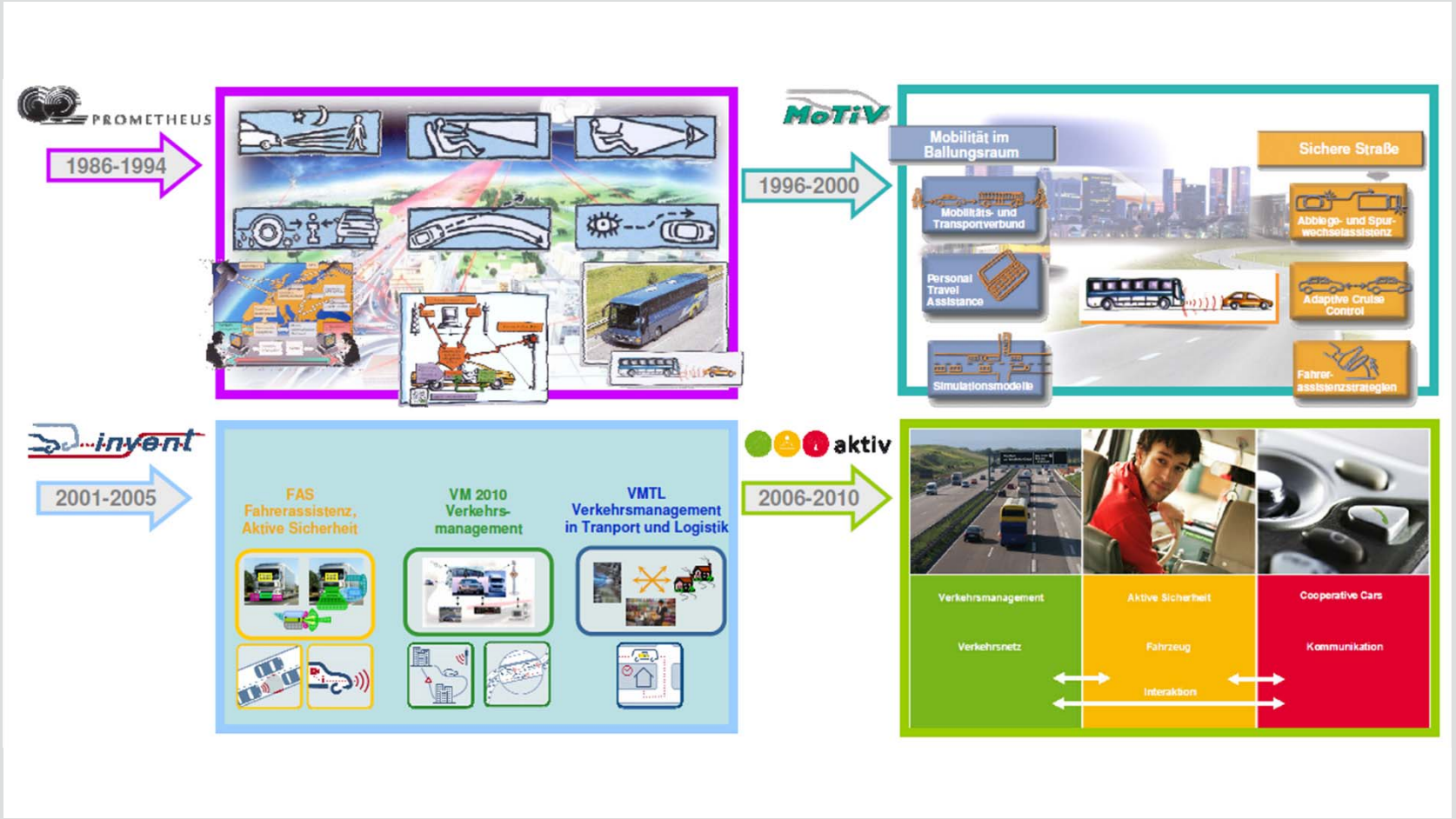
1 The research initiative AKTIV

2 Measuring the driver's attention –
Driving parameters, operating behavior and interior cameras

3 Using the information on the driver's attention in prototypes –
Adapting driver assistance systems and managing driver's attention

4 Outlook and summary

AKTIV – History of the Research Initiative



AKTIV – Cost, Funding

- AKTIV Adaptive and cooperative technologies for intelligent traffic
  (Adaptive und kooperative Technologien für den intelligenten Verkehr)
- Total Budget 60 Mio. €
- Duration 01.09.2006 – 31.12.2010
- Funding about 27 Mio. €
- Supported by the

- More information www.aktiv-online.org

AKTIV – Project Overview

Traffic Management

Traffic Network

Active Safety

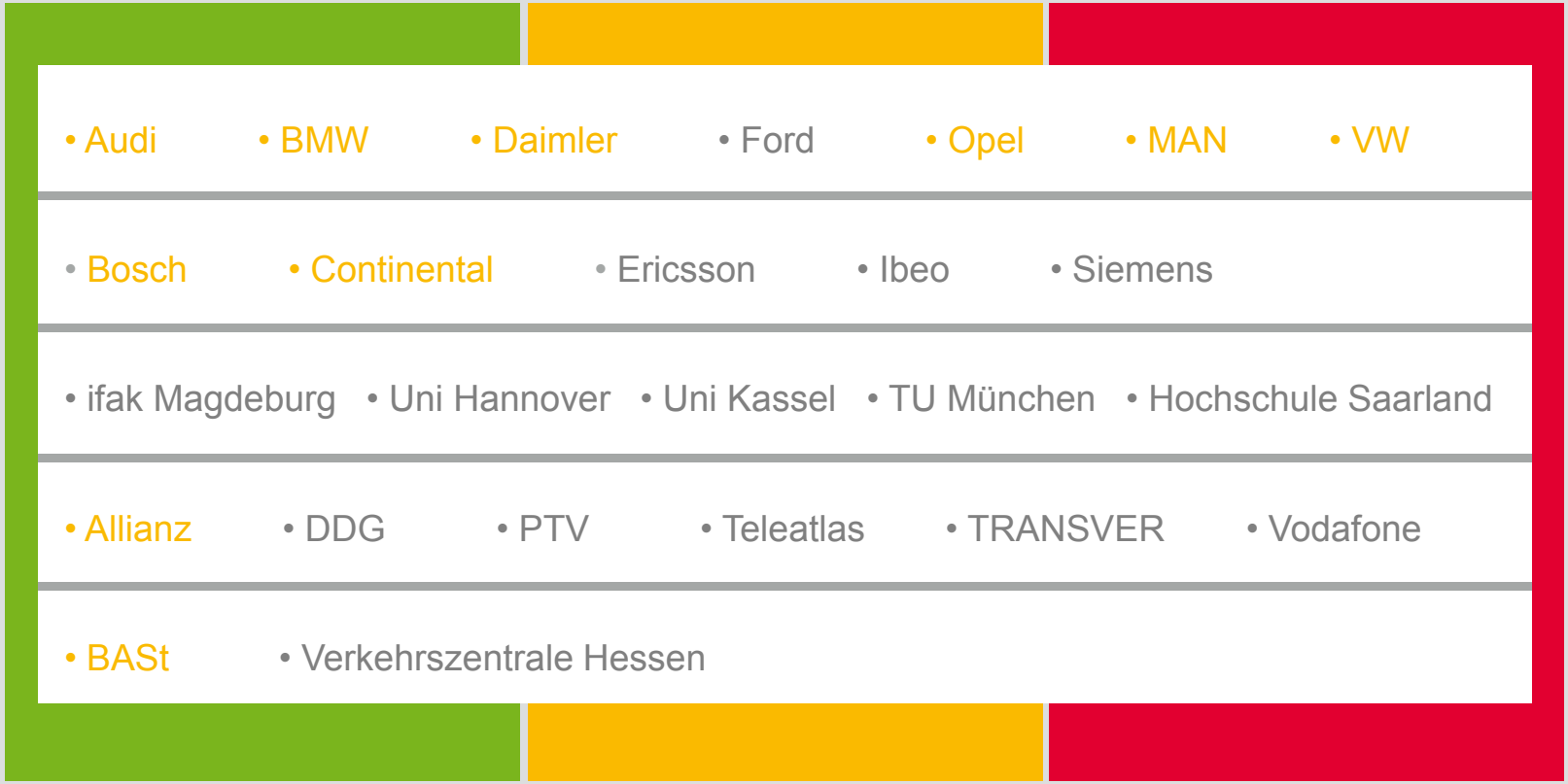
Vehicle

Cooperative Cars

Communication

Interaction

AKTIV – 24 partners



Development of assistance systems

- to increase traffic safety
- to reduce road traffic accidents
- to ease the driver‘s load
- to improve safety for vulnerable road users

- by holistic and robust perception of the driving environment
- considering the driver

AKTIV – Structure of Project Active Safety

Active Safety – AS

Dr. Ulrich Kreßel, Daimler

Active Hazard Braking	Integrated Lateral Assistance	Intersection Assistance	Pedestrian and Cyclist Safety
W. Schwertberger, MAN	S. Scholz, VW	Dr. G. Breuel, Daimler	S. Munder, Conti

Driver Awareness and Safety Dr. D. Manstetten, Bosch

Objective: Development of systems to avoid collisions and to reduce consequences of accidents by automatic braking adapted to the situation, earlier than existing emergency braking systems.

Base:

- High grade detection of the driving environment
- Accurate interpretation of the driving situation
- Plausible system decision adapted to situation

Concept:

Typically graduated warning and interfering concept
(warning > braking > full braking)
considering driver awareness and active
driver assistance to avoid accidents or
to reduce their consequences.
Single warning steps can be shortened or skipped,
if necessary.

Objective: Continuous lateral guidance over full speed range:

- during lane keeping in straights and curves
- by taking into account objects in the driving environment
- with high availability also in congested traffic and within construction zones

Base:
Detection of driving environment with high performance front oriented sensors as well as integration of high-precision digital maps and positioning.

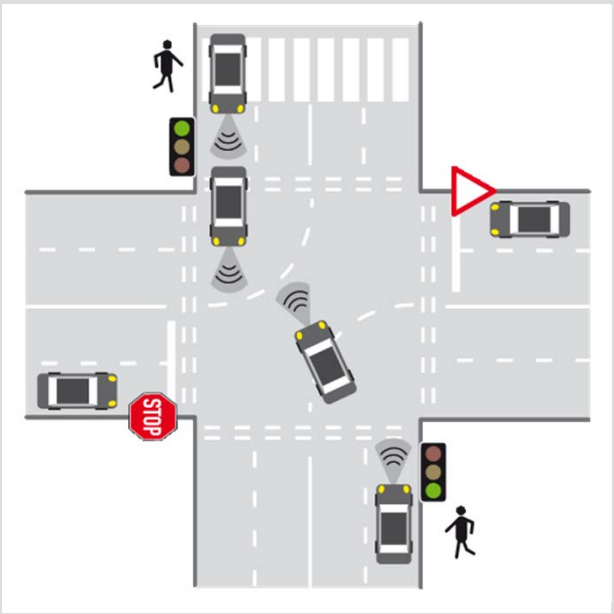
Objective: Enhancement of safety at intersections by avoiding driver failures and critical manoeuvres.

Support of the driver

- while crossing the intersection,
- during turning and entering,
- to keep the adequate distance to the preceding vehicle

Base:

Onboard sensing systems (radar, lidar, video), cooperative sensors such as V2V communication,
Integration of positioning and digital maps, comprehensive situation analysis



Objective: Enhancement of safety for vulnerable road users

Development of active means for protection:

- Driver warning (acoustic, optic and tactile)
- Warning the environment (horn)
- Active intervention in braking and steering
- Active protection mechanisms
  (e.g. reversible tilting hoods)

Big challenge for sensor systems (radar, lidar, video)

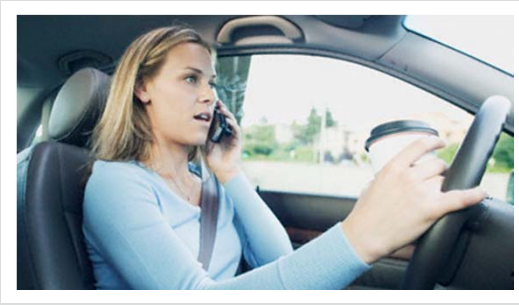
- High diversity of appearance in complex traffic environment
- High processing speed and robust environment detection
- Adaptive situation analysis

Development and test of strategies to avoid accidents and to soften impacts.

Horizontal project with the objectives of …

Monitoring driver attention
- by detection of driver behavior
- by detection of line of sight and position of head
- prototypic presentation and comparison

Consideration of attentional level for driver assistance systems
- integration of driver attention in warning and interfering concepts of the applications
- methods to enhance driver's attentional level



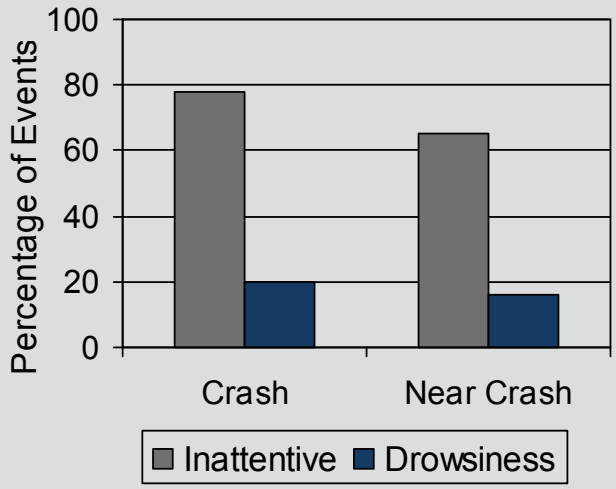
Test methods in the process of development
- development tools for testing sensor systems
- test methods for usability & controllability for driving simulator and field

General conditions and consequences of use
- long-term effects of assistance systems on traffic safety
- analysis of effects and benefits based on accident studies
- legal aspects regarding liability and introduction of assistance systems

Motivation: Inattention as a main accident cause

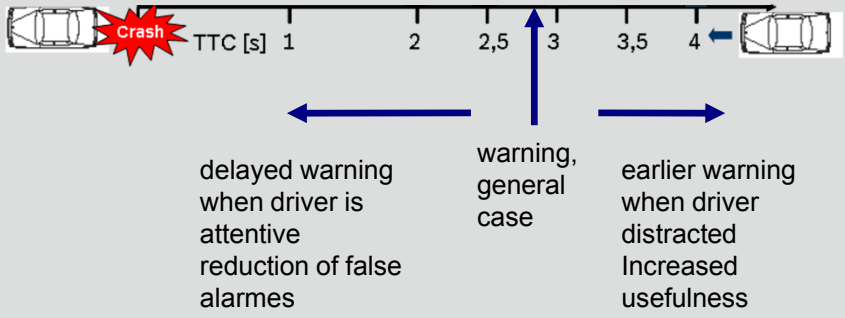
Result of 100 car-study (NHTSA, 2006): driver distraction or inattention involved at

- 78% of accidents
- 65% of near-accidents



Benefit of information about attentional level

- Feedback system
- Reduce warn dilemma by parameterization of Driver Assistance Systems (DAS)



Agenda

1 The research initiative AKTIV

2 Measuring the driver's attention –
Driving parameters, operating behavior and interior cameras

3 Using the information on the driver's attention in prototypes –
Adapting driver assistance systems and managing driver's attention

4 Outlook and summary

Principle approach within AKTIV

A driver has the correct attentional level to fulfill the primary driving if …

- he can perceive all visual and acoustic information relevant for the driving task
- he has the cognitive ressources to react in an appropriate way.

There is no direct measurement of the attentional level.

The approach in AKTIV is to assess the attentional level by behavioral analysis.

Measurement of driver attention

by driving parameters

by operational behavior

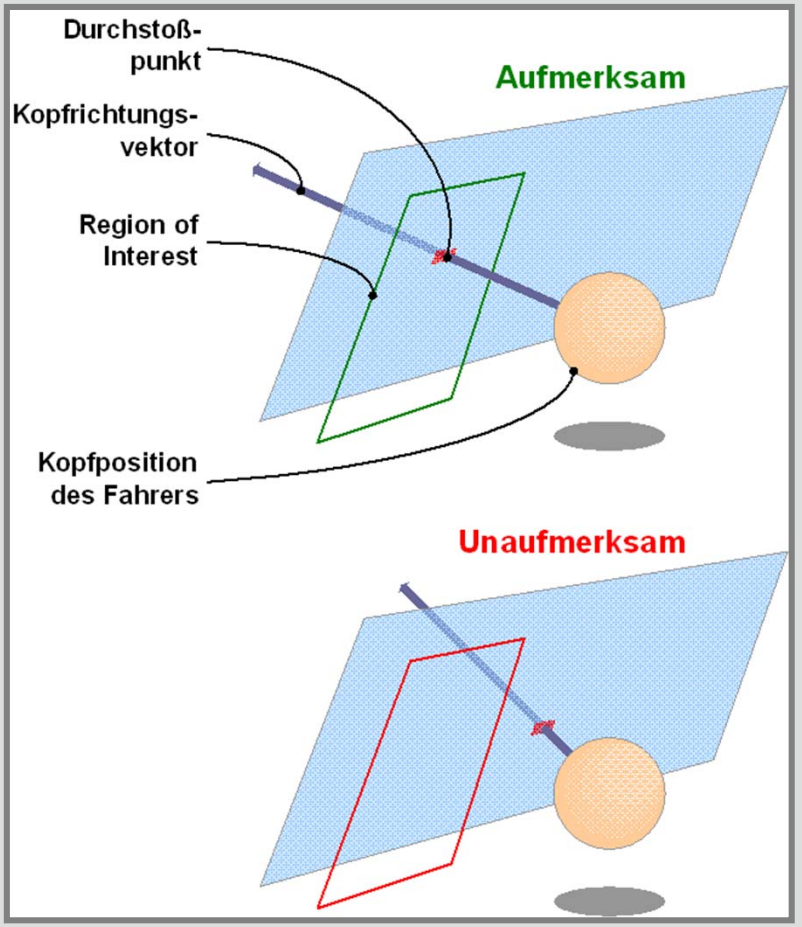
by interior camera

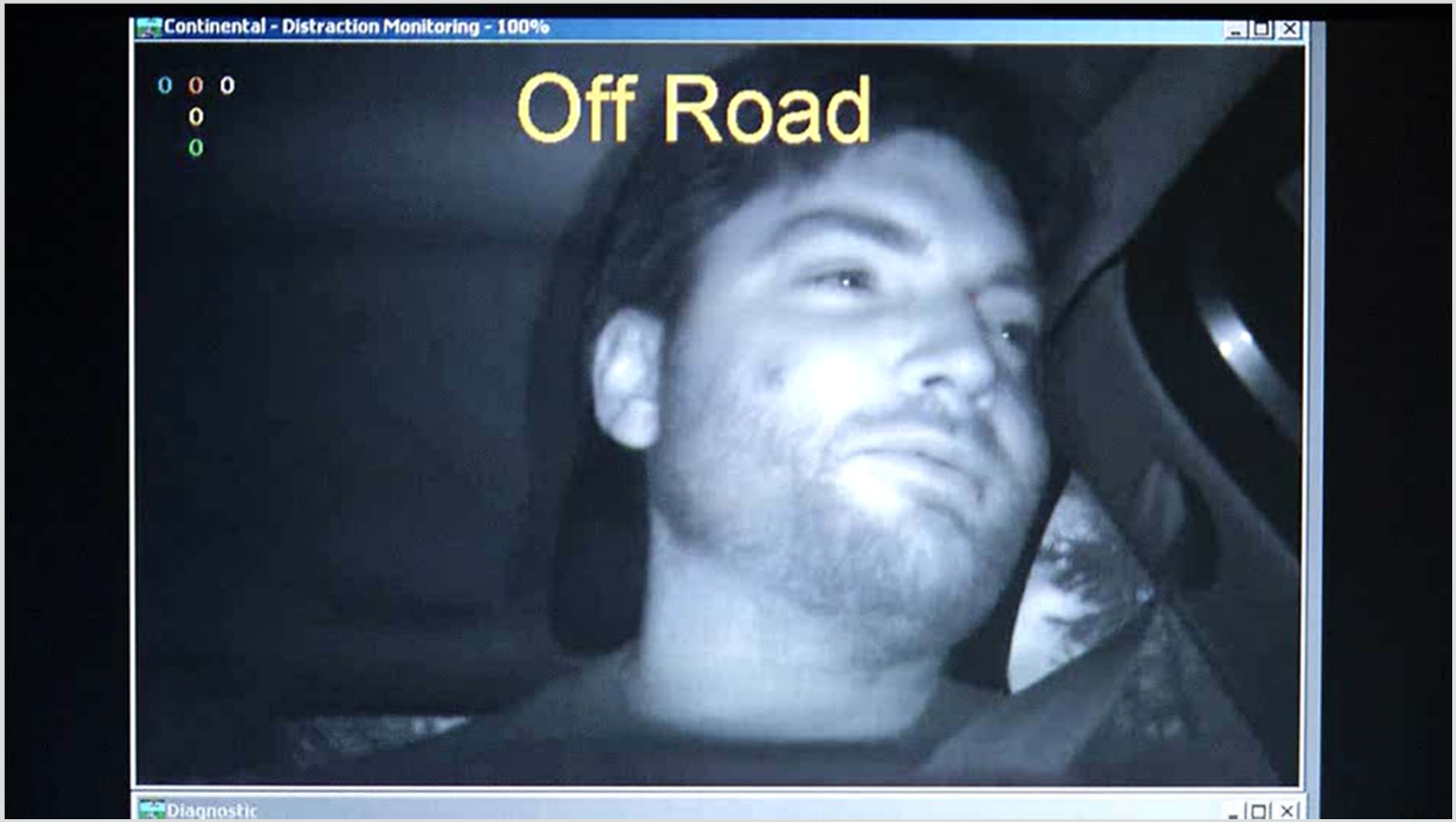
Head orientation and gaze direction to assess the driver‘s visual behavior

Use of different systems within AKTIV

- Seeing Machines DSS-R 3.0
- SmartEye AntiSleep and SmartEye Pro
- own camera modules (Continental)

Vehicle integration of cameras





Video Statement (German language with English subtitles)

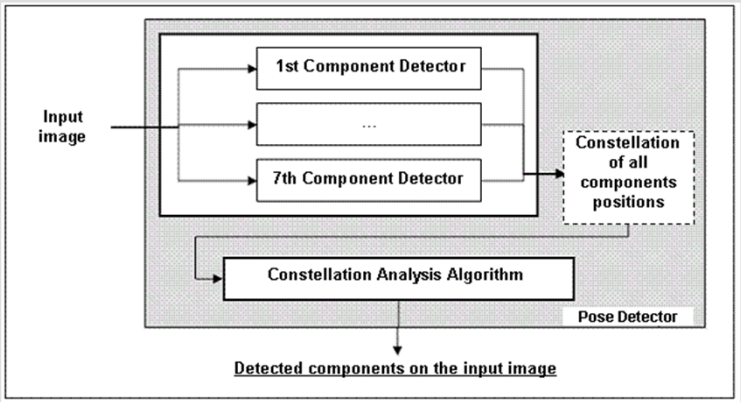
- "On road" poses (Not distracted)

Looking at IP (15°) | Leaning backward on head rest | Looking in front or central mirror (15°, 5°) | Roll rotations

- "Off road" poses (distracted))

Looking at right mirror (40°) | Looking at left mirror (25°) | Looking through left window (90°) | Looking through right window (90°) | Looking at gloves box (20°, 15°)

Decision criterias



DDS basic pose detector

System description

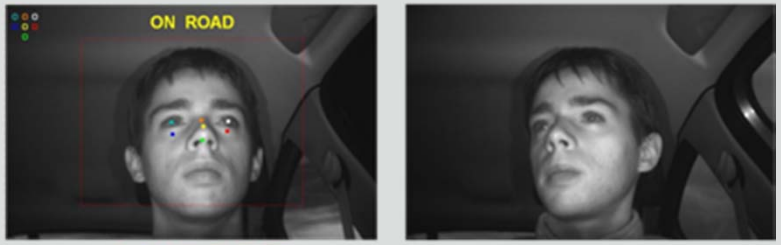
CMOS mono-camera system

Integration of camera and near-infrared LEDs

Search for components in driver's face

- right eye
- left eye
- nose bridge
- whole nose
- nostrils

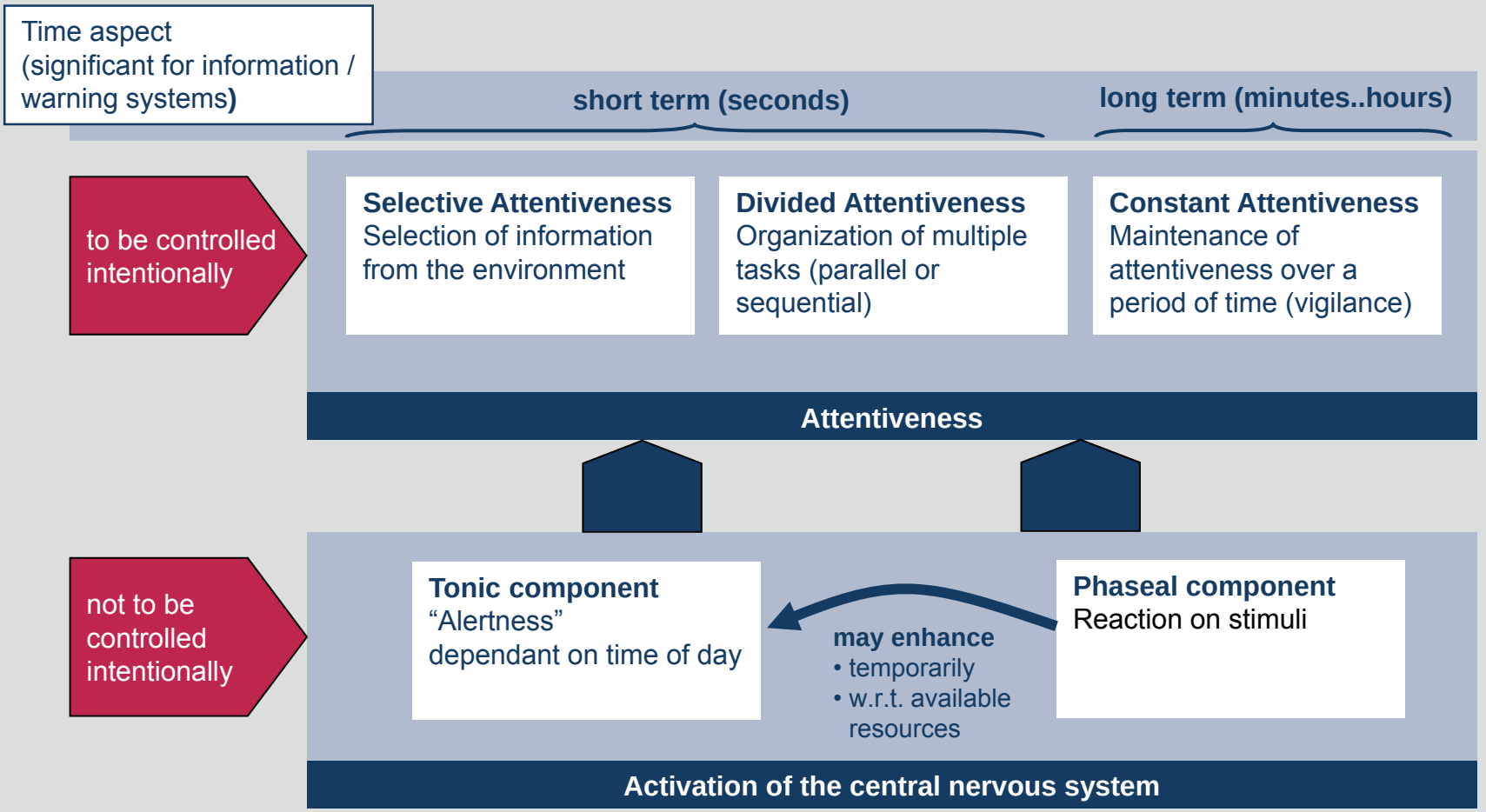
On-road classification within 25° (hor.) / 12° (vert.)



ON ROAD | OFF ROAD

Use „on-road“ value when occultations are detected to avoid false alarms

Driving Parameters – Physiological Model



Source: Würzburg University

Driving Parameters – Literature Overview

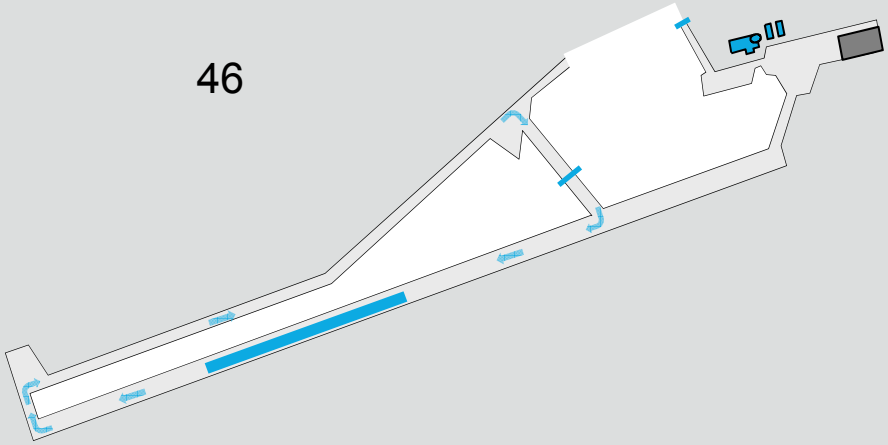
Parametergruppe	Parameter	Time on Task	kognitive Ablenkung	visuelle Ablenkung	unsichere Situationen	komplexe Situationen	unkontrollierbare Situationen	Zeitdruck
Längsregulation	Abstand	0	+	+	+			-
	v_mean	0	0	-	-	-		
	v_sd	+	+	+		+		
Querregulation	SDLP	+	0 (-)	+	+	0		0
	n Spurübertretungen	+		0				
	t Spurübertretung	+		0				
	Spurposition_mean	0	0	0		+		-
	t innerhalb Spur			0				
Lenkverhalten	Lenkfrequenz		0	+		0		
	Lenkfrequenz_sd	+				+		
	Lenkgeschwindigkeit	0						+
	Lenkgeschwin._sd	+						+
	SWRR	-	0	+				
	Steering Entropy		+	+				
	N große Korrekturen	+		+				
	N kleine Korrekturen	-						
	N schnelle Lenkbewegungen	+-	0	+				
Kohärenzmaße	Güte des Folgeverhaltens		-	-				
RT auf kritische Ereignisse	Bremsreaktionszeiten		+	+				
	RT in PDT	+	+	+	+			
	RT in VA	0						
	% vermiedene Koll					0		
N Fahrfehlern			0	+	+	+		
Risikoverhalten	Anzahl Spurwechsel	-	-		-			
	Aggressives Verhalten						+	+
	Regelverstöße		+				+	

Driving parameters and their relation to attentional level (studies from literature)

Source: Würzburg University

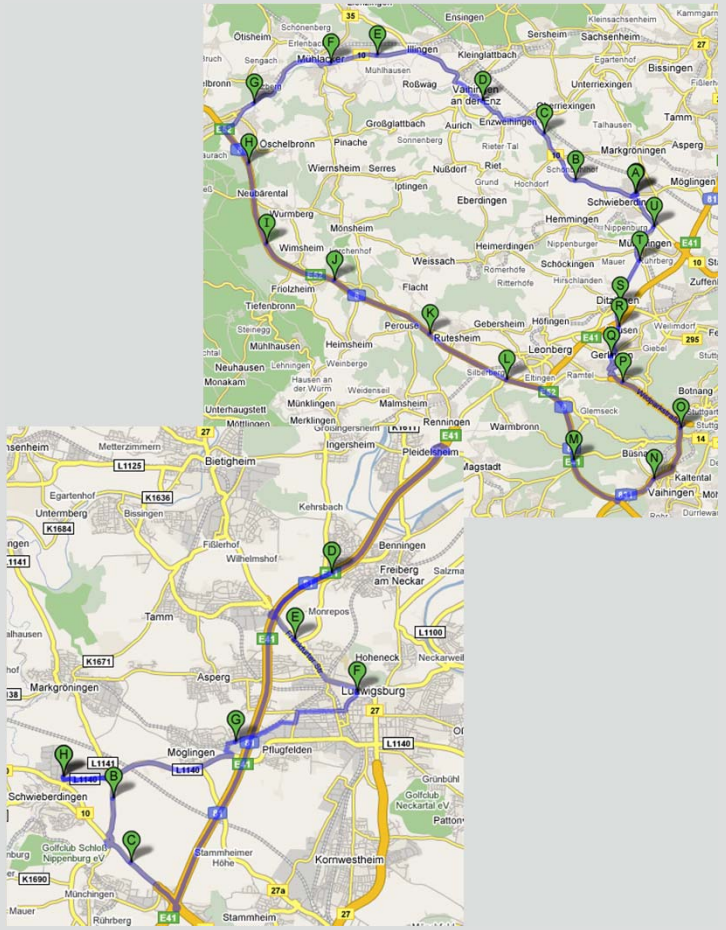
Get more Empirical Data – Drowsiness

road:	width 3,5m length of lap 1,9 km
duration:	3h
stimuli:	predictable
driving task:	maintaining a speed of 50 km/h
	driving according to their habits no conversation
subjects:	46

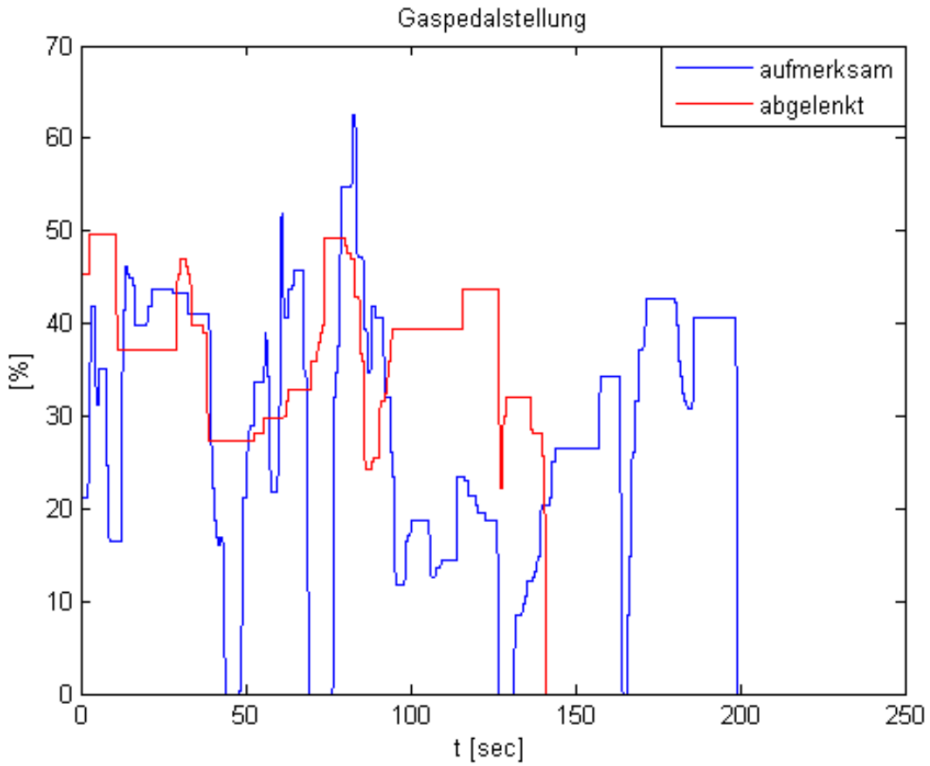


… more Data – Driving with Secondary Tasks

- Road trial 1: induce distraction by fixed secondary tasks
  - Length 92km, mixed roads
  - 16 subjects
  - 20 secondary tasks on DIS
- Road trial 2: check for self-induced secondary tasks
  - Length 41km, mixed roads
  - 33 subjects
  - secondary tasks: self determined



Analyze Individual Features in Driving Data

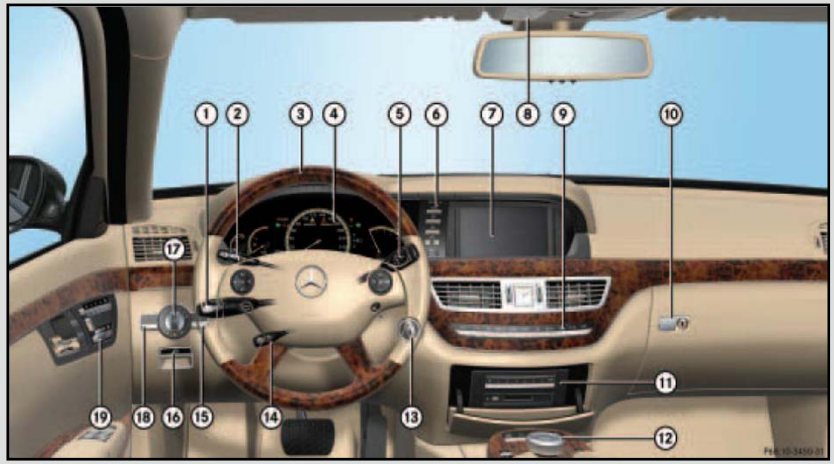


Typical example of plateaus in throttle position (blue=attentive, red=distracted)

Additional Approaches via Machine Learning

Features for machine learning approach (Random Forests, Decision Trees)

- velocity
- acceleration pedal
- pedal plateau sum
- pedal prediction error
- steering angle
- steering velocity
- steering deadband
- steering prediction error
- steering gap
- std of steering angle
- yaw rate
- offset left
- offset right
- tlc left
- tlc right
- tlc event
- steering angle zero crossings
- lane change index
- turn index
- Features of Torkkola
  - distToLeftLaneEdge_rd5_ra9
  - steeringWheel_rv9
  - stat3_of_steeringWheel_accel
  - steeringWheel_ent15_ra9
  - distToLeftLaneEdge_rv9
  - crossLaneVelocity_rv9
  - stat3_of_crossLaneVelocity_distToLeftLaneEdge
  - steeringWheel_rd5_ra9
  - accelerator_ent15_ra9
  - accelerator_rv9
  - accelerator_rd5_ra9



	Funktion	Seite
1	Kombischalter	
	• Fernlicht	275
	• Blinken	283
	• Scheibenwischer	279
2	TEMPOMAT-Hebel	
	• TEMPOMAT	296
	• Variable SPEEDTRONIC	316
	• DISTRONIC*	299
	• DISTRONIC PLUS*	306
3	Multifunktions-Lenkrad	231
4	Kombi-Instrument	294
5	Wählhebel	286

	Funktion	Seite
6	**Bedienfeld mit Tasten bzw. Reglern für**	
	Fahrzeugniveau	319 321
	ESP®	51
	PARKTRONIC-System*/ Parkassistent*	322
	COMAND-Display schwenken	57
	Helligkeit COMAND-Display/Kombi-Instrument einstellen	294
7	COMAND-Display	57
8	Dach-Bedieneinheit	277
9	Klimatisierungsautomatik	334
	Mittelkonsole oben	14

	Funktion	Seite
10	Handschuhfach verriegeln	364
11	CD- und DVD-Player/-Wechsler*	75
12	Mittelkonsole unten	15
13	Zündschloss/ KEYLESS-GO*-Taste	253
14	Lenkrad einstellen	264
	Lenkradheizung*	264
15	Scheinwerfer-Reinigungs-anlage*	275
16	Elektrische Feststellbremse	284
17	Lichtschalter	273
18	Nachtsichtassistent*	332
19	Tür-Bedieneinheit	20

Easy in-vehicle access to numerous operating elements – what do they mean ?

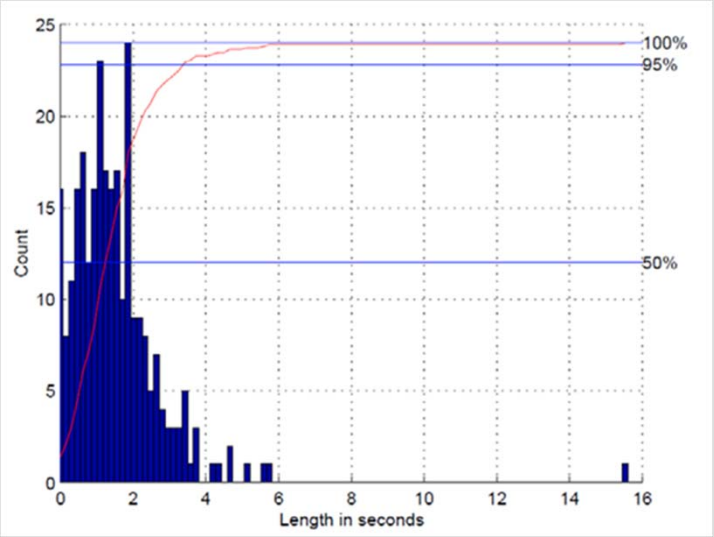
Experiment on Operating Complexity

Method:

- test drive of 90 km length
- 31 secondary tasks given to the drivers
- subjective assessment of operating difficulty
- objective assessment of operating difficulty
- 24 subjects

Results:

- complexity assessment for each individual secondary task
- criticality of control task by assessment of driving performance
- model to evaluate distraction effect of operation derived from these values



Histogram of distribution of pause lengths between subsequent steps of operation

Summary of main assessment of the different approaches

Technical approach	Advantages	Disdavantages	Suitability
Driving parameters	• no additional HW • can be individualized	• interference with assistance systems • long learning phase	drowsiness (distraction)
Operating behavior	• no additional HW • instantaneous values • visual and cognitive	• no nomadic devices • driver‘s preparation phase not detectable • not differing driver and co-driver	distraction (vis./cogn.)
interior camera	• detection of head and gaze direction • best measurement for visual distraction	• requires camera HW and integration • no cognitive distraction detectable • robustness of measurement	distraction (visual)

Agenda

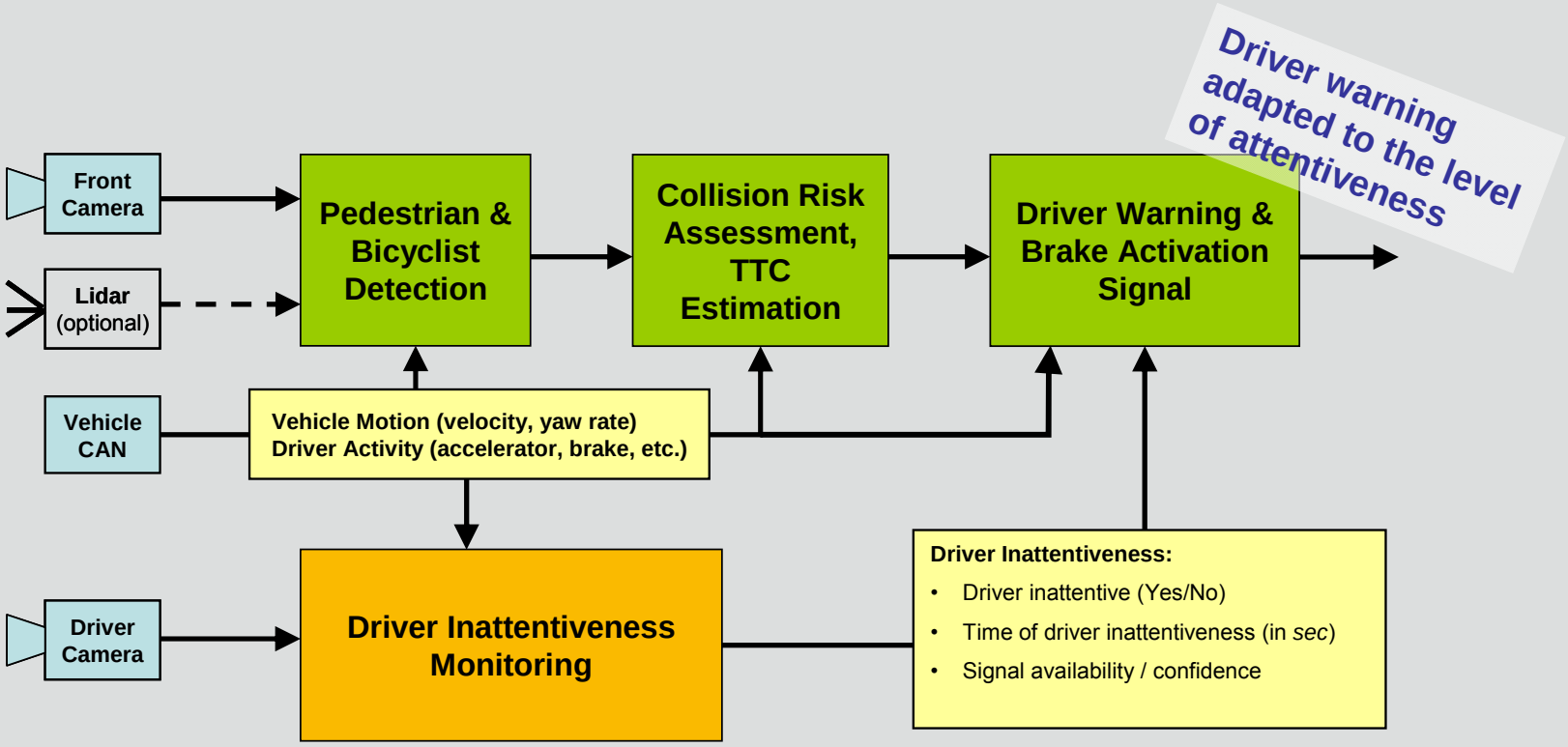
1 The research initiative AKTIV

2 Measuring the driver's attention –
Driving parameters, operating behavior and interior cameras

3 Using the information on the driver's attention in prototypes –
Adapting driver assistance systems and managing driver's attention

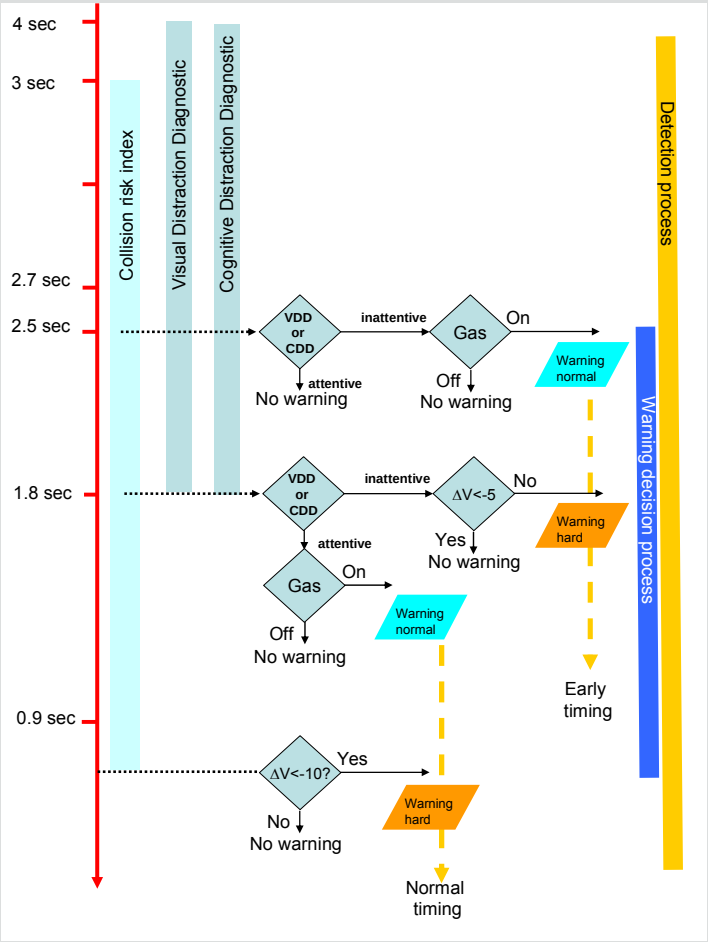
4 Outlook and summary

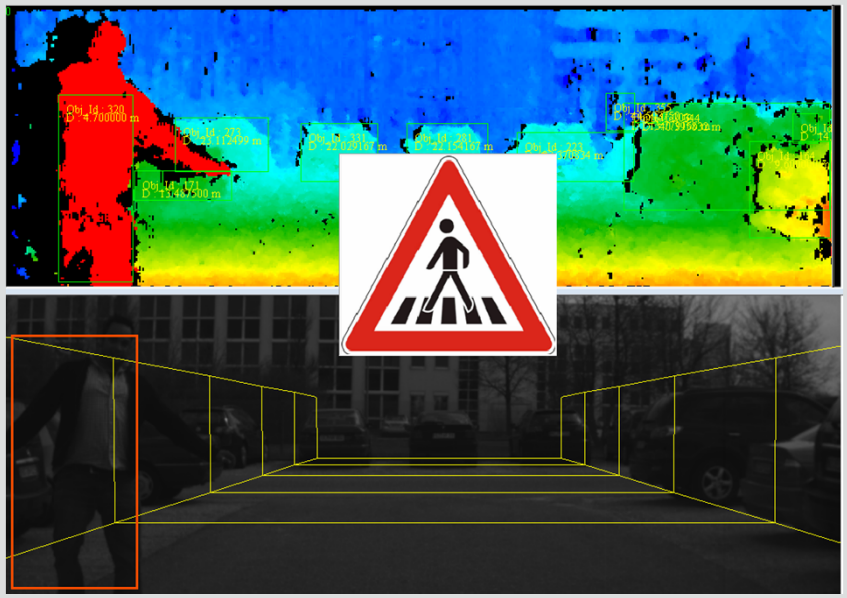
Principle for Adaptation of Assistance Systems



Functional architecture for adaptation of system for pedestrian and cyclist safety

Principle for Adaptation of Assistance Systems



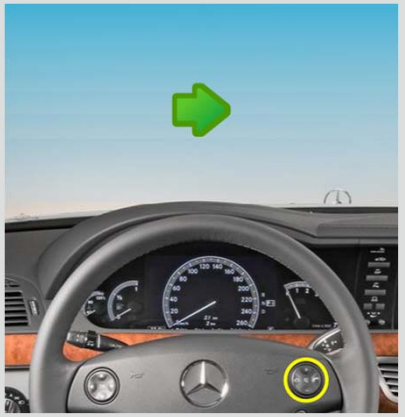


Warning concept for pedestrian and cyclist safety system considering driver attention

Effects in Reaction Time – Secondary Tasks

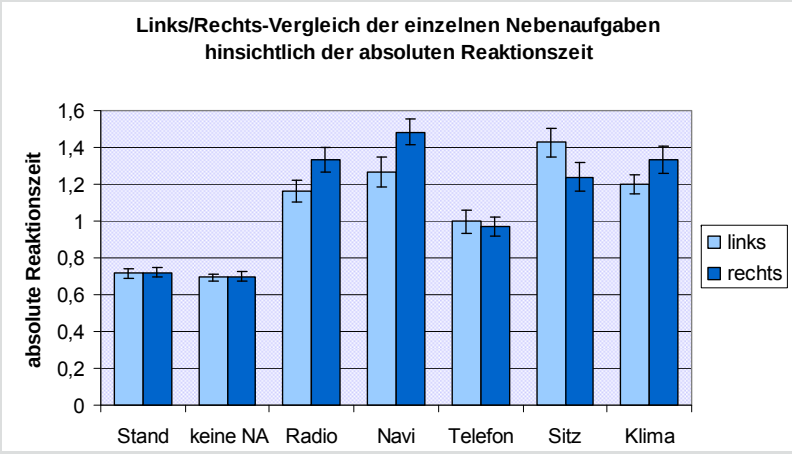
Method:

- driving on freeway behind truck at 80 km/h (ACC controlled for safety reasons)
- 4 conditions with secondary tasks
  - use of information system (radio, navigation)
  - phone conversation
  - seat/climate control operation
  - no task (control)
- visual reaction task in head-up Display - react on steering wheel control (left/right)
- 25 subjects, 40 trials per condition



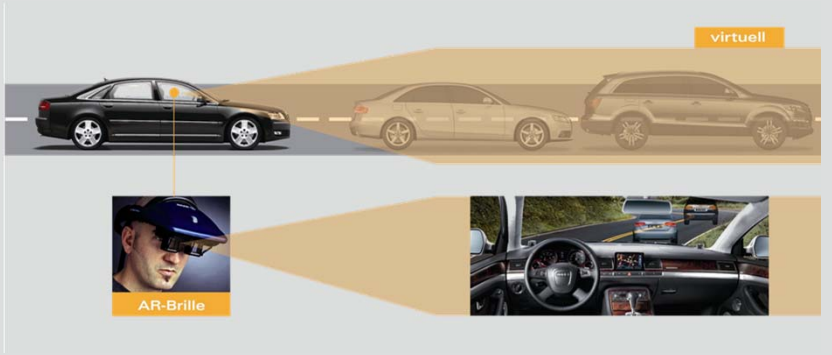
Results:

- mean reaction time difference of 0.5 sec (for all tasks without motoric aspects but phone conversation)
- 85th percentile of most difficult task at 1 sec (can be chosen as value to adapt systems)



Principle: Coupling of driving simulator and test vehicle

- The subject receives virtual objects within a real driving environment (perception on Head-mounted Display)
- Driving dynamics, kinesthetic and vestibular cues remain realistic due to real vehicle surrounding (minimizing simulator-sickness)
- Two different operation modes
  - Augmented Reality (semi-transparent)
  - completely virtual
- Suitable especially for safety-critical driving experiments



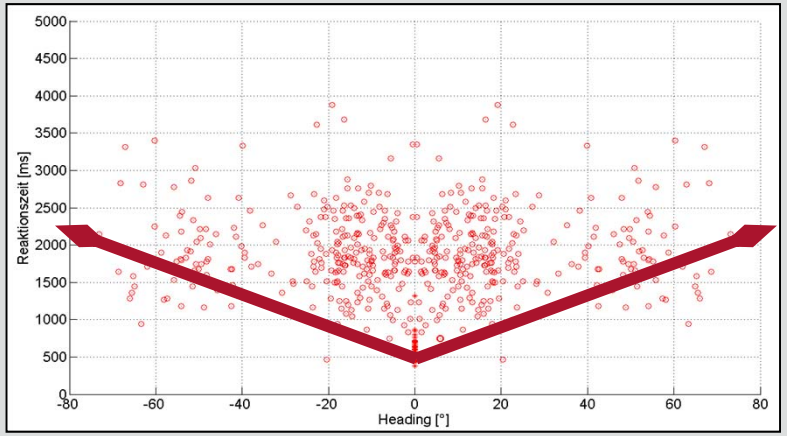
Effects in Reaction Time – Safety-critical Situation

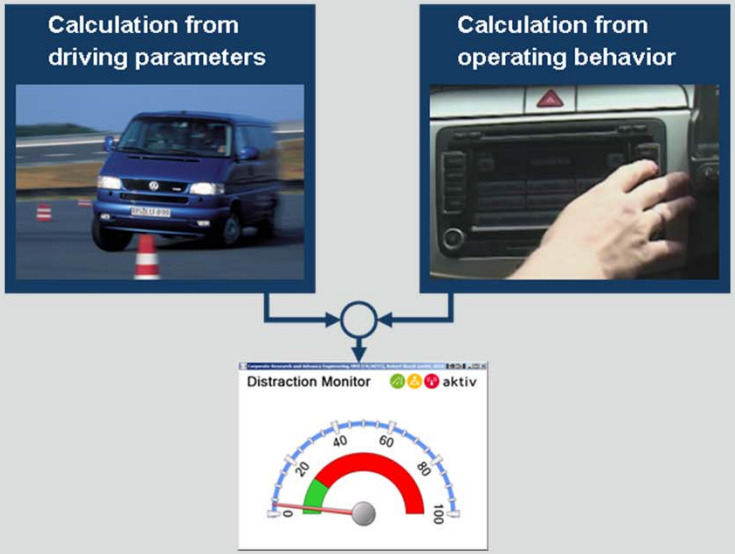
Method:

- use of „vehicle-in-the-loop“ on test track (augmented reality mode)
- car-following situation with virtual lead car
- road signs to motivate head turning for different degrees (observe the change in color)
- sudden braking maneuver of lead car
- measurement of driver‘s braking reaction time (dependent of actual head orientation at start)
- 45 subjects

Results:

- individual differences and large variance, but reaction time difference of 20 ms / ° can be used as approximate value
- method of vehicle-in-the-loop suitable for safety critical tasks





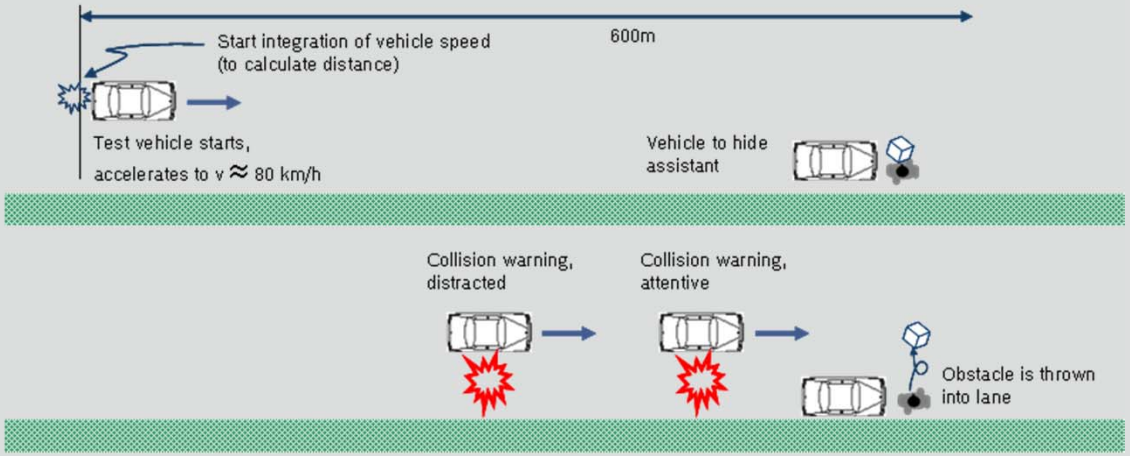
Demonstration of a collision avoidance function

Calculate distraction from

- driving parameters (steering wheel, throttle)
- operating behavior

Combine for overall level of distraction

Adapt the time of driver warning
(acoustic and visual warning)



Demonstration 1 – Collision Avoidance

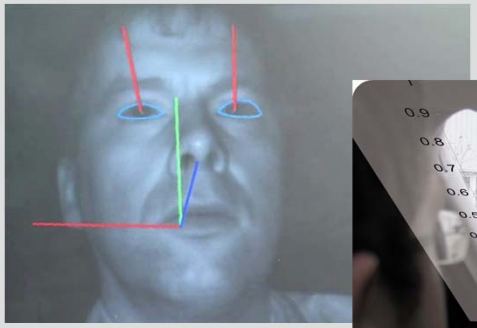
Conventional Warning

The collision warning will be issued too late, if the driver is distracted –
his reaction time is too long to avoid the colision

Adaptive Warning

If a distraction of the driver is recognized, the warning will be issued earlier –
a collision can be avoided

Demonstration 2 – Traffic Light Assistance



Demonstration of a traffic light assistance

Calculate distraction from

- operating behavior
- head orientation

Combine for overall level of distraction

Adapt the time of driver warning
(acoustic and visual warning)

Additional adaptation of position of visual warning
(cluster instrument plus overlay in information system)

Demonstration 2 – Traffic Light Assistance

Conventional Warning

The conventional warning can be too late for an inattentive driver –

late reaction results in need for sharp braking maneuver

Adaptive Warning

The attention-adaptive traffic light assistant issiues an earlier warning –

the driver has enough time to stop with an ordinary braking maneuver

Objective: Keep the driver‘s attention on appropriate level

What is the effect of a continous lateral support on driver attention?

Options for system adaptation:

- change degree of lateral support (more support if workload is higher)
- vary following distance to avoid monotonous situations
- give driver the option to choose the level of support

Different approaches were implemented in truck driving simulator.
Effects studied in empirical tests.

Agenda

1 The research initiative AKTIV

2 Measuring the driver's attention –
Driving parameters, operating behavior and interior cameras

3 Using the information on the driver's attention in prototypes –
Adapting driver assistance systems and managing driver's attention

4 Outlook and summary

Exploitation of AKTIV results

Status of AKTIV initiative

presented to the public at Final Presentation
June 23/24, 2010 (Mendig)

project officially terminated at
December 31, 2010

Follow-up activities

exploitation of project results
individually by partners

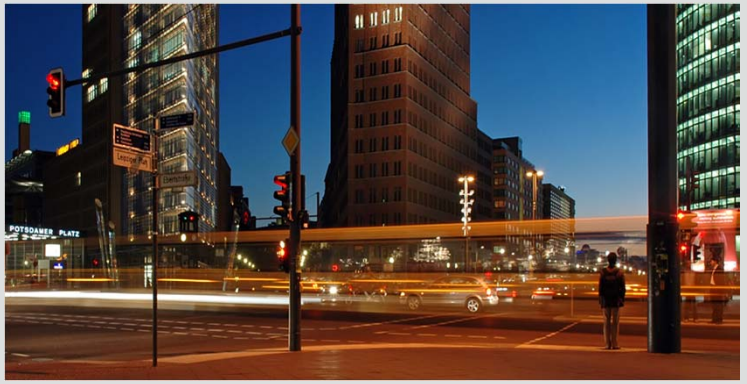
For driver attention this means:
Introduce the results to series cars

UR:BAN

Outlook – the research initiative UR:BAN

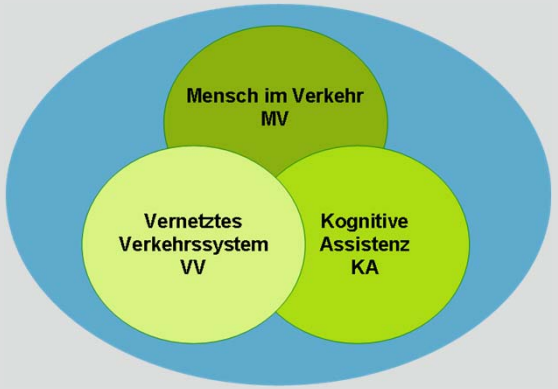
Trends and Challenges

- increased mobility requirements in highly populated areas
- sustainable design of urban mobility
- increased safety expectations in urban traffic
- need for integrated driver assistance
- more intelligent traffic infrastructure
- user-friendly driving and traffic assistance



The UR:BAN approach

- former activities were concentrated on freeway and highway traffic
- trend towards urbanization asks for city-friendly assistance and traffic management



Summary

Video Statement (German language with English subtitles)

Thanks for your attention !