TECHNISCHE UNIVERSITÄT DARMSTADT

Dipl.-Ing. Matthias Pfromm

Human Machine Interface

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Agenda

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Safety Corridor HMI

- Requirements
- Design of HMI
- Evaluation
- Final Design

Cooperative Automation HMI

- Requirements
- Design of HMI & Evaluation
- Final Design

Outlook

- Transitions of Control

Agenda

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Requirements – Safety Corridor

93.5 % of accidents in Germany happen due to driver error [1]

Causes of driver error [2]	Assistance Strategy
Lack of perception of essential information	Information
Misinterpretation of essential information	Warning
Wrong decisions made by the driver	Action recommendation
Faulty execution of driving tasks	Intervention

- **4 Assistance Strategies required**
- **Adaptive to driver's state**

Direction of Attention

- **Direction of attention improves perception of stimulus and accelerates reaction [3, 4]**
- **HMI must direct driver‘s view towards relevant traffic objects**

Requirements – Safety Corridor

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Sensory Channels [5]

Human: transmit	Human: receive	Channel	Machine: transmit	Machine: receive	
Gestures, facial expression	Eyes	Visual	Displays	Camera	+ : fast, high bandwidth - : gaze direction
Speech	Ears	Auditive	Speaker	Micro-phones	+ : attract attention - : low bandwidth
Hand, Feet, ..	Hand, Feet, ..	Tactile / Kinesthetic	Actuators	Manual controls	+ : very fast - : low bandwidth

- **Multimodal exchange of information required**

Related Work

State of technology ADAS HMIs

- Work in a limited number of use cases
- Driver may be overstrained by multiple HMIs [6]
- are unspecific ➔ driver loses time [7]
- don‘t provide multiple assistance strategies
- rarely multimodal support

PRORETA HMI

- Works in a high number of use cases
- Not bothering, not annoying
- Specific, multimodal support

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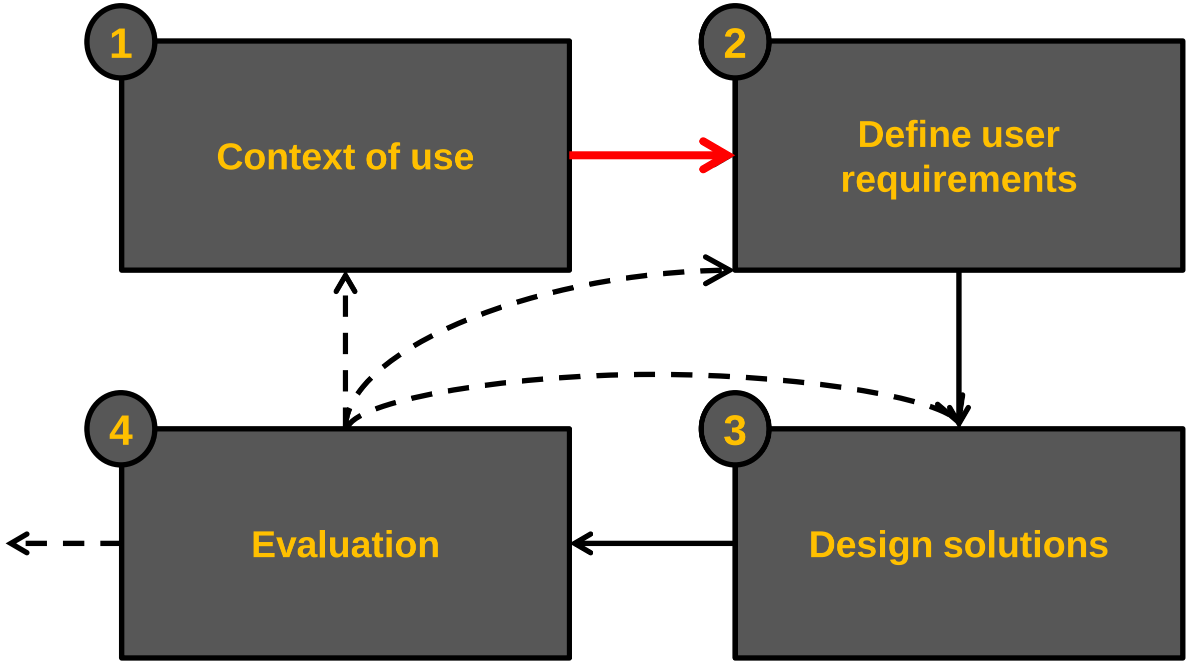
Methodology

User Centered Approach (ISO 9241-210)



Design of HMI

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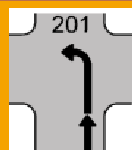
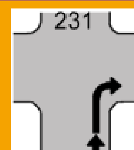
Requirements from Use Cases

Driver‘s tasks
- Stabilization
- Guidance

Traffic Situations





Error → Accident

context of use

Support Content

Information	Warning	Action recommendation
position in freespace	approaching lane markers	brake
position of relevant traffic object	approaching traffic object	steer left
	approaching freespace	steer right
	inappropriate speed	

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Design of HMI

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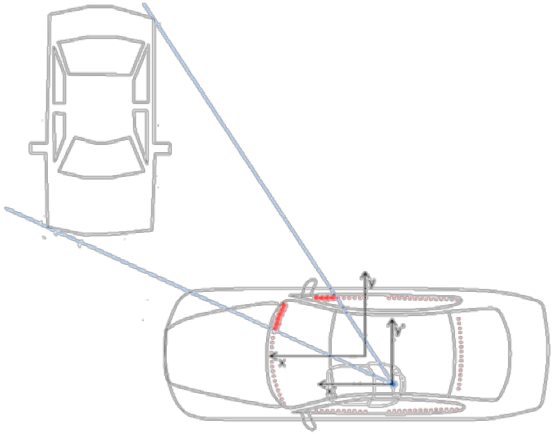
Spacial reference

- 3D sound
- 360° LED Lights Strip

LED Lights Strip

- Submits the position and distance of a traffic object
- „Projecting" relevant traffic objects on the LED strip



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Evaluation of HMI

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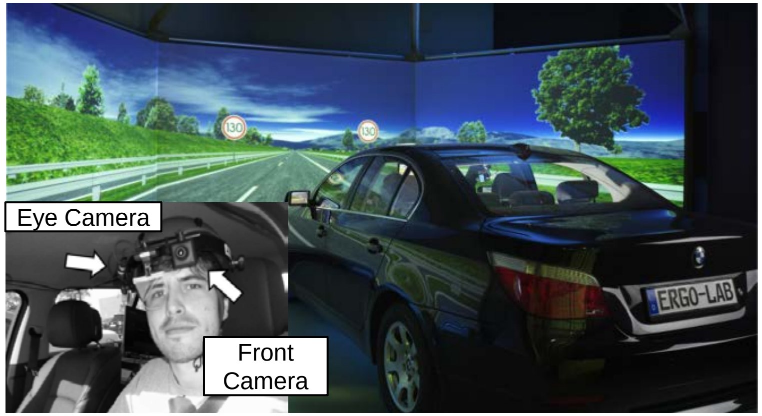
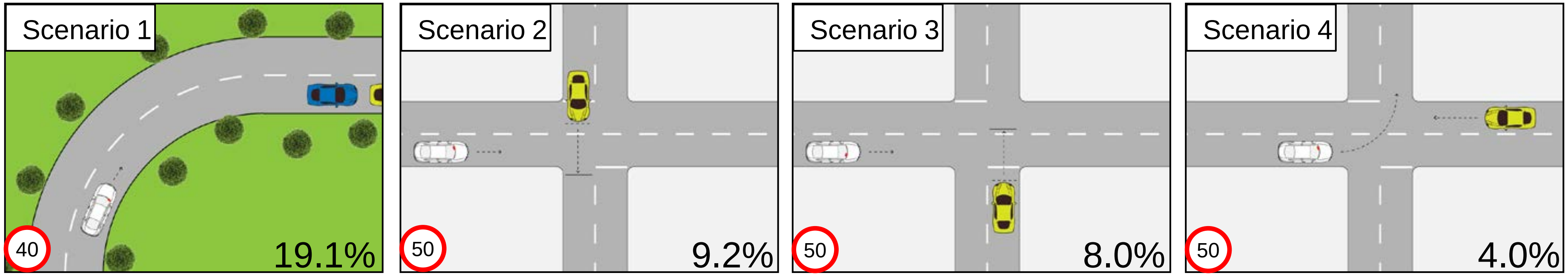
Design of Simulator Study

- **Fixed-base driving Simulator (Silab 3.0)**
- **SMI eye-tracking device**
- **13 subjects (f: 8; M=43.3 years)**
- **Scenarios represent 41.2% of German traffic accidents [8]**





End of Traffic Jam
$t_{warn} = t_{vis} - 2s$

Vehicle from left
$t_{warn} = t_{vis}$

Vehicle from right
$t_{warn} = t_{vis}$

Turn Left
$t_{warn} = t_{vis}$

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Evaluation of HMI

Dependent Variables

Gaze attention time

- Focus of attention ≙ visual fixation [9]
- $t_{gaze\ attention} = t_{visual\ fixation} - t_{appearance}$

Acceptance

- General Acceptance: Questionaire by van der Laan el al. [10] + additional items
- Situation Specific: 5 items

Semi-structured interviews

- understood intuitively?
- hints for improvement

Mental effort

- measured by RSME-Scale [11]

Results

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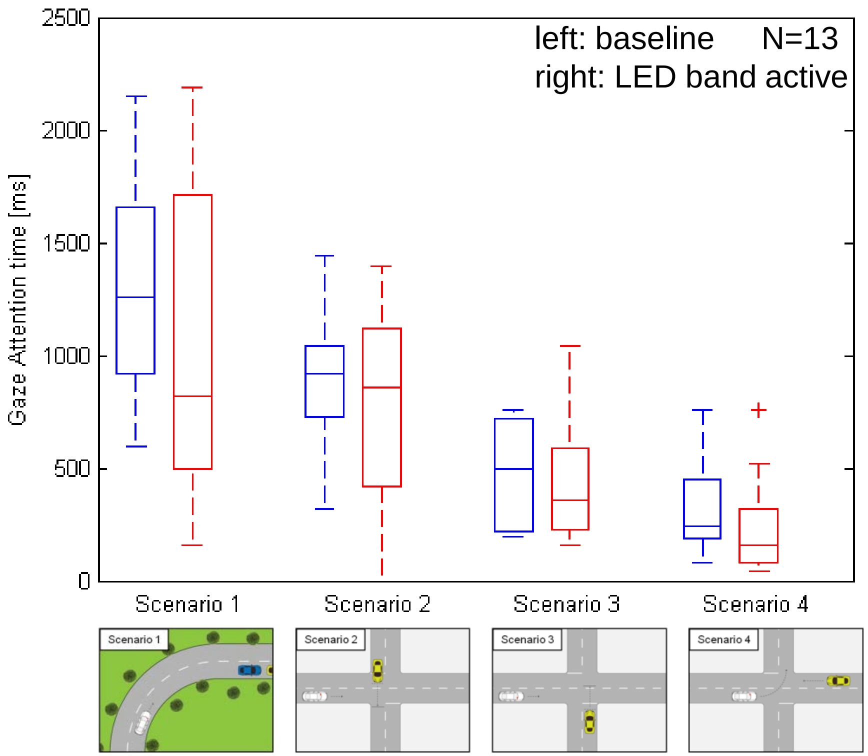
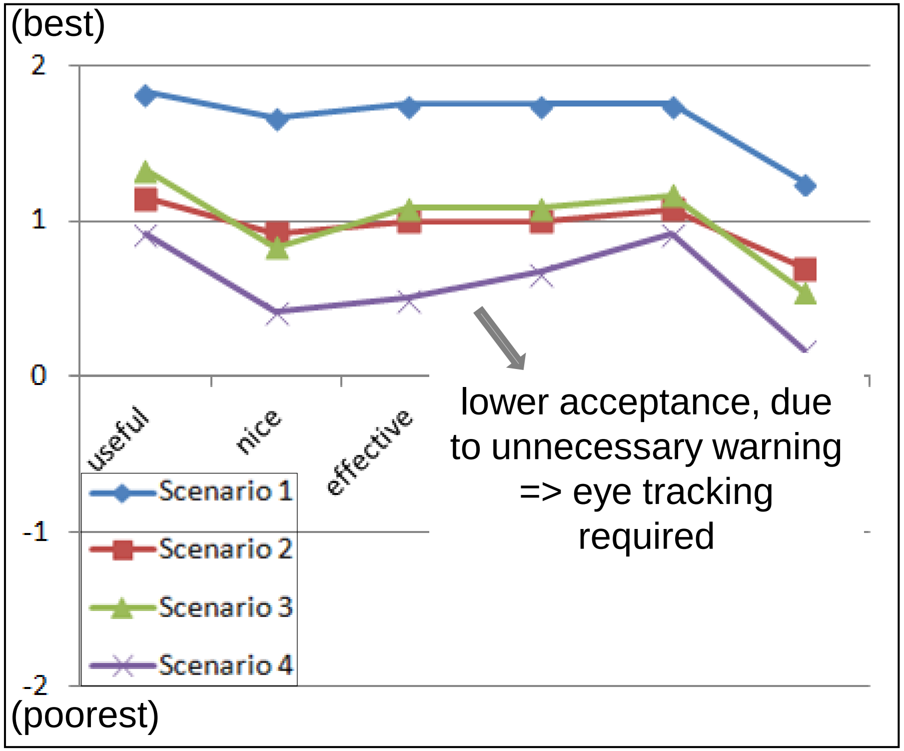
Gaze Behavior – Gaze Attention Times



Situation-Specific Assessment of Acceptance



Results

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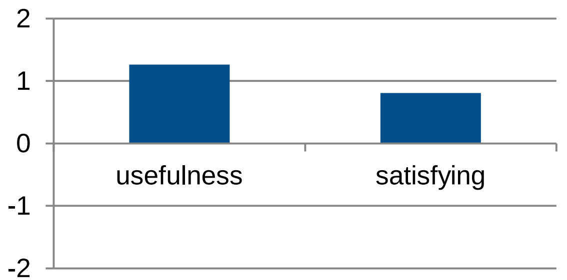
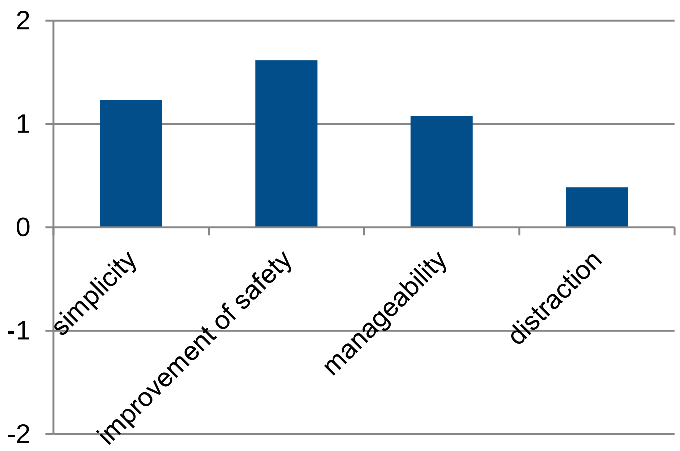
General Assessment of Acceptance

van der Laan et al. [10] Scale



Additional items



Semi-Structured Interviews

- **LED band ist intuitively understandable**
- **10 out of 13: LED becomes active in dangerous situations**
- **3 out of 13: did not understand LED band**
- **5 out of 13: stated that LED band showed the distance to critical vehicle**

Mental Effort

- **no difference between baseline and LED band**

Design Solutions

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Instrument Cluster: Design Draft

- First prototype
- Submits the position and distance of relevant traffic object
- 3 level support concept
  - Information
  - Warning
  - Action recommendation

prototype HMI

Evaluation

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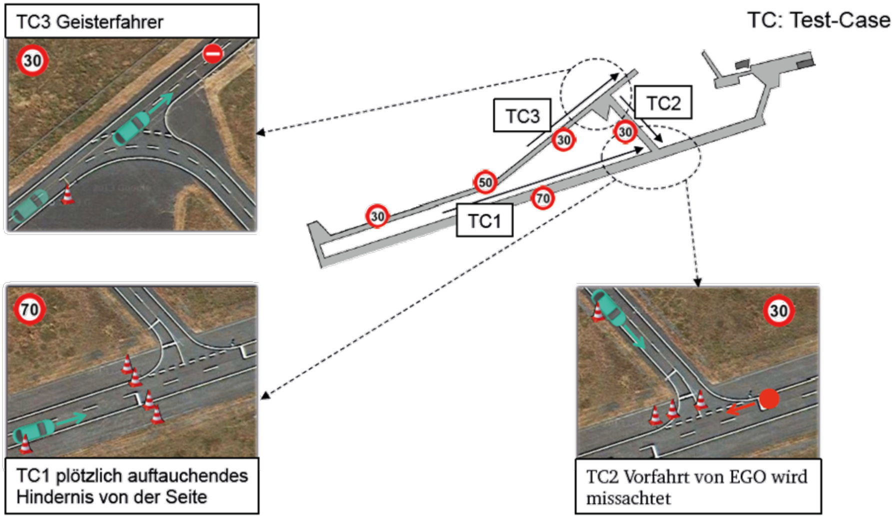
Goals

- Determination of escalation-level trigger times
- Usability Evaluation

Methodology

- driving tets: 23 subjects (f: 5; M=23.2 years)
- „Herstellung“ method to determine trigger times
- Evaluation of support functions by custom questionnaires



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Evaluation

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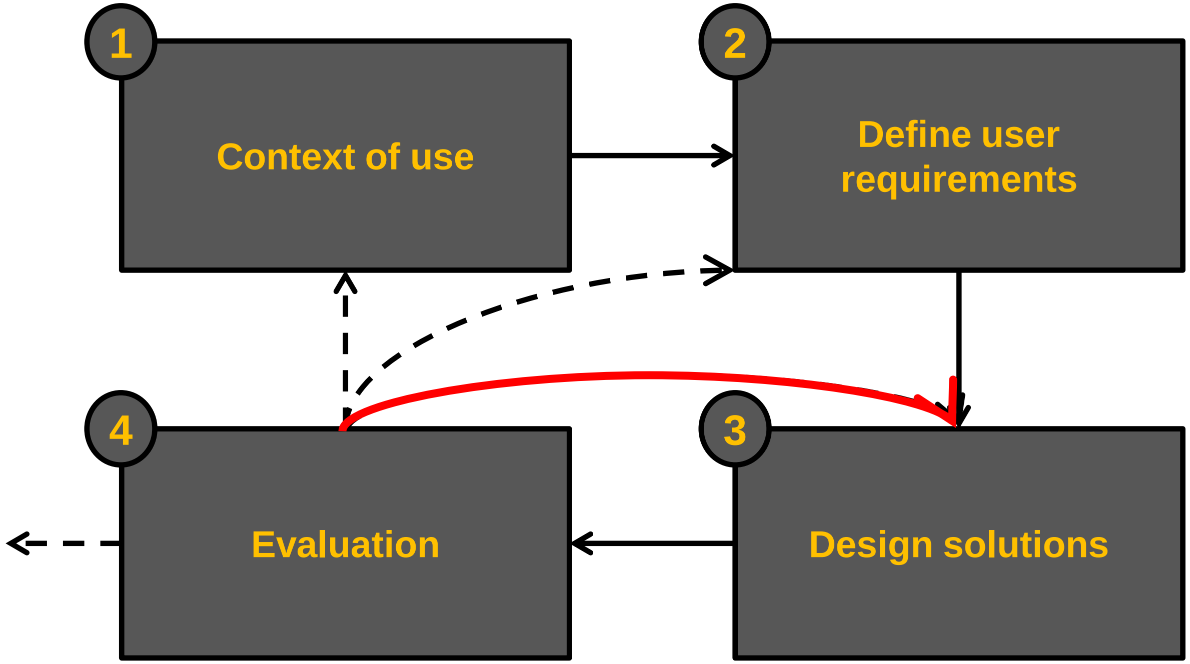
Results

- Determination of escalation-level trigger times
- High general satisfaction with support functions
- Subjects identify direction of danger by representation in display as well as by LED Lights strip
- Support content in display generally rated as helpful
- Acoustical warnings make driver gaze on display
- AFFP makes driver brake faster in case of danger
- Lower ratings of “radar” design in higher escalation levels => takes time to interpret
- Lower satisfaction-rating for escalation level 1 => only visual support
- Too much information represented on the display

Methodology

User Centered Approach (ISO 9241-210)

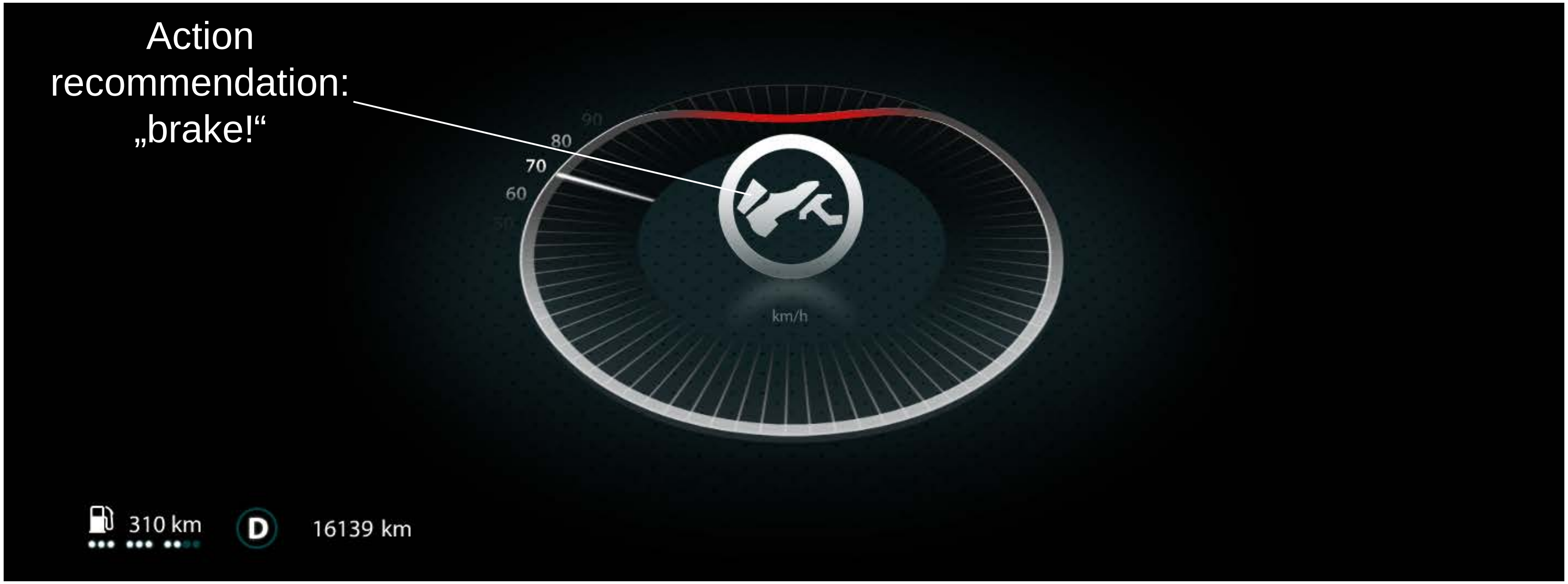


Final design

Safety Corridor

Final design

Safety Corridor



Final design

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Safety Corridor

Final design

Safety Corridor

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Requirements – Cooperative Automation

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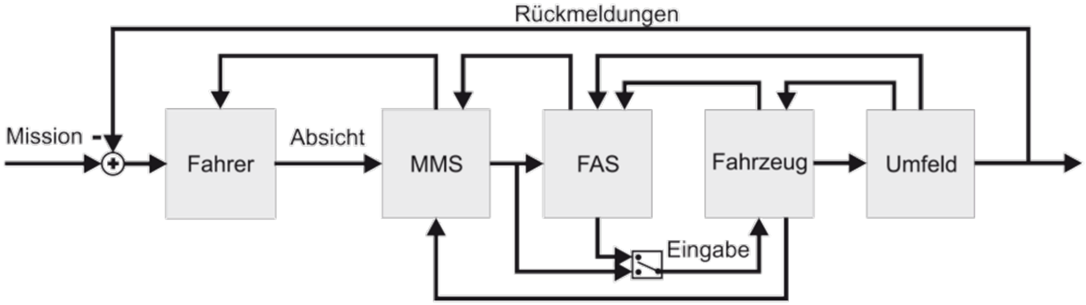
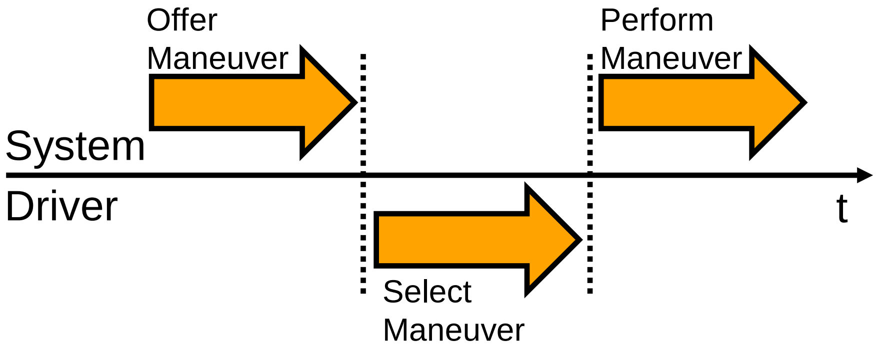
Maneuver based driving

- **Parallel sequential assistance [12]**



- **Simple and efficient method for maneuver delegation required**



Requirements – Cooperative Automation

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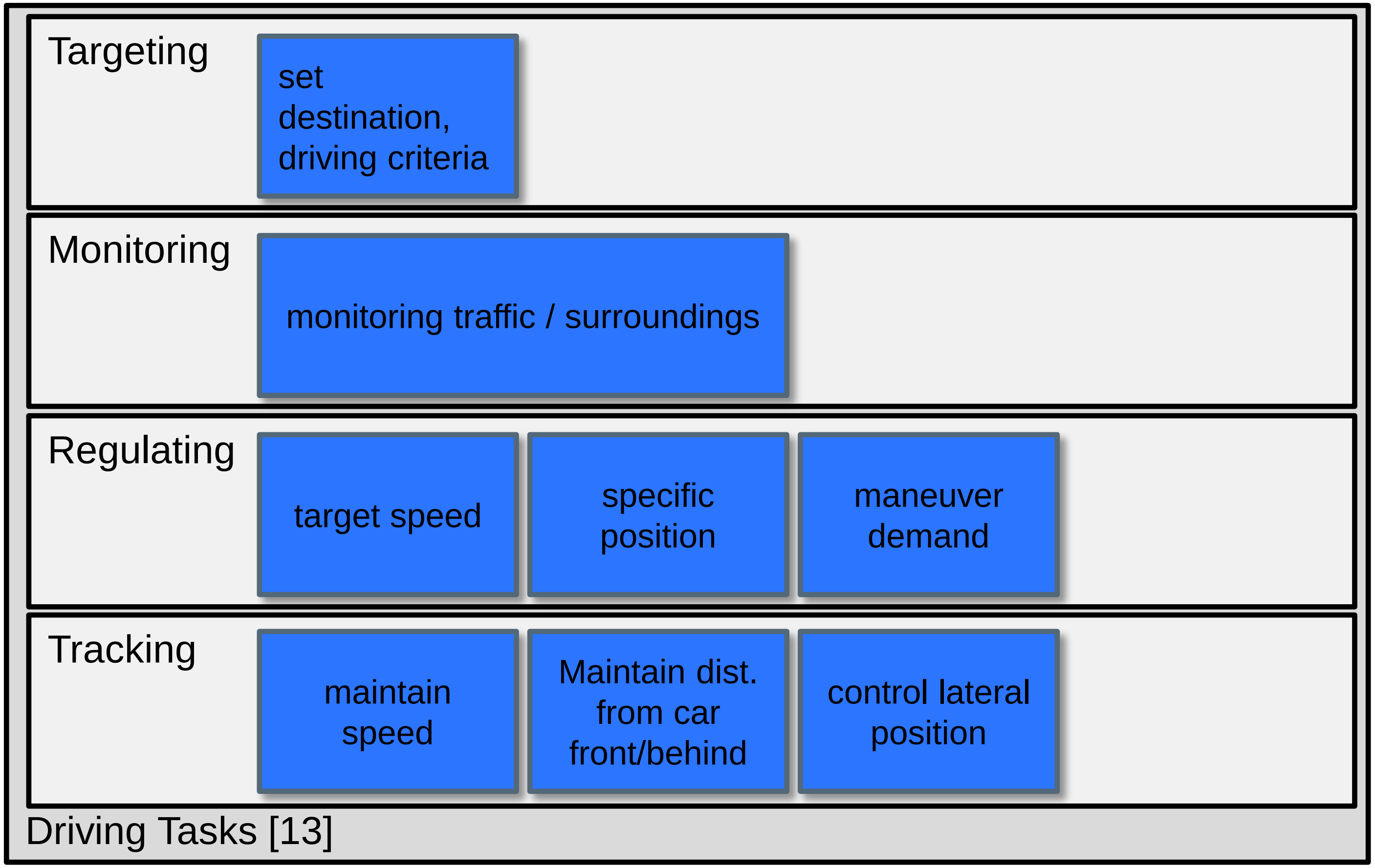
Conventional Driving



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Requirements – Cooperative Automation

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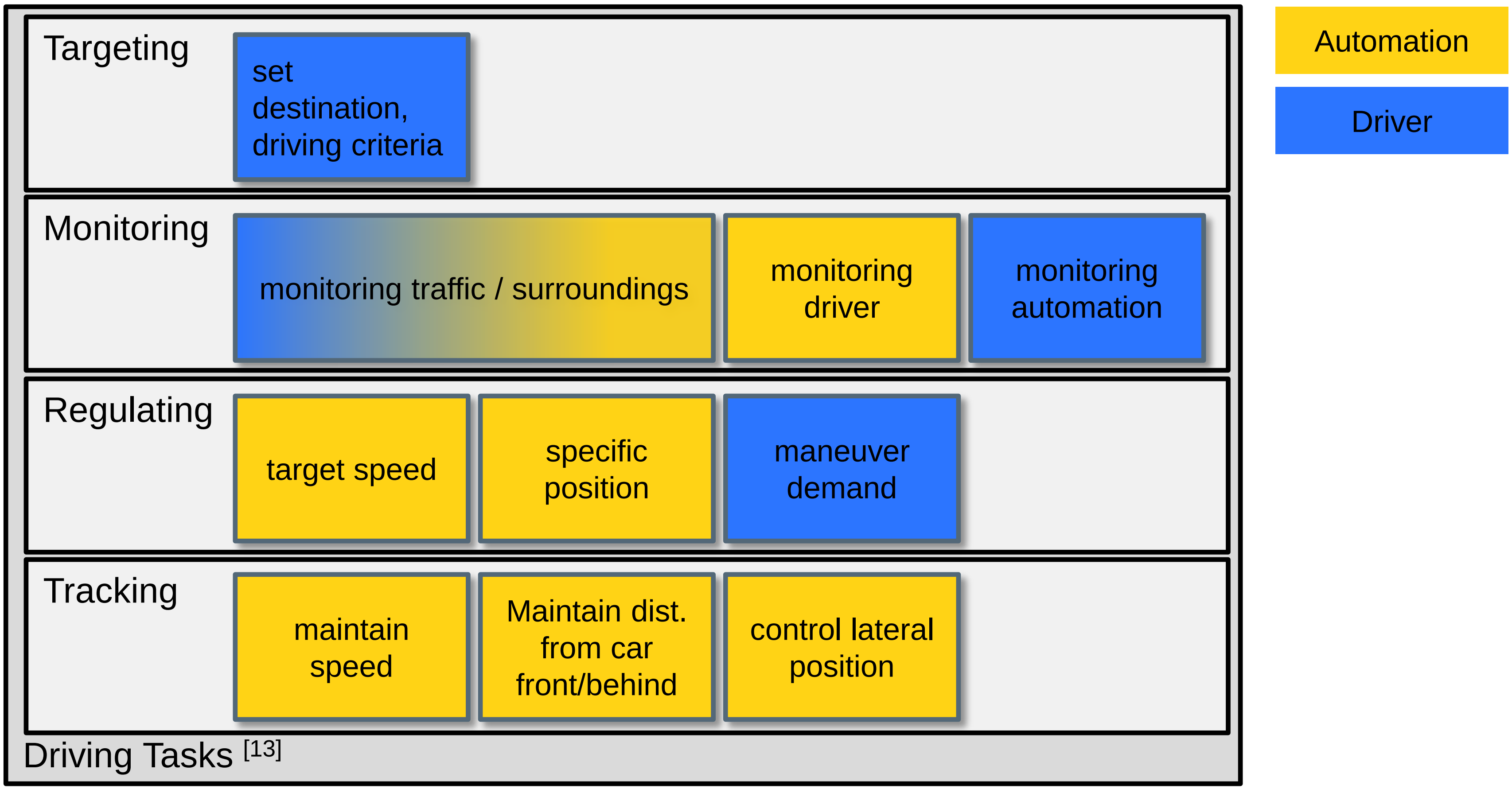
Task sharing – Cooperative Automation



Requirements – Cooperative Automation

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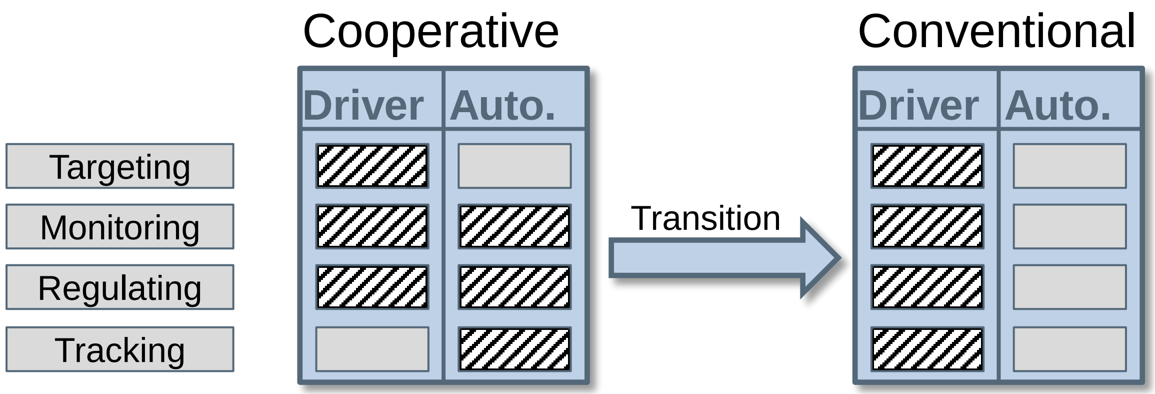
Task sharing – Cooperative Automation

- Distribution of tasks must be made clear to driver
- Current system state must be transparent (Mode Awareness)
- System behavior must be understandable
- Transitions of control must be manageable



[13]

Related Work

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State of research

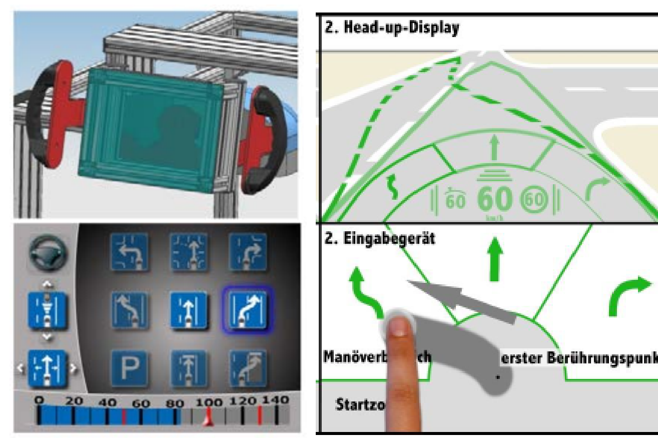
- H-Mode & CbW: Highly sophisticated interfaces needed
- Applied in driving simulators only

Goal

- Maneuver based driving with common interfaces in a real car
- Simple and efficient method for maneuver delegation

H-Mode [14]

Conduct by Wire [15, 16]



Design Solutions & Evalutation

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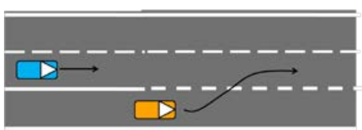
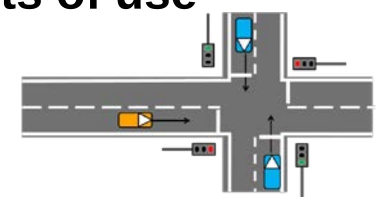
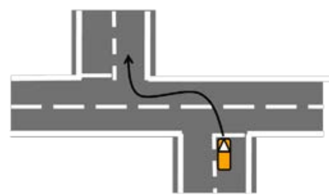
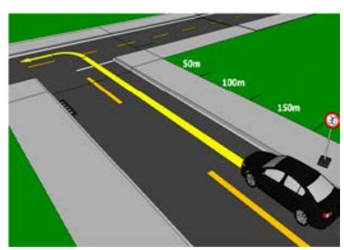
Interaction Cooperative Automation

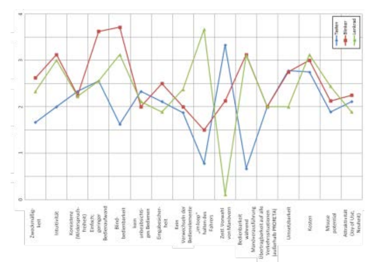
- **Investigate different means of maneuver selection**


- **in different contexts of use**

- **in workshops an a field study**





Design Solutions

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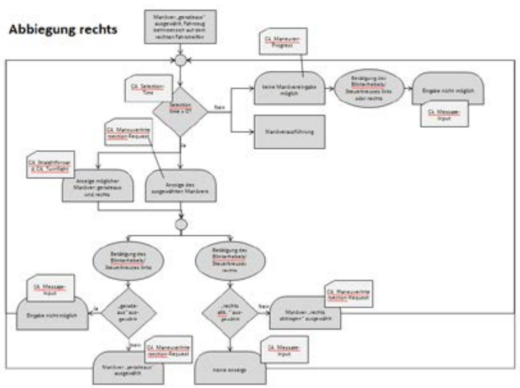
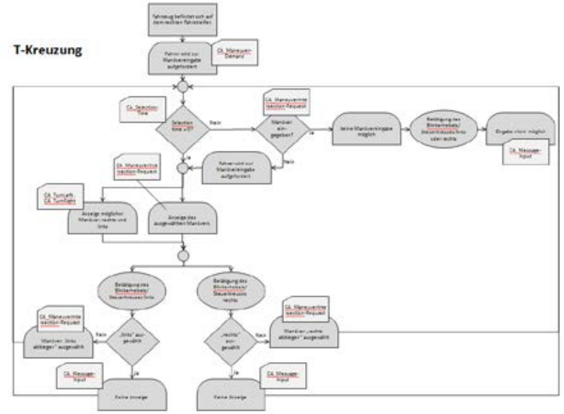
Interaction Cooperative Automation

- **Model Interaction for different use cases**





- **Final design**

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Final design

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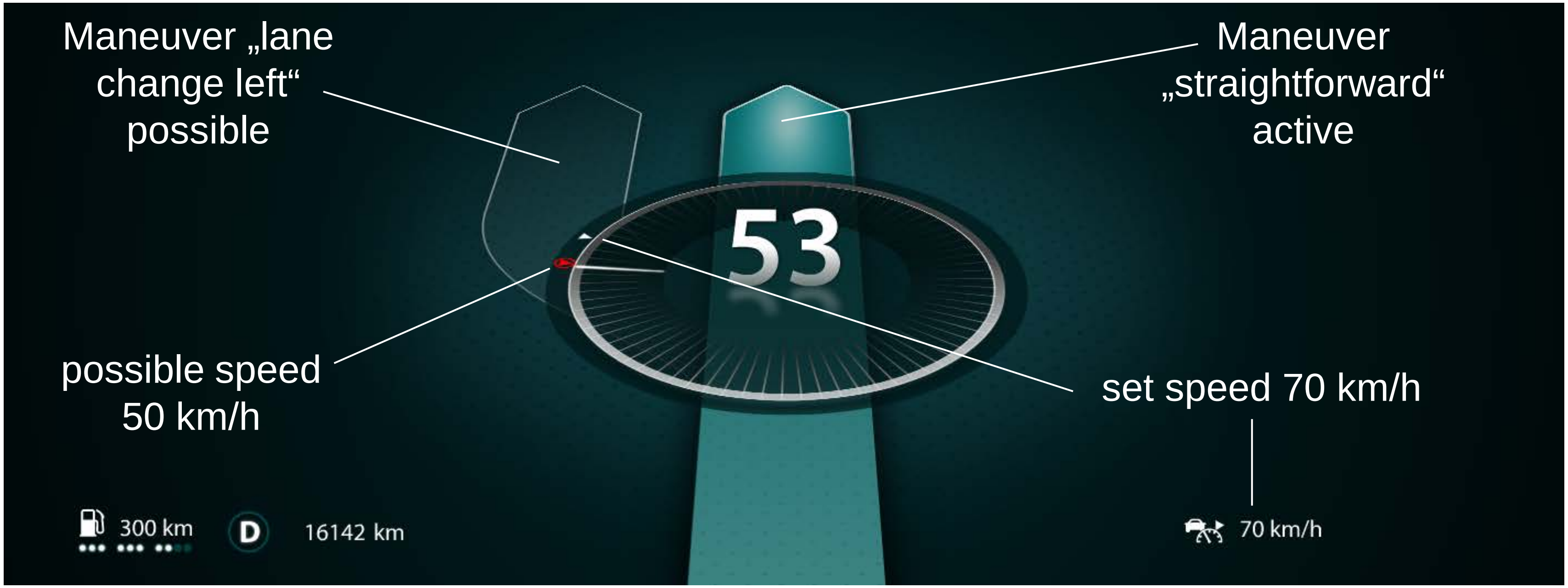
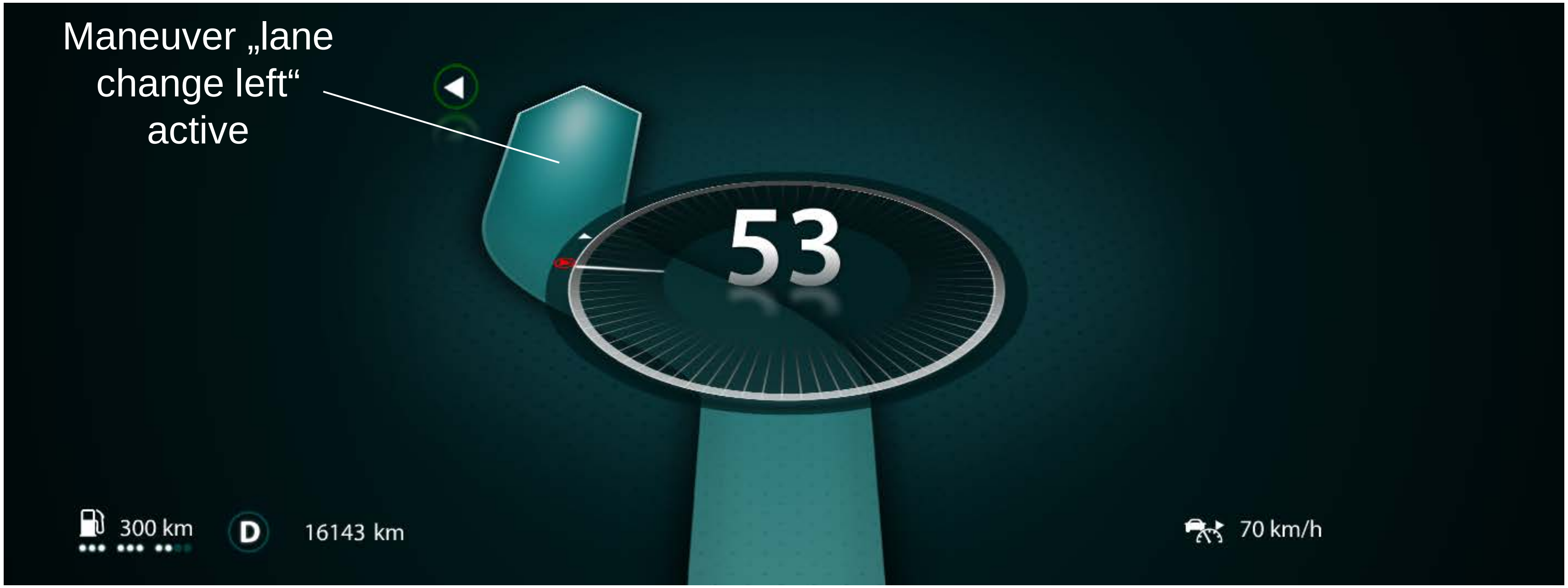
Cooperative Automation



Final design

Cooperative Automation



Outlook

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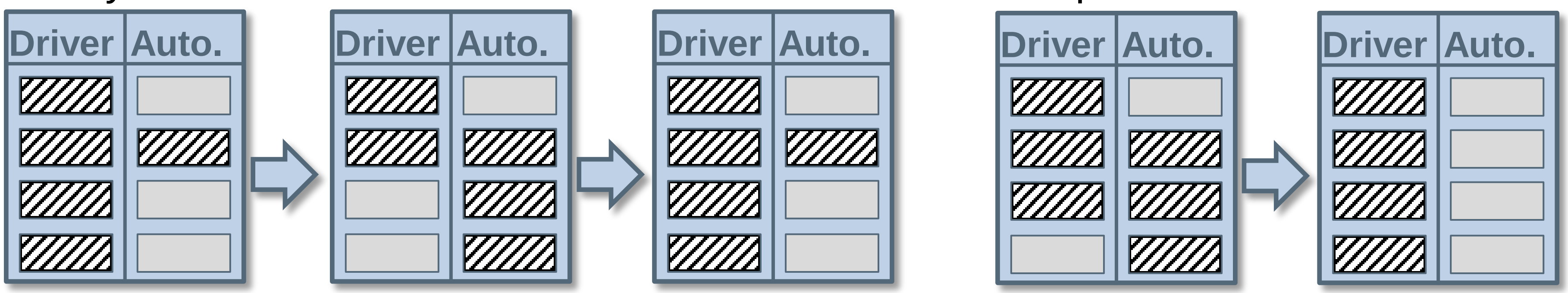
Investigation of Transitions

Safety Corridor

Cooperative Automation



Questions

- **Does the driver take back tasks from the system safely?**
- **Does the driver understand, which tasks are performed by the automation and which have to be performed by him?**
- **Driver strain – is the driver relieved by the system?**
- **Acceptance/ Ux – Does the driver accept the system?**

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