

Dr. Frank Diermeyer, Technical University of Munich



IMAGinE

12 MAY 22

FINAL EVENT



HMI Development for Cooperative Driver Assistance for Trucks on Highways

STRUCTURE

Goals & Procedure in the Project

Results of our Research

- Requirements Analysis

- HMI Development under Ideal Conditions

- HMI Development under Real Conditions

- Overall Evaluation

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TUM. Technical University of Munich

Institute of Automotive Technology



Dr. Frank Diermeyer



Maria Wolf



Jana Fank



Christian Knies



Development of an Innovative HMI for Cooperative Driving of the Future

- Analysis of human-centered requirements and acceptance boundaries
 - Metrics for cooperation performance and driver acceptance
 - Investigation of motivation-enhancing measures
-
- Concept design HMI
 - Evaluation and test
-
- Design recommendation for a cooperative HMI

Our Work Packages



AP 1.3

**Requirement
Analysis**

AP 2.4

**HMI Development
under Ideal Conditions**

- Motivation enhancement
- Design recommendations

AP 3.5

**HMI Development
under Real Conditions**

- Further Development
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AP 1.3 Requirements Analysis

Goals and Methods



Goals:

- Analysis of current cooperation in road traffic
- Consideration of different road users: cars & trucks
- Conclusions on requirements of cooperative driver assistance

Identification

Guided interview
7 car and truck drivers

→ Contextual survey to *identify relevant factors for acceptance criteria*

Qualification

Online Survey
77 car and truck drivers

→ Qualitative survey to *analyze the relevance of identified factors for acceptance criteria*

AP 1.3 Requirements Analysis Results

Goals:

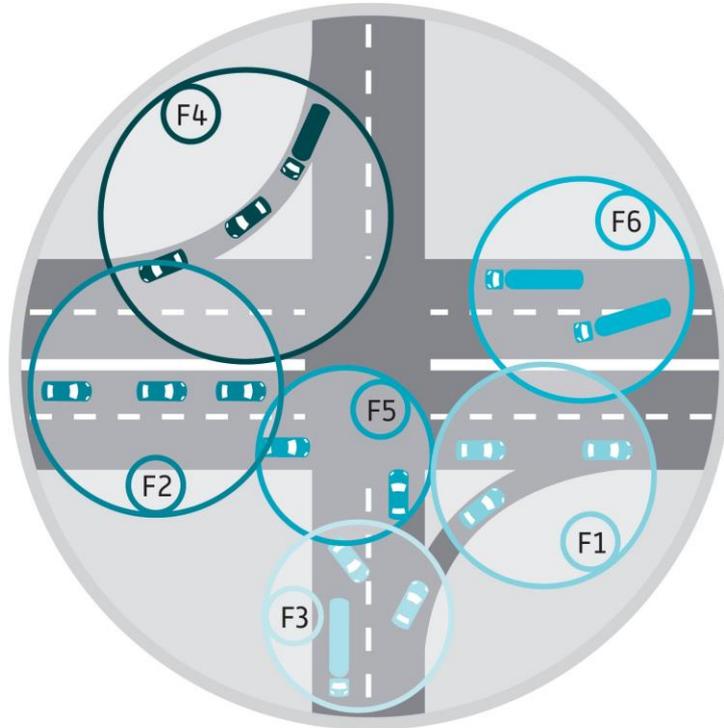
- Analysis of current cooperation in road traffic
- Consideration of different road users: cars & trucks
- Conclusions on requirements of cooperative driver assistance

The differences between car and truck drivers show, that these user groups should be considered separately.



AP 1.3 Requirements Analyses

Identify context of use – Tasks



F1 Cooperative merging
on highways

F2 Cooperative longitudinal control
on highways

Truck

F3 Cooperative overtaking
on rural roads

F4 Cooperative strategic traffic
distribution

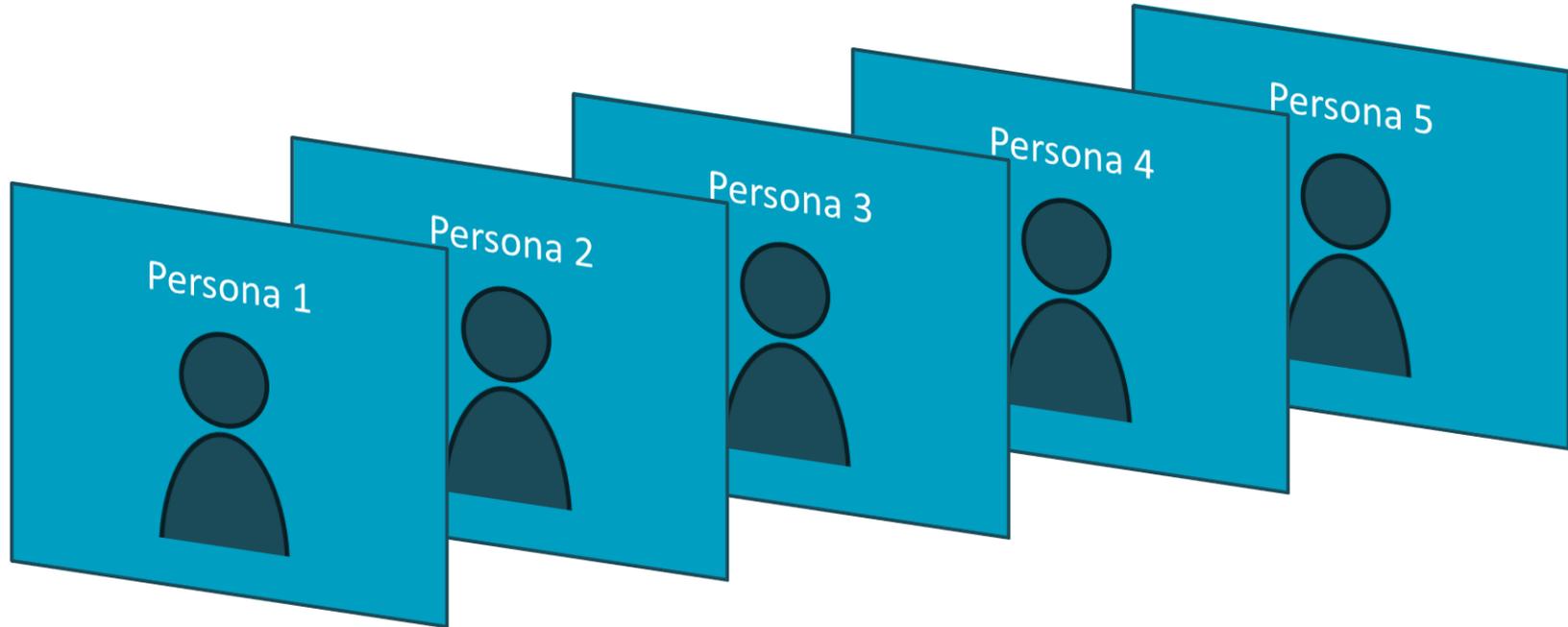
F5 Cooperative turning
at junctions

F6 Cooperative overtaking by heavy-
goods vehicles on highways

Truck

AP 1.3 Requirements Analyses

Identify context of use – User





Erwin Zechner, 63 years

Job setting: The appointed

Traffic type:
The safety conscious type

From Eichstätt



- Truck driver for 40 years
- In the same company for 25 years
- Active in long-distance as well as local transport



- Appreciates the feeling of freedom
- Appreciates being his own boss on the road
- Appreciates the varied routes and the new foreign places



- Cohesion between truck drivers not as it used to be
- Many Eastern European drivers on the roads, hired at dumping wages



- Reacts routinely and non-emotionally in stressful situations

„ For me, the long-distance romance still exists“

German language skills:



Technology affinity:



Open-mindedness towards new technologies:



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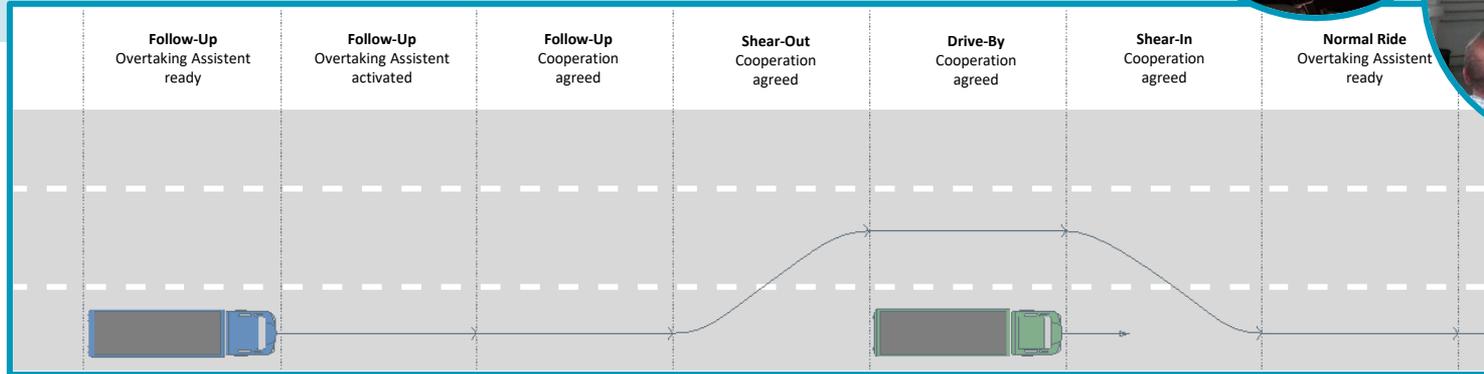
- Design recommendations

AP 2.4 HMI Development under Ideal Conditions



PRE-STUDIES

- Benchmark analysis
- Driving simulator study
- Expert survey
- Expert workshop

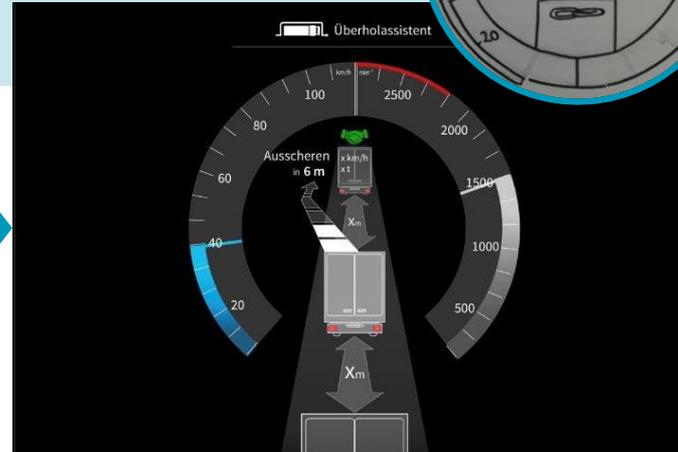
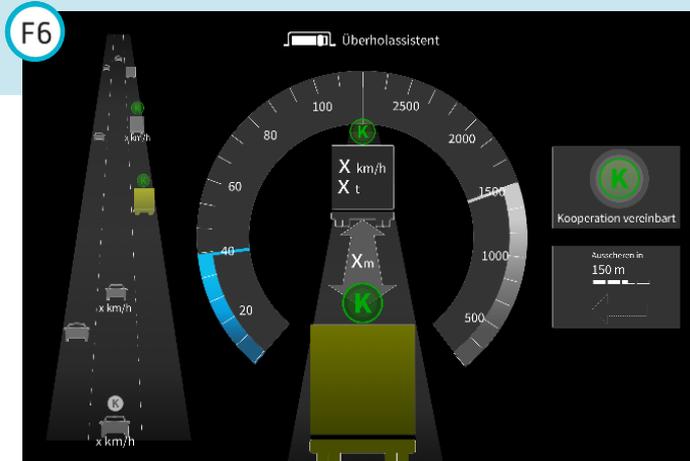
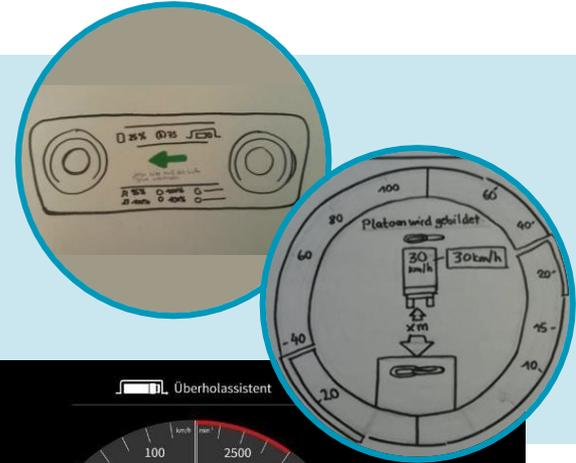


AP 2.4 HMI Development under Ideal Conditions



DESIGN

Quick sketches and scribbles
Expert evaluation

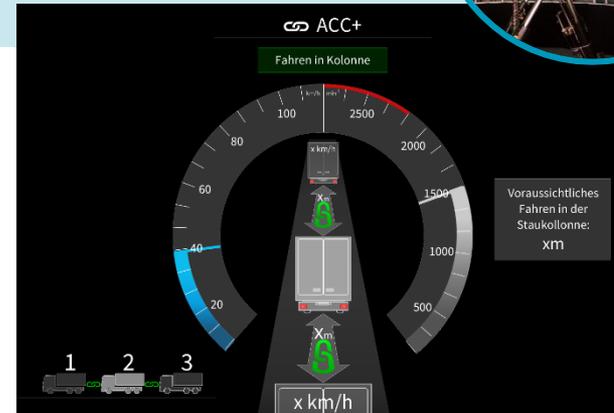




EVALUATION

Driving simulator study
with 31 truck drivers

F2



RESULTS

→ Information content

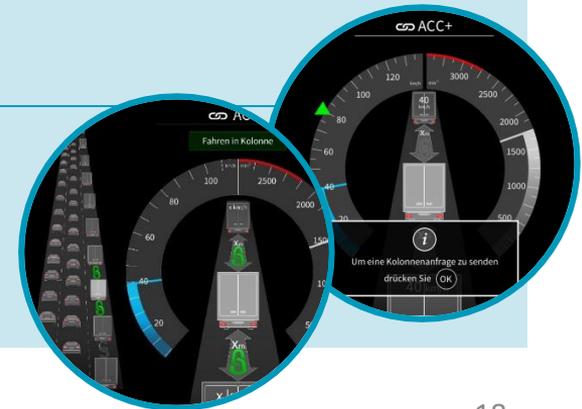
- ✓ HMI F2: satisfying results
- ⚡ HMI F6 overtake: $\frac{1}{3}$ overtaking maneuvers successful

→ Confirmation of the cooperation request

- ⚡ HMI F6 be overtaken:
 - manual confirmation → more driver consent
 - automated confirmation → more cooperation

→ Representation of the surrounding traffic

- ✓ visual distraction
- no difference in objective workload
- representation omitted



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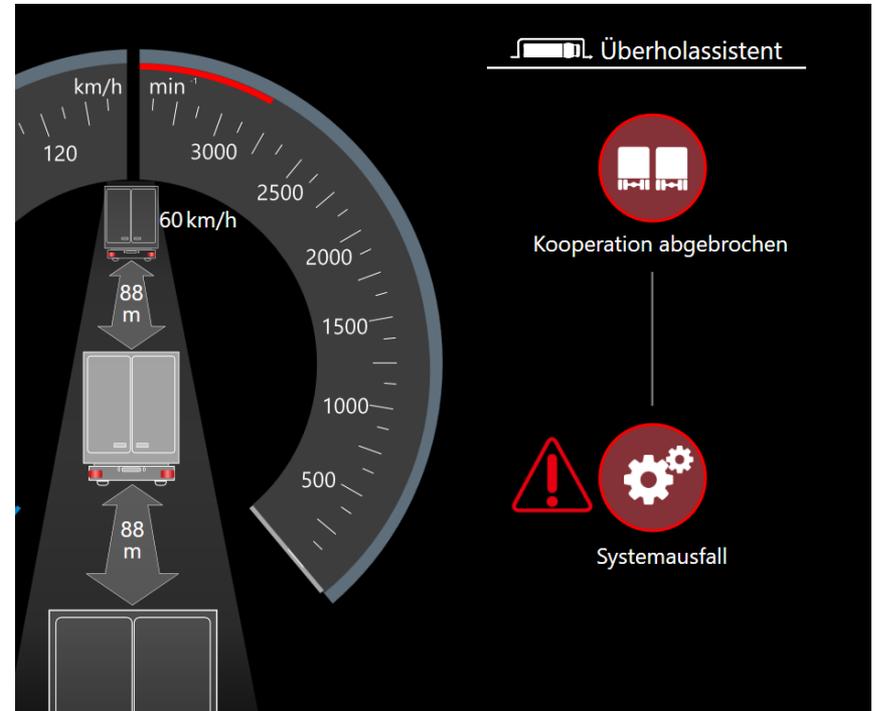
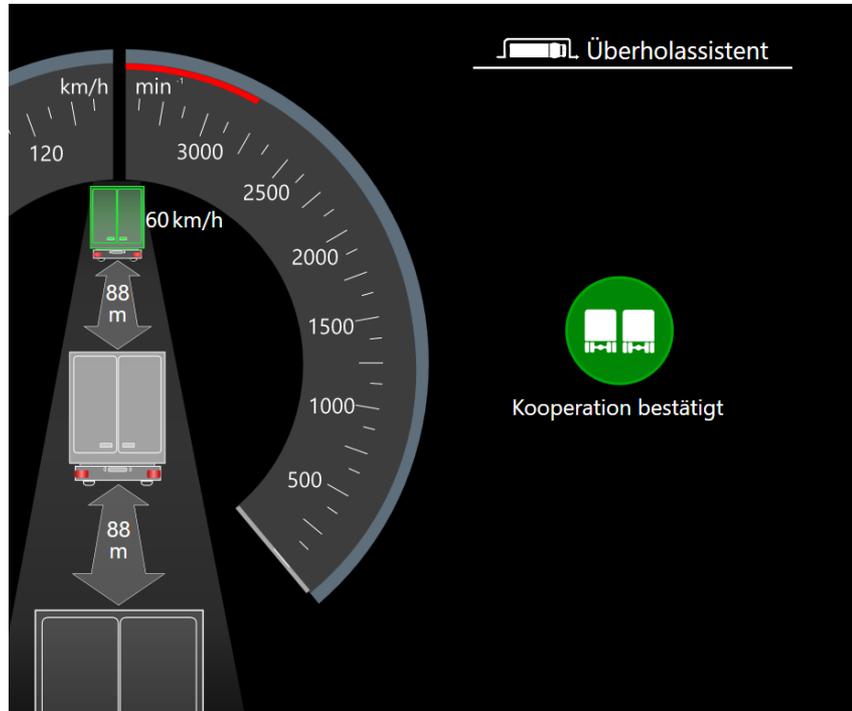
AP 5.2

Overall Evaluation

- Design recommendations

AP 3.5 HMI Development under Real Conditions

HMI with abort criterion



AP 3.5 HMI Development under Real Conditions

Results



System aborts lead to significantly **longer overtaking** maneuvers.
Truck drivers do **not consider function aborts to be critical** to safety.

Automated sending of cooperation requests
achieves a significant improvement in usability.

Slightly more cooperation **with voice assistant ICo**.
64% of truck drivers would prefer a **humanized visual HMI**.

Driving simulator
study
with 30 truck drivers



Our Work Packages



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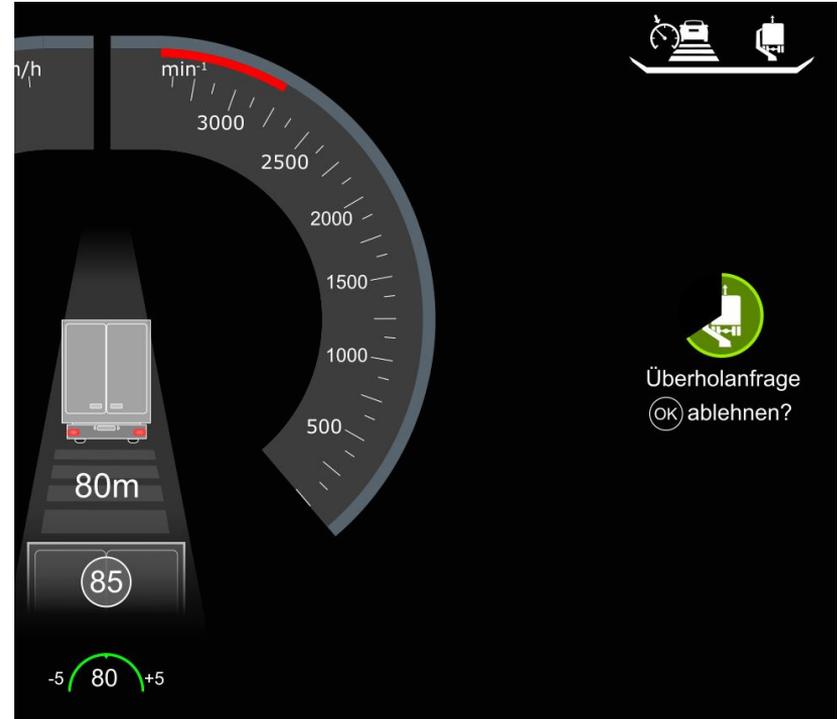
- Design recommendations

AP 5.2 Overall Evaluation

Further Development of HMI

Test Final Prototype

- **Information in text form**
moved to the right in the status bar
- uniform **symbolism**
- Default value for **cooperation requests**
set to "Accept"



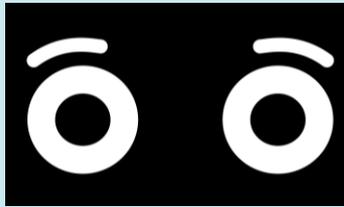
AP 5.2 Overall Evaluation

Further Development of HMI with ICo assistant



Test Final Prototype

- Extension with humanized assistant ICo



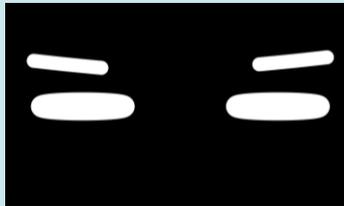
Default



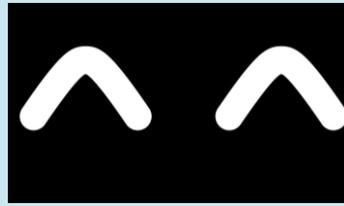
Sleeping



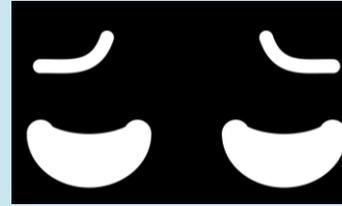
Winking



Angry



Happy



Sad

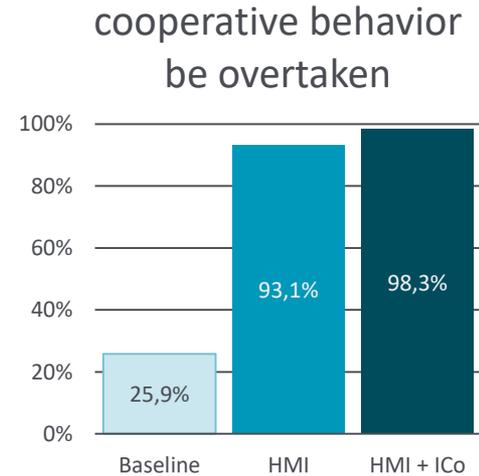
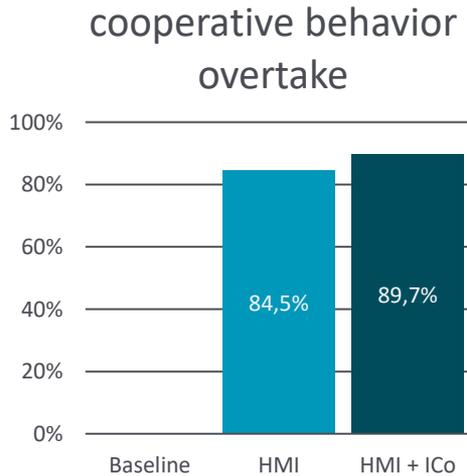


AP 5.2 Overall Evaluation

Results Cooperative Behavior



1. How does assistance affect the **overtaking behavior of truck drivers**?
Does assistance lead to **successful cooperative interactions**?



AP 5.2 Overall Evaluation

Results Cooperative Behavior



1. How does assistance affect the **overtaking behavior of truck drivers**?
Does assistance lead to **successful cooperative interactions**?



Time for overtaking



Shear-Out distance

Truck drivers wait until system predetermines ideal time.



Shear-In distance

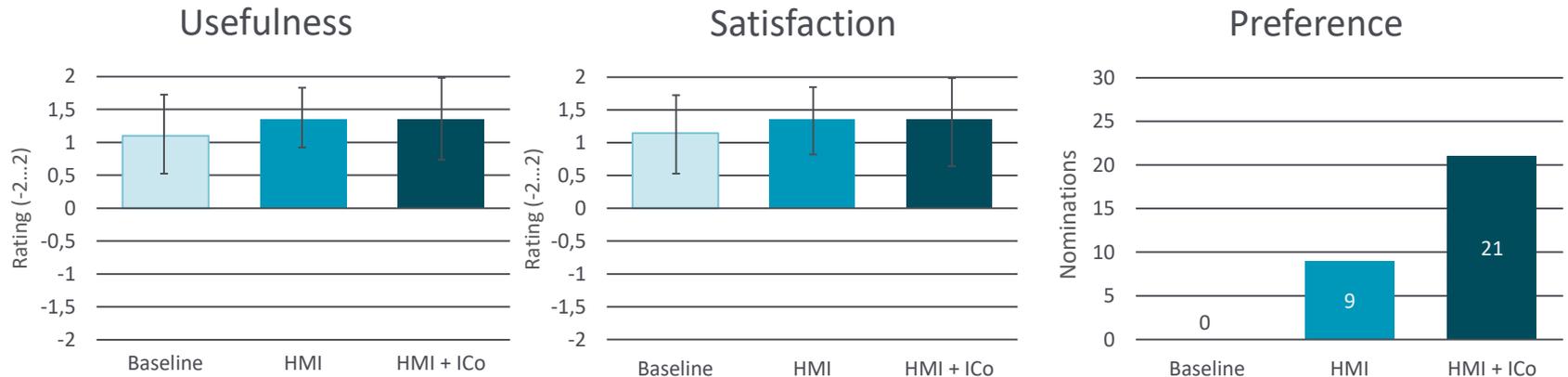
Truck drivers wait until system has reached a sufficiently safe distance.

AP 5.2 Overall Evaluation Results Acceptance



2. Do drivers accept overtaking assistance?

Acceptance (n=30)



AP 5.2 Overall Evaluation

Results Usability, User Experience, Trust

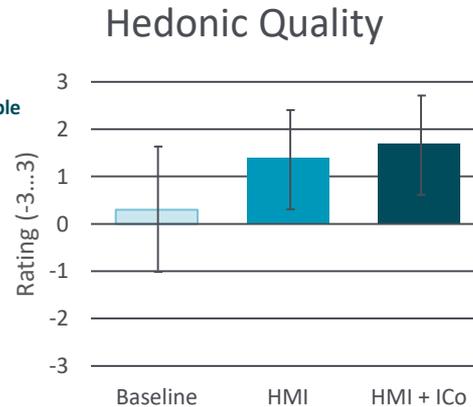


3. How do drivers rate the **usability**, **user experience** and **trust in the assistance**?

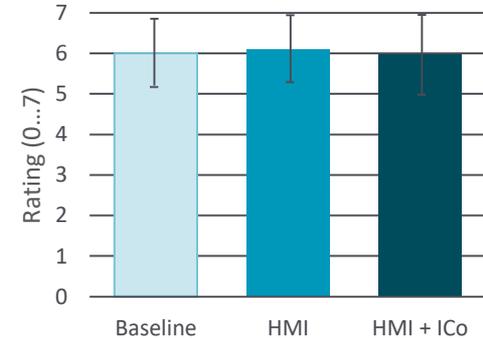
SUS-Score (n=30)



User Experience (n=30)



Trust (n=30)



AP 5.2 Overall Evaluation

Results Assistant ICo

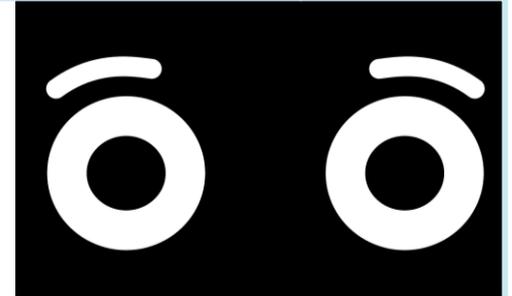
4. Will a **humanized assistant increase** acceptance and user experience?



Willingness to cooperate

But

- No significant difference in time for overtaking or subjective data
- HMI + ICo preferred, although subjective data do not provide a reason for this



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HMI Development for Cooperative Driver Assistance
Design Recommendations

Cross-functional HMI Principles and Findings

1. Interface Design

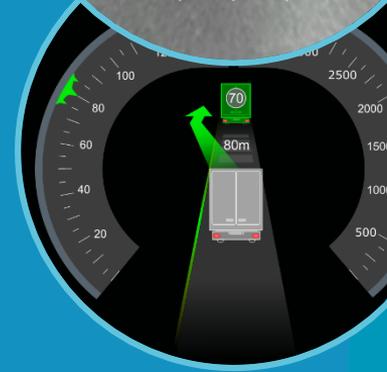
- Display type and location
- Display elements

2. Interaction with the system

- Design of cooperation requests
- Interaction under uncertainty conditions
- Motivation and persuasion strategies (e.g. gamification or humanization)

3. Driver information

- Cooperation partner
- Abort reason
- ...



Functionality and Characteristics of Cooperative Assistance

1. Evidence of general acceptance



2. Functionality requirements

- ...
- The simultaneous termination of cooperation of the system and automation in highly automated driving is inappropriate.
- ...



THANK YOU

Dr. Frank Diermeyer

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Supported by:



Federal Ministry
for Economic Affairs
and Climate Action

on the basis of a decision
by the German Bundestag

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