interACT

Designing cooperative interaction of automated vehicles with other road users in mixed traffic environments

Developing External Interfaces for Automated Vehicles: Preliminary results from the European interACT project

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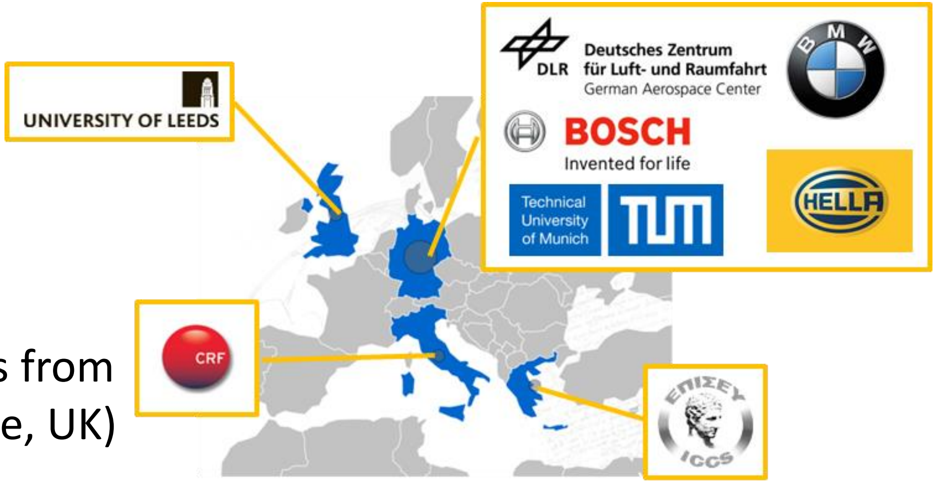
UNIVERSITY OF LEEDS

Project facts

- **Programme:** EU/H2020-**ART04** - *Safety and end-user acceptance aspects of road automation in the transition period*
- **Duration**: 36 months
- **Period**: May 2017 – April 2020
- **EU Funding**: 5.527.581 €
- **Coordinator:** Anna Schieben, DLR
- **Partners:** 8 industrial and academic partners from 4 European countries (Germany, Italy, Greece, UK)
- **Project Officer:** Begona Munoz (INEA)
- **US - EU twinning project**: AVIntent (NHTSA)



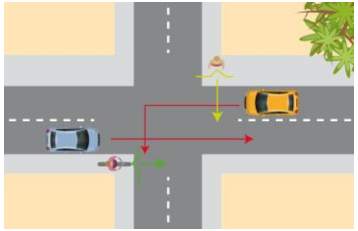
Integrating automated vehicles in mixed traffic

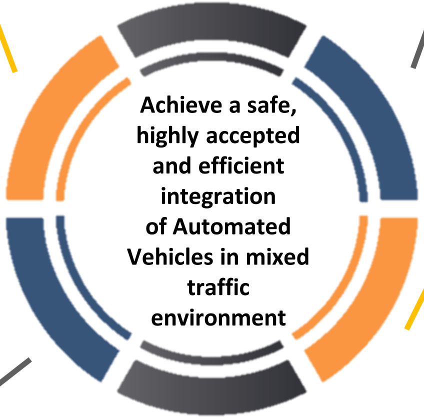
interACT

The challenge

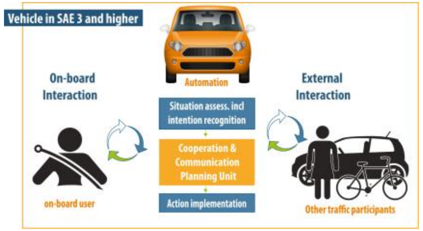
1st Objective
Psychological models

2nd Objective
Intention recognition & behavioural predictions





3rd Objective
CCPU & safety layer

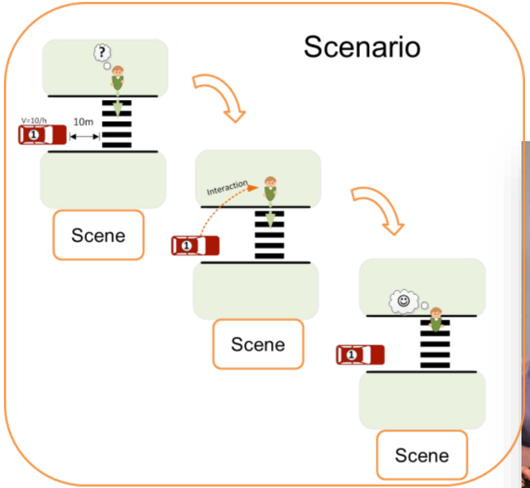


4th Objective
Novel HMI elements

5th Objective
Methodology for assessing the quality of interaction

Identification of suitable use cases

Common definition of use case and Scenario



Workshops to identify relevant use cases

Rating and agreement of addressed use cases

- relevance for safety
- frequency of occurrence
- relevance for traffic flow
- need for interaction with human road user
- Realisation in demo vehicles
- Realisation in driving simulator

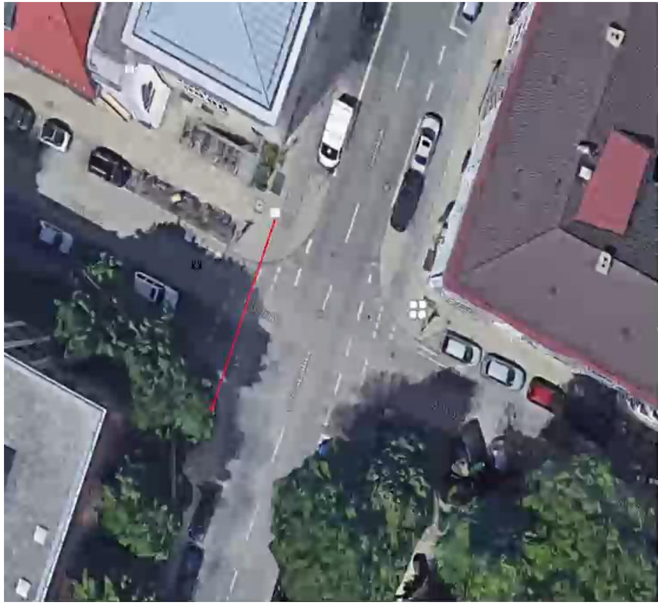
1st Objective:
Psychological models – results achieved

- Observational studies successfully conducted in three EU countries
- Data used:
  - to refine user requirements for the design of explicit and implicit communication strategies for AVs
  - to improve the situation assessment algorithms of the AV by providing a set of communication signs and behaviours intuitive to humans;
  - to design suitable algorithms for the *CCP Unit,* which ensures the AV behaves in an intuitive, expectation-conforming manner
- Further details: https://www.interact-roadautomation.eu/cad-webinar-series-ix-interact-project/

1st Objective:
Psychological models – results achieved

Generalizable Findings

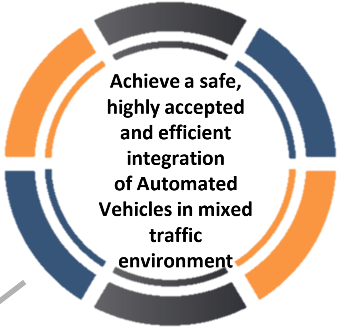
- Occurrence and **necessity of interactions** depends on the **situation** and a variety of **other influences**, such as traffic density, time of day and specific traffic conditions
- **Explicit communication (e.g. gesturing, flashing lights etc.) happens rarely** - most potential interaction-demanding situations are resolved before they actually arise, mostly by adjusting kinematic motion
- **Cooperation, communication and thus interaction** between human road users takes place at **low speeds**, usually below 20 km/h
- At **higher speeds conflict avoidance** is predominant – pedestrians use large enough inter-vehicle gaps to cross without expecting the second vehicle to adapt
- **Self reports ≠ reality**: Some pedestrians reported that they use some sort of visual information from the driver – even when the driver could not have been physically perceived



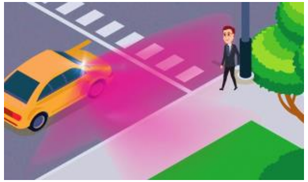
See Lee et al., submitted

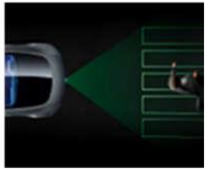
- Informed by:
  - Our observation studies
  - Current designs from others
  - Informed by discussions at various standardisation/regulatory fora, such as UNECE, OICA, ISO, SAE, CLEPA etc.

The challenge



4th Objective
Novel HMI elements





- Created a "catalogue of interaction messages"
  - → AV will turn
  - → AV turns
  - → AV will start moving
  - → AV has detected me etc.

- Must be clear, not distracting, visible, perceivable in daylight/rain/snow, for different speeds etc.

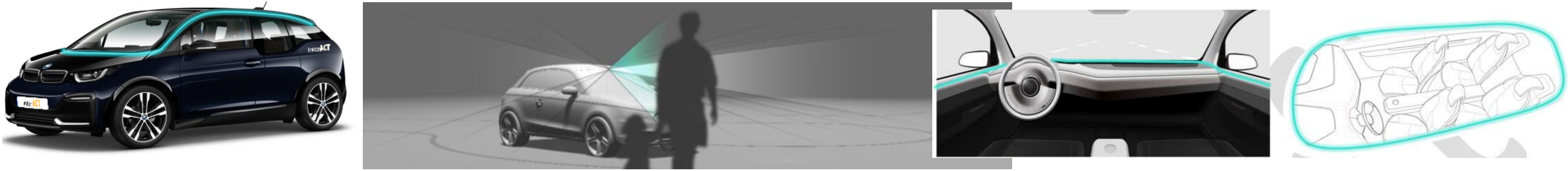
Main design decisions

- **Vehicle behaviour:**
  - Use as main communication means to communicate the intention clearly
  - Adapt vehicle behaviour when there is a “give way“ intention by the AV
- **eHMI design strategy:**
  - eHMI supports the smooth interaction with AVs
  - Same eHMI designs suitable for different urban scenarios
  - Only communication in situations that do need interaction, e.g. no communication such as “AV will not give way“
  - No advice/suggestions such as “walk“

4th Objective:

Novel HMI elements

- Provides research and solutions on how to design interaction strategies required for the three-way cooperation between all agents
- Under development:
  - 360° LED light band
  - Directed signal lamp
  - On-board HMI LED band and additional displays



[Willrodt et al. 2017; Kaup, 2019]

4th Objective:
Novel HMI elements

- Design the integrated interaction strategy and define messages (continuing from Sorokin et al., 2019)

Next manoeuvre
AV will start moving
AV starts moving

Cooperation Capability
AV gives way

Intention-based design (Next manoeuvre, Cooperation Capability)

Environmental perception
AV has detected (one or more) other/specific TPs

Perception-based design (Environmental perception)

D4.1: https://www.interact-roadautomation.eu/projects-deliverables/

Intention-based design

AV gives way

AV will start moving

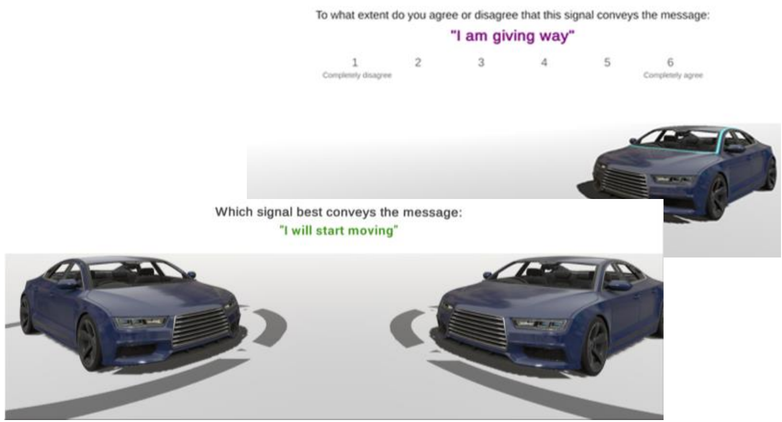
Perception-based design

Perception-based design

AV has detected other TPs

4th Objective:
Testing the novel HMI elements

- In total 10 different studies conducted so far at BMW, DLR and ITS Leeds, testing different eHMI and on-board HMI variants
- Research on:
  - Understanding the messages conveyed by Automated Vehicles (Lee et al., 2019)
  - Effects of eHMI on pedestrian and vehicle-AV interaction (Dietrich et al., 2019; Weber et al., 2019)
  - Comparison of different eHMI design variants (perception vs. intention based) (Kettwich et al., 2019)
  - Potential negative effects of eHMI designs
  - Multiple-actor scenarios
  - Effect of different urban scenarios on eHMI design



Lee et al. (2019)

Publications

- Lee, Y.M., Uttley, J., Madigan, R., Garcia, J., Tomlinson, A., Solernou, A., Romano, R., Markkula, G., & Merat, N. (2019). Understanding the messages conveyed by automated vehicles. 2019 Automotive User Interfaces, Utrecht, Netherlands.
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- Kaup, M. (2019). ‘I have detected you’ – Technical Approach of Perception based interaction of Automated Vehicles. ISAL 2019.
- Kettwich, C., Dodiya, J., Wibrink, M., & Schieben, A. (2019) Designing the interaction of pedestrians with automated vehicles – results of a virtual reality study testing intention- and perception-based design variants.
- Merat, N., Lee, Y. M., Markkula, G., Uttley, J., Camara, F., Fox, C., ... & Schieben, A. (2019, July). How Do We Study Pedestrian Interaction with Automated Vehicles? Preliminary Findings from the European interACT Project. In Automated Vehicles Symposium (pp. 21-33). Springer, Cham. DOI: 10.1007/987-3-030-22933-7_3
- Sorokin, L., Chadowitz, R., & Kauffmann, N. (2019). Accepted. A Change of Perspective: Designing the
- Automated Vehicle as a New Social Actor in a Public Space. In *CHI Conference on Human Factors*
- *in Computing Systems Extended Abstracts (CHI’19 Extended Abstracts)*.
- Schieben, A., Wilbrink, M., Kettwich, C., Dodiya, J., Weber, F., Sorokin, L., Lee, Y.M., Madigan, R., Markkula, G., Merat, N., Dietrich, A., Kaup, M. (2019). Testing external HMI designs for automated vehicles – An overview on user study results from the EU project interACT. Automatisiertes Fahren, 2019, Munich.

Understanding the Value of External HMI in Communication of Intent by Automated Vehicles

Room: Crystal E/F
Wednesday, July 17, 2019: 1:30 PM - 5:30 PM

Speaker(s)

Andy Schaudt
Project Director, Automated Vehicle Systems
Virginia Tech Transportation Institute

Azra Habibovic
Senior Researcher
RISE Research Institutes of Sweden

Josh Domeyer
Engineer
Toyota Collaborative Safety Research Center

Natasha Merat
Professor, Human factors and transport systems, Institute for Transport Studies
Univesrity of Leeds

Satoshi Kitazaki
Director, Automotive Human Factors Research Center
National Institute of Advanced Industrial Science and Technology

Sid Misra
Co-founder and CEO
Perceptive Automata

Upcoming activities of interACT

The challenge

5th Objective
Methodology for assessing the quality of interaction

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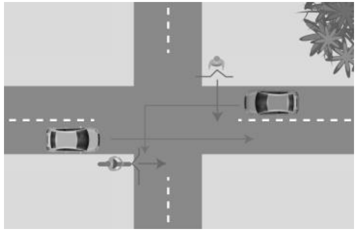
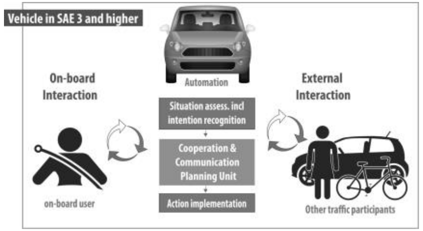
4th Objective
Novel HMI elements



2nd Objective
Intention recognition & behavioural predictions

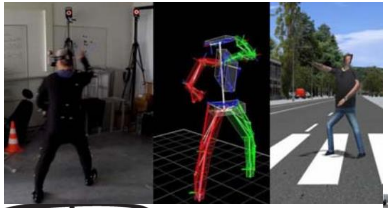


3rd Objective
CCPU & safety layer

5th Objective:

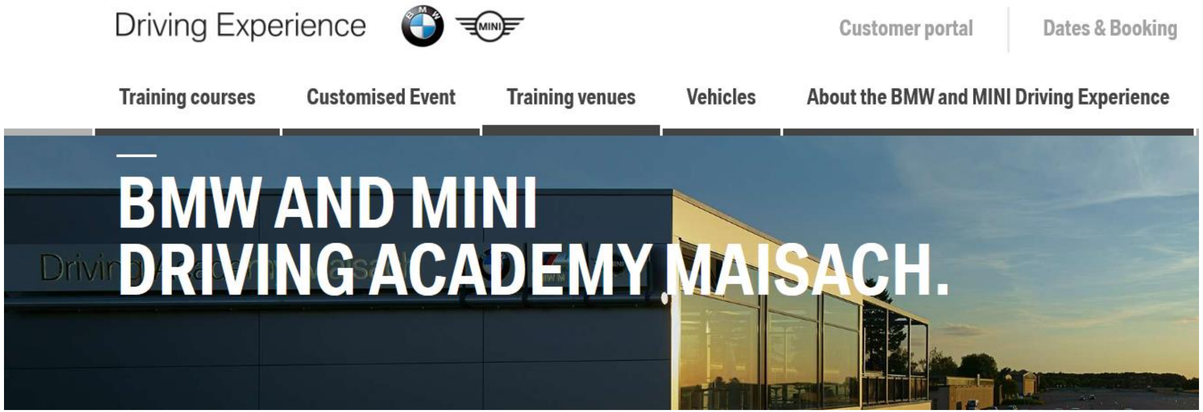
Methodology for assessing the quality of interaction

- Measuring cooperation capabilities of AVs with other road users is a new area of research.
- Develop methodologies required to measure and quantify how the on-board user, the AV and other road users establish and use each-others' intentions and behaviour
- Impact assessment, safety and user acceptance



Want to find out more?

- Come to our Final Event: 1st of April 2020!



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http://interact-roadautomation.eu

Thank you

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