interACT

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

Automated vehicles in mixed traffic environments
The interACT Project

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Institute of Transportation Systems, DLR e.V.
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Integrating automated vehicles in mixed traffic

interACT project facts

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

Programme: EU/H2020-**ART04** - *Safety and end-user acceptance aspects of road automation in the transition period*

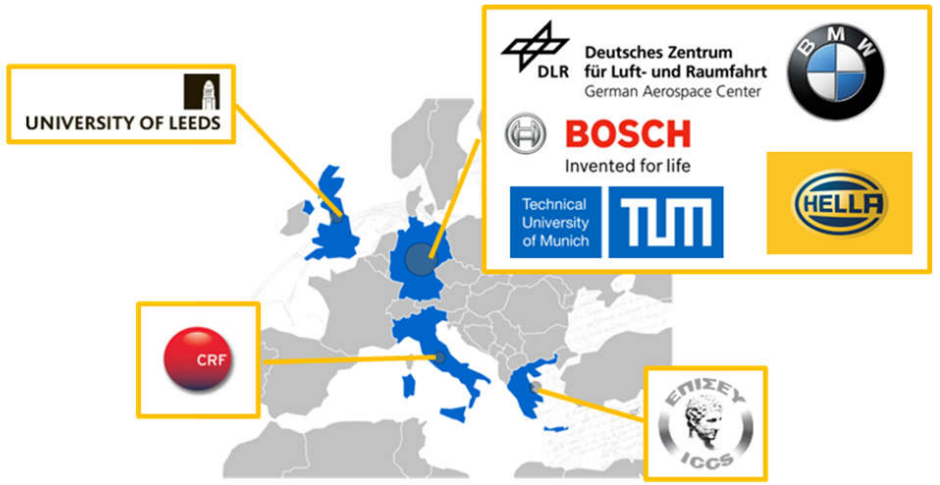
Period: May 2017 – April 2020

EU Funding: 5.527.581 €

Coordinator: Anna Schieben, DLR e.V.

Partners: 8 industrial and academic partners from 4 European countries (Germany, Italy, Greece, UK)

EU twinning project: AVIntent (NHTSA)



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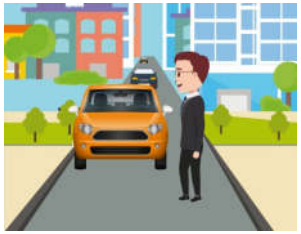

The challenge

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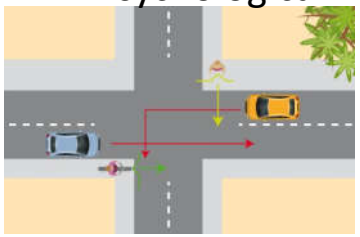
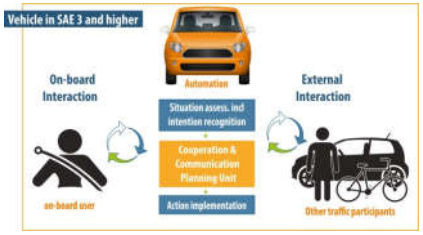
5th Enabler
Methodology for assessing the quality of interaction

Achieve a safe, highly accepted and efficient integration of Automated Vehicles in mixed traffic environment

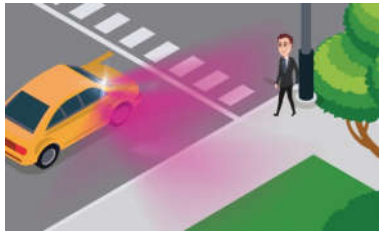
1st Enabler
Psychological models



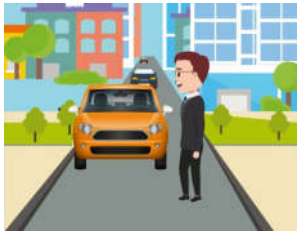
2nd Enabler
Intention recognition & behavioural predictions



3rd Enabler
CCPU & safety layer



4th Enabler
Novel HMI elements



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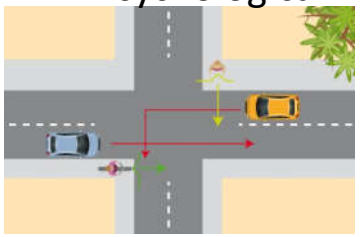

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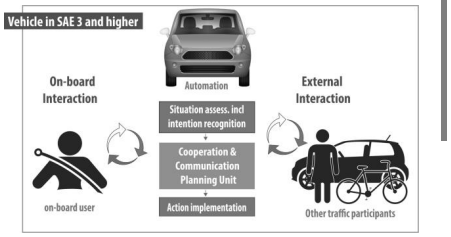

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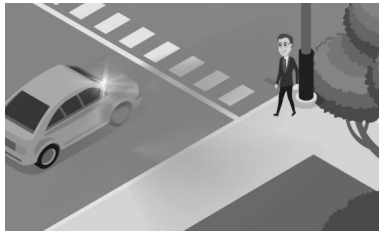


OBSERVATIONAL STUDIES

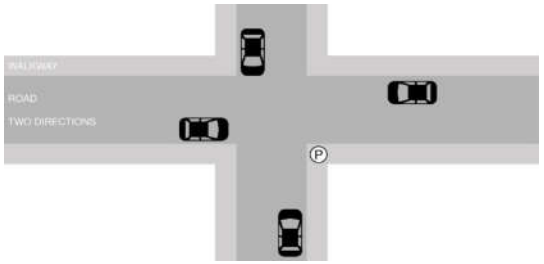
Objectives of the studies

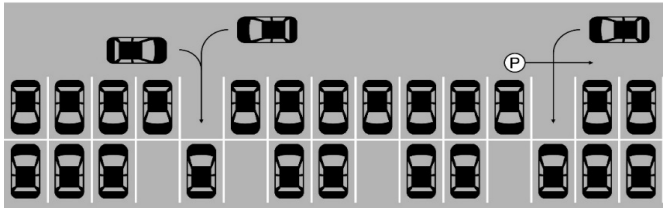
- Observe human-human interactions in current complex urban environments
- Model interaction using different approaches
  - Interaction vocabulary: *How do TPs communicate and anticipate intent*
  - Interaction sequences: *What is the general interaction process in specific use cases, scenarios and scenes?*
  - Quantitative models: *How can interactions be mathematically formulated to allow model in the loop simulations?*
- Develop real-time situation and intention analysis algorithms based on the interaction models

Observe, Model, Predict

Methodology

- 3 Countries: Greece, UK, Germany
- 4 urban use cases

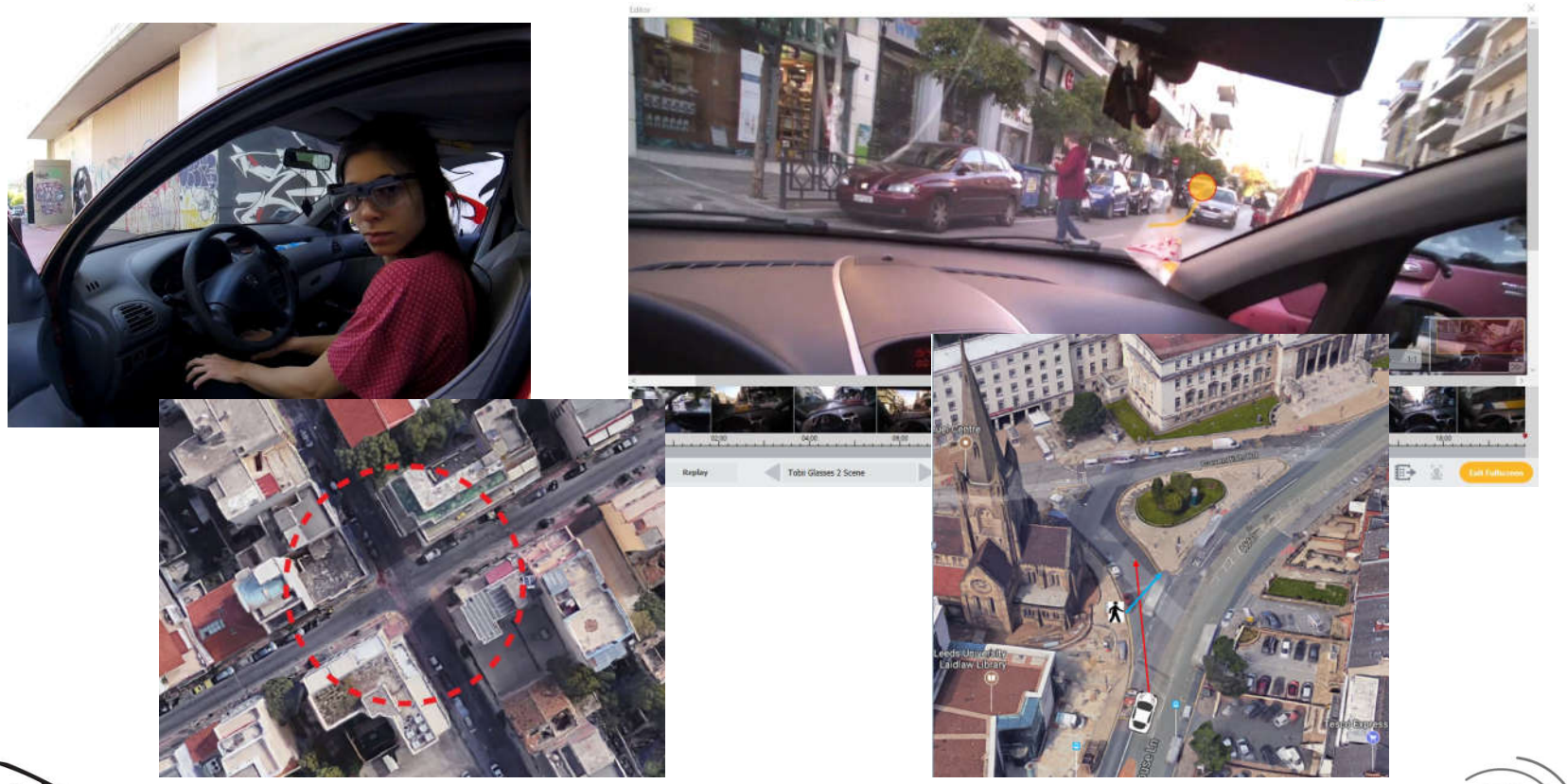




Data assessment

- Videos
- Observation Protocols
- Questionnaires
- LiDAR

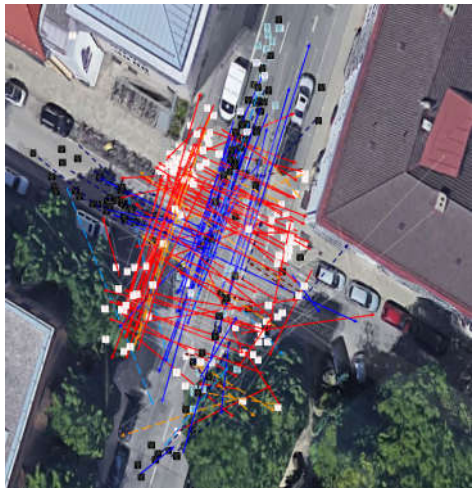
Observation sites



Preliminary Results – Manual Observation

- Over 100 Protocols per use case and country

- Also: combined 100+ hours of videos, 20+ hours of LiDAR Data and 150+ people interviewed



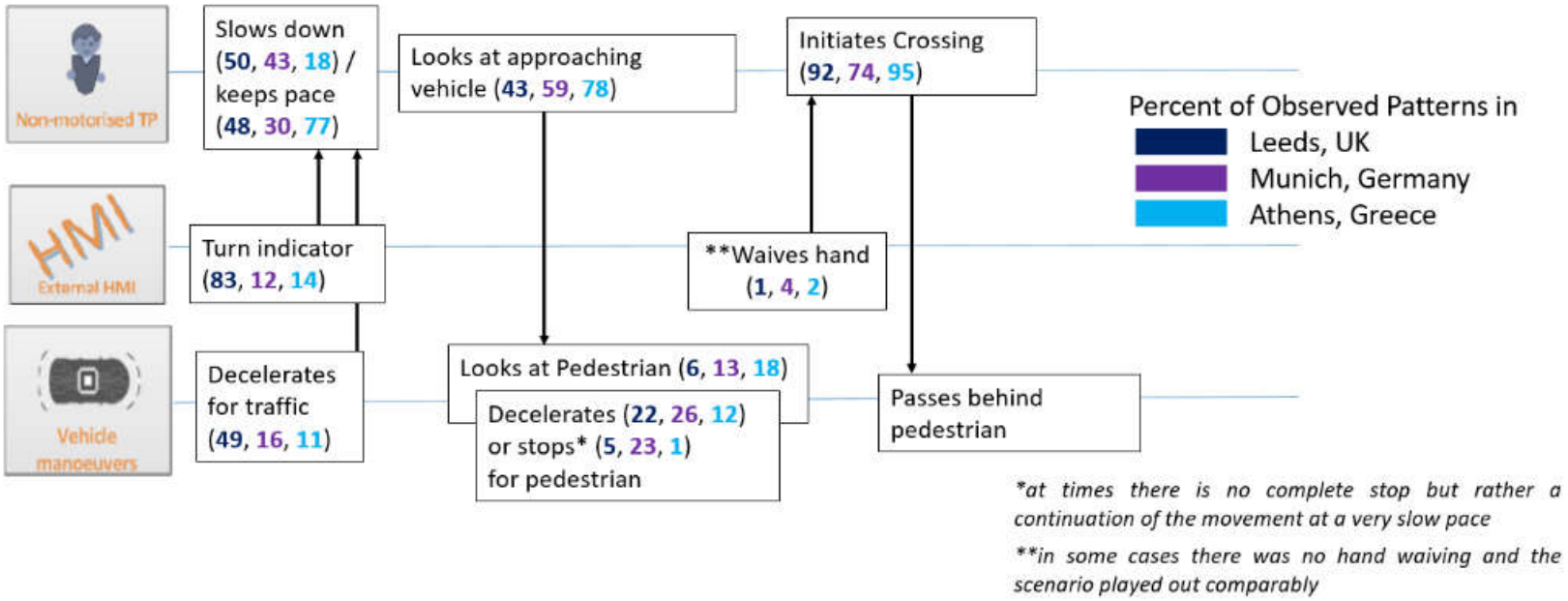
Interaction vocabulary

Table 6: Interaction Vocabulary

Traffic Participant	type of physical signifier	Sign type (physical signifier)	examples
Car/Driver	Driver's behaviour	**Hand gesture**	e.g. move hand sideways, show palm
		Head Nodding	e.g. sideways, downwards, …
		Eye-contact	e.g. with pedestrian, with other driver
	Car	**Car movement**	e.g. accelerate, kept pace, Stopped, turned
		Car positioning	e.g. protruding on intersection, keeps left/right
		Engine noise	e.g. rev-up the engine on idle
	Car HMI	**Turn indicator**	Left / right
		Headlights flashing	
		Horn	e.g. one long press, one momentary, two.…
		Alarm indicator	
Pedestrian	Pedestrian's body	**Hand gesture**	e.g. raised hand, extending palm, waving …
		Head Nodding	e.g. sideways, downwards, …
		Eye-contact (with car driver)	
		Gaze towards car (when it is clear that the pedestrian has seen the car)	
		Head/body orientation (combined since semantically they form a whole)	e.g. facing car, facing sideways, …
		Body movement	e.g. walking parallel towards car, hesitating, accelerating, …

Preliminary Results – Manual Observation

“Interaction Sequence” - Intersection – pedestrian goes first:



Driver-driver interaction

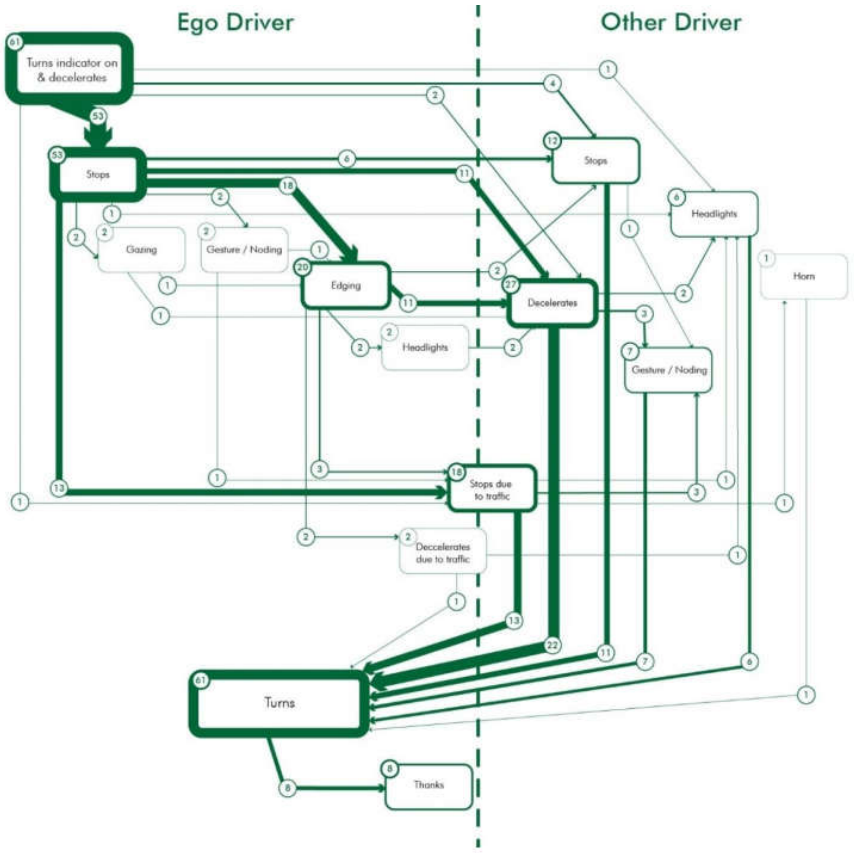


Figure 37: Sequences of observed signals/cues in interactions between drivers relevant to left turns

Overall findings

- The occurrence and necessity of interactions depends on the situation and a variety of **other factors**, 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**
- At **higher speeds, conflict avoidance** is predominant – pedestrians use large enough inter-vehicle gaps to cross without expecting the second vehicle to adapt

Some (preliminary) conclusions

- The use of “external Human Machine Interfaces” is only relevant in **ambiguous situations**, when explicit communication is necessary above and beyond *kinematic cues*

- **BUT** – Unlike manually driven vehicles, in addition to adapting their movement, perhaps Automated Vehicles could **enhance acceptance, safety and traffic flow** by communicating to other traffic participants earlier.

HMI Design

Design considerations for automated vehicles

Which information could be needed by other road users?

- Category A: **Vehicle driving mode**
  - Automated or manually driven vehicle
- Category B: **Vehicle's next manoeuvres**
  - E.g. Vehicle will start moving
- Category C: **Perception of environment**
  - E.g. pedestrian is detected
- Category D: **Cooperation capability**
  - E.g. Vehicle willing to cooperate, gives right of way

Cited from *Schieben, Wilbrink, Kettwich, Madigan, Louw & Merat* (2018): Designing the interaction of automated vehicles with other traffic participants: Design considerations based on human needs and expectations. Cognition, Technology and Work. pp 1-17. https://doi.org/10.1007/s10111-018-0521-z

Design options

Design of infrastructure

- Separated tracks, signs

Design of vehicle shape

- e.g. Google car

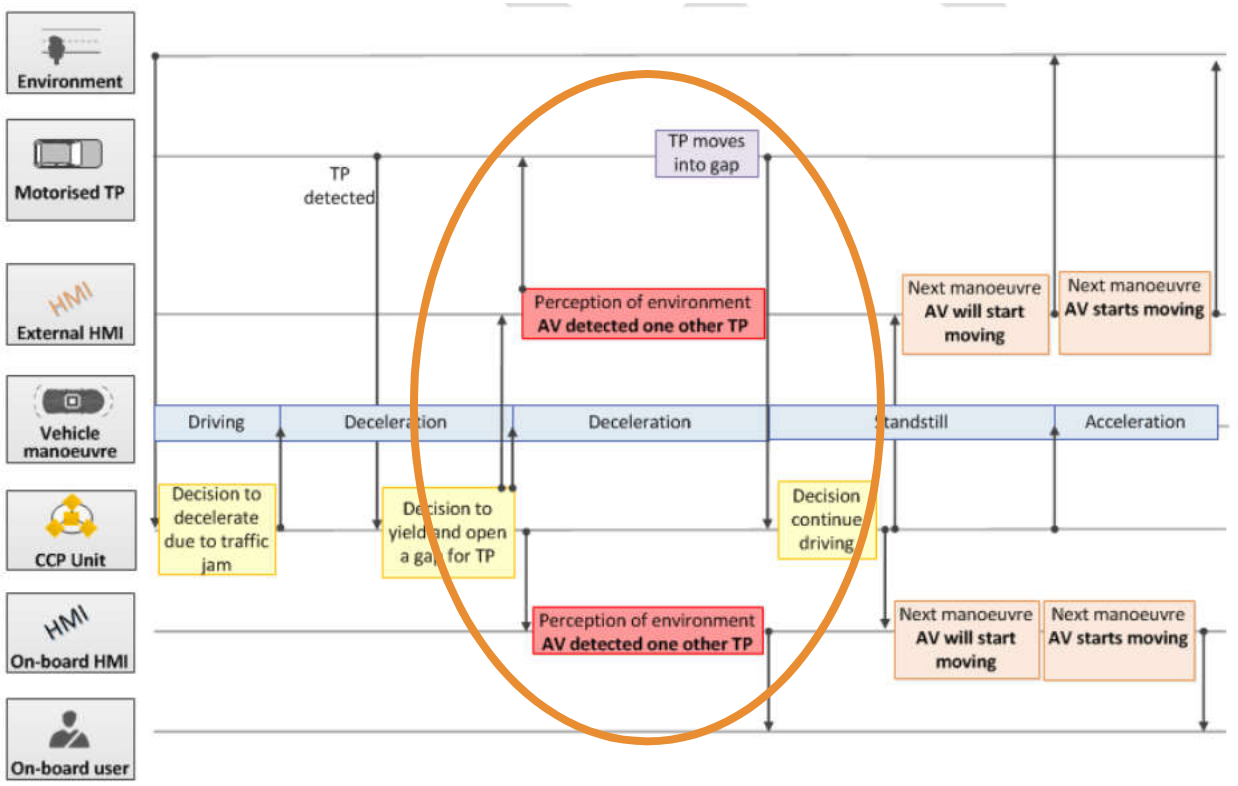
Design of vehicle movements

- e.g. approaching behaviour

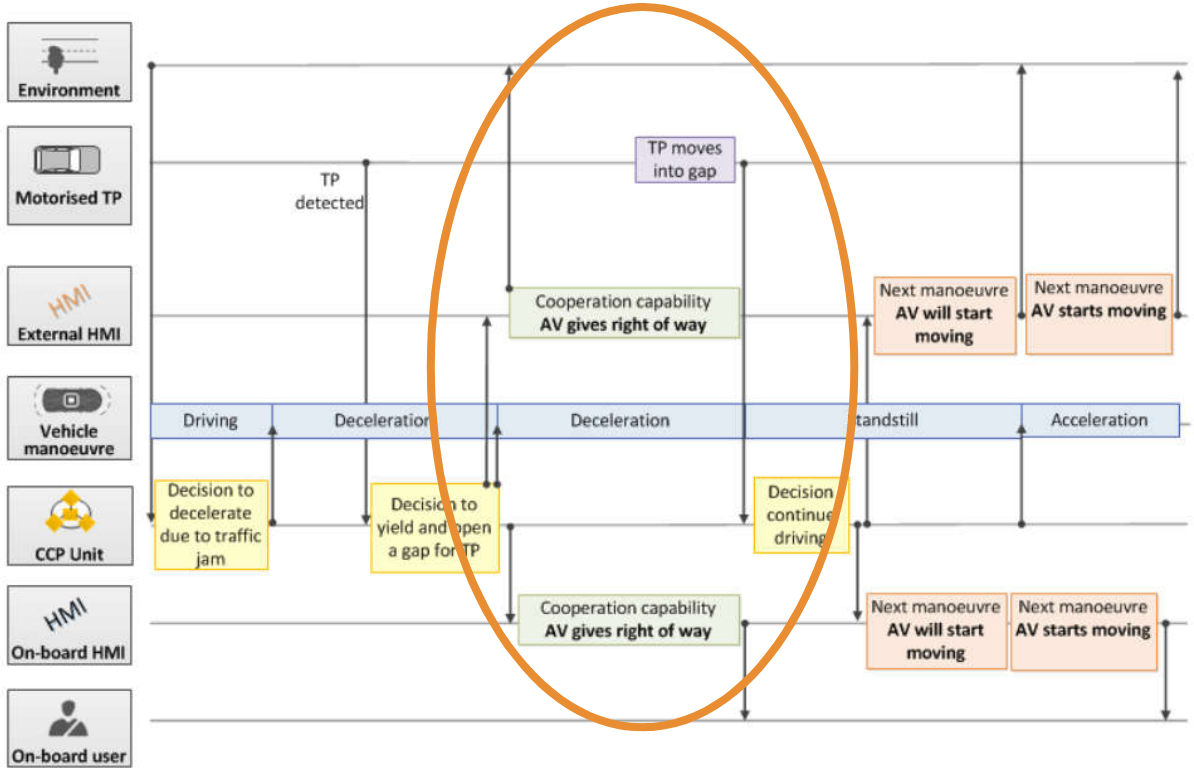
Design of external HMI

- Visual, acoustic signals

Interaction strategies: Perception-signaling design



Interaction strategies: Intention-signaling design



Further project information

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Deliverables: https://www.interact-roadautomation.eu/projects-deliverables/

Webinar Results Observational studies:
https://www.interact-roadautomation.eu/cad-webinar-series-ix-interact-project/
https://www.youtube.com/watch?v=in4eTz1f5Fc&feature=youtu.be

Webinar Technical Approach:
https://www.interact-roadautomation.eu/cad-webinar-series-xii-designing-cooperating-interactions-of-avs-with-other-road-users-interact-project/
https://www.youtube.com/watch?v=Xy2soHjSAxY&t=11s

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Thank you

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