interACT Scenarios: Selection & Implementation

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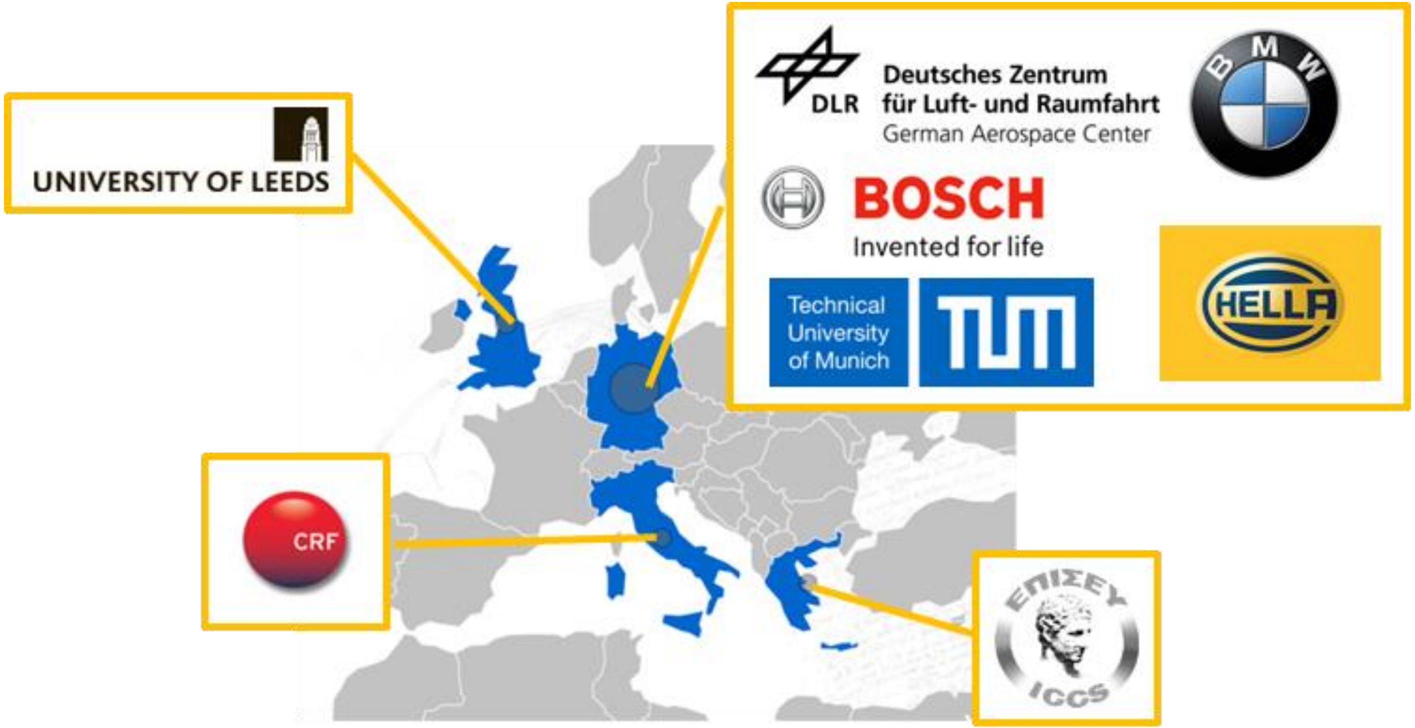
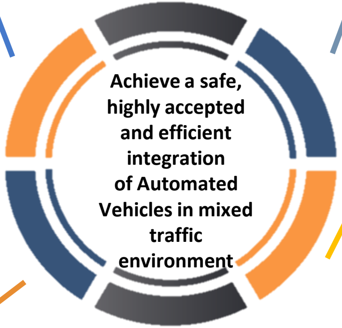
Project Consortium



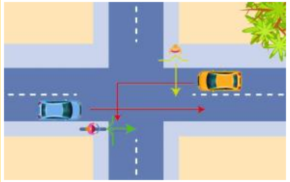
The challenge

1[st] Enabler
Psychological models

5[th] Enabler
Methodology for assessing the quality of interaction



4[th] Enabler
Novel HMI elements

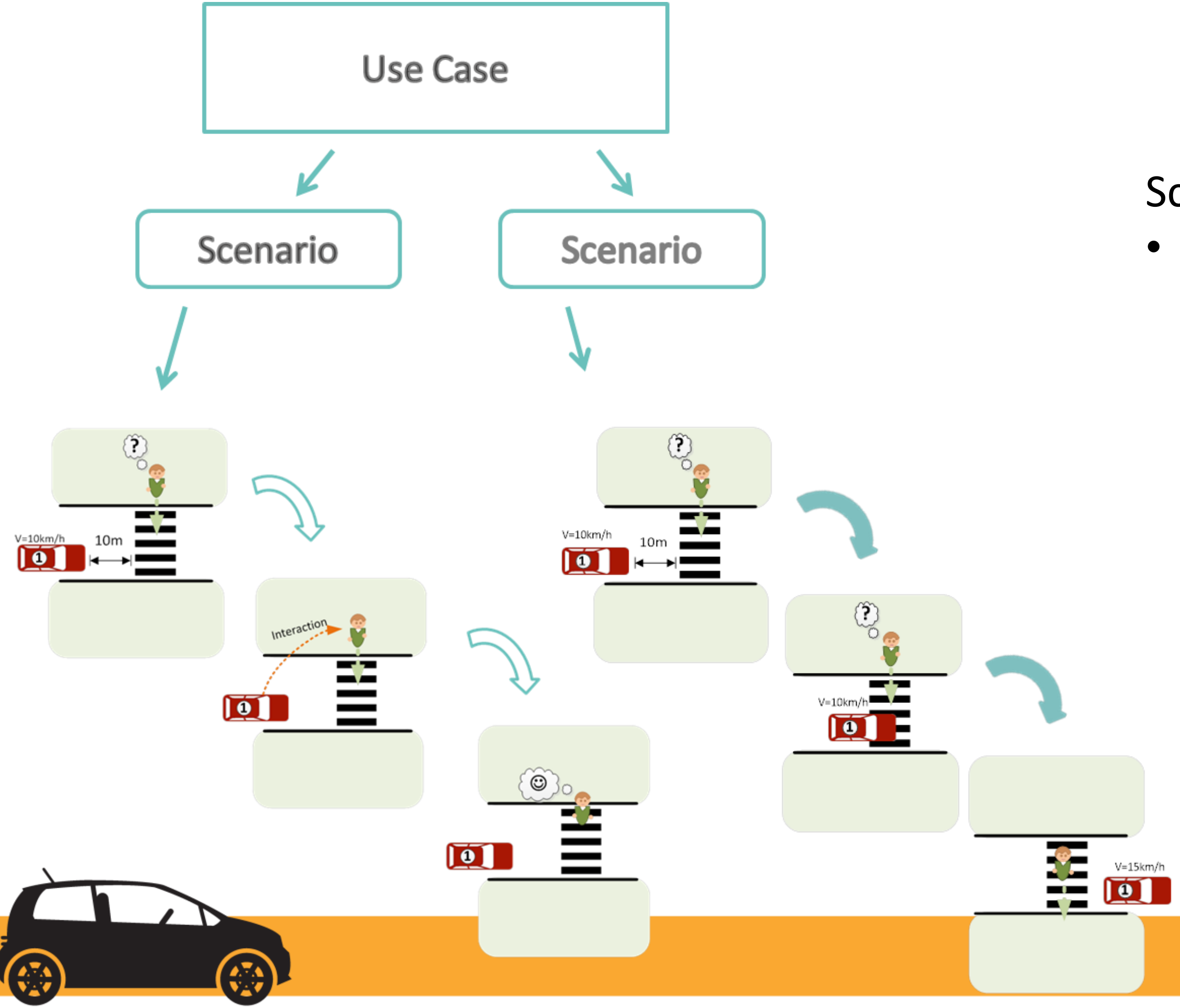


2[nd] Enabler
Intention recognition & behavioural predictions

3[rd] Enabler
CCPU & safety layer

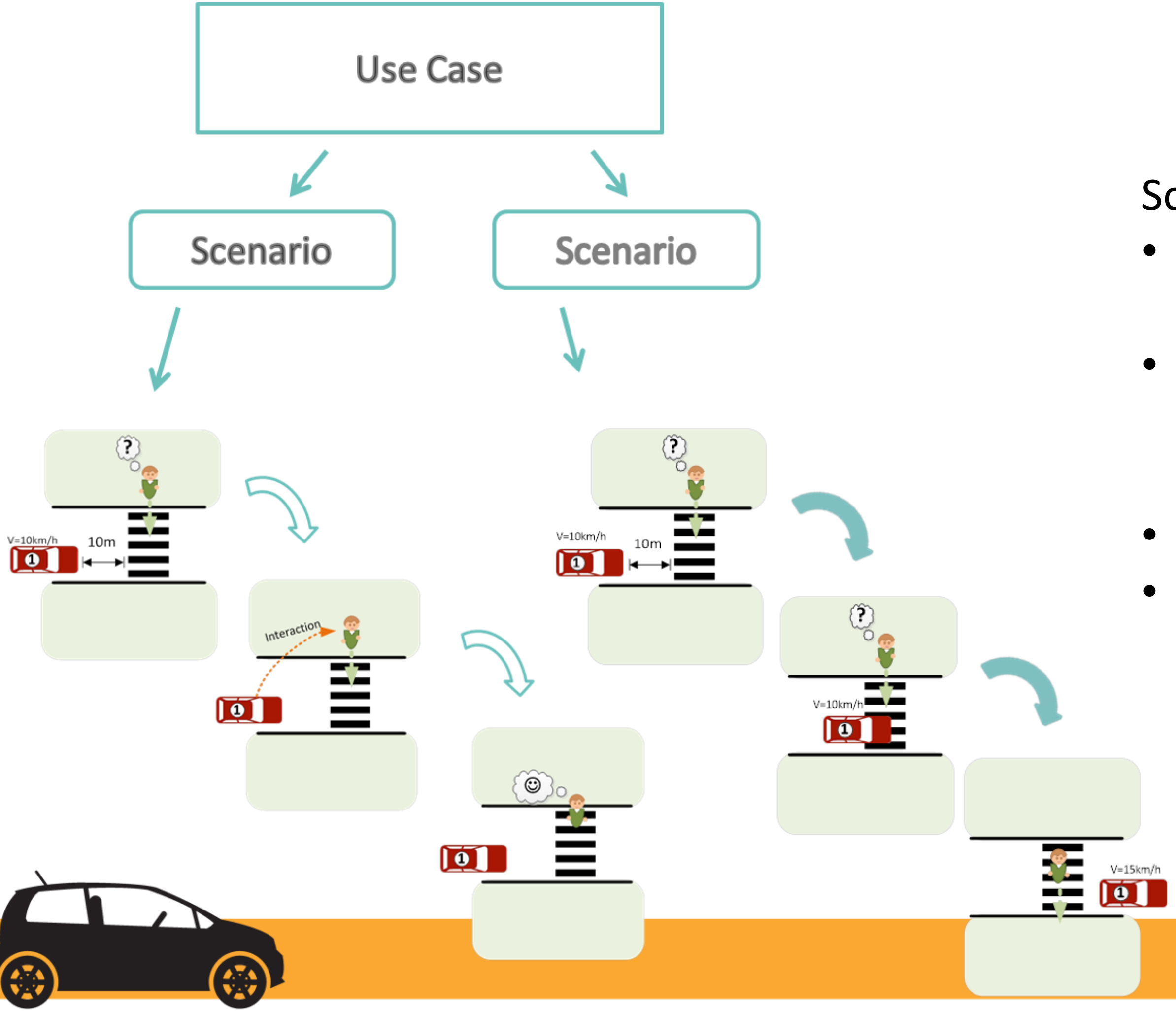
Purpose of Presentation

- Overview of initial interACT scenario selection process:
  - Definition of terms
  - Description of selected use cases
- Implementation and adaptation process:
  - Evaluation of current traffic interactions
  - Specification of scenario details for implementation within AV systems
- Plans for evaluation of AV – human interactions within selected scenarios



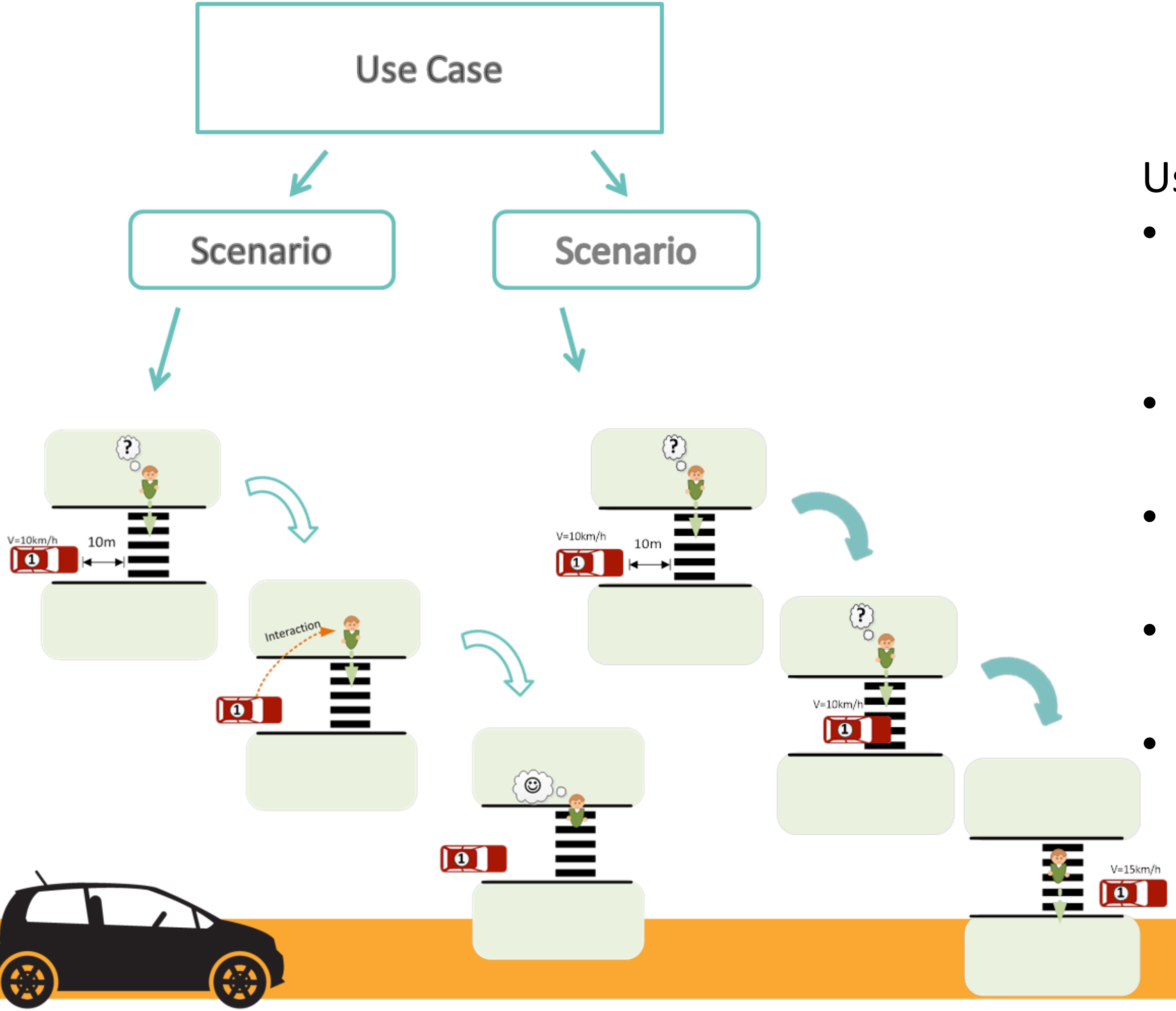
Scene:

- Provides a snapshot of the environment:
  - Scenery (Lane network, stationary elements, traffic lights, obstacles);
  - Dynamic elements (cars, road users);
  - Lasts only a few seconds



Scenario:

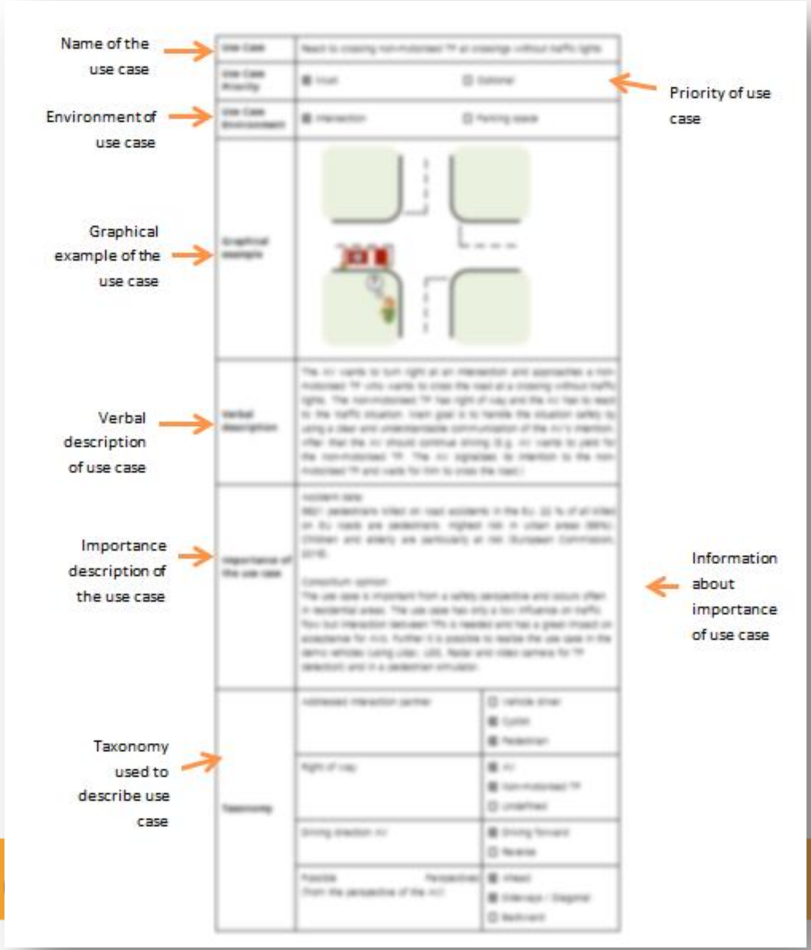
- Temporal development between several scenes;
- A sequence of scenes connected by actions & events;
- Includes goals of the agents;
- Spans a longer amount of time



Use Case:

- Functional description for a technical system (AV) & its behaviour for a specific usage
- E.g. the AV has to pass a zebra crossing safely;
- Specification of system boundaries;
- Definition of one or several scenarios;
- Not as specific as the scenario or scene descriptions

Template for Use Case Description



Attributes	
Addressed interaction partner(s)	Vehicle driver Cyclist Pedestrian
Right of way	AV Human road user Undefined
Driving direction AV	Driving forward Reverse
Possible perspectives of the interaction (from the perspective of the AV)	Ahead Sideways / Diagonal Backward

Sequence Diagrams

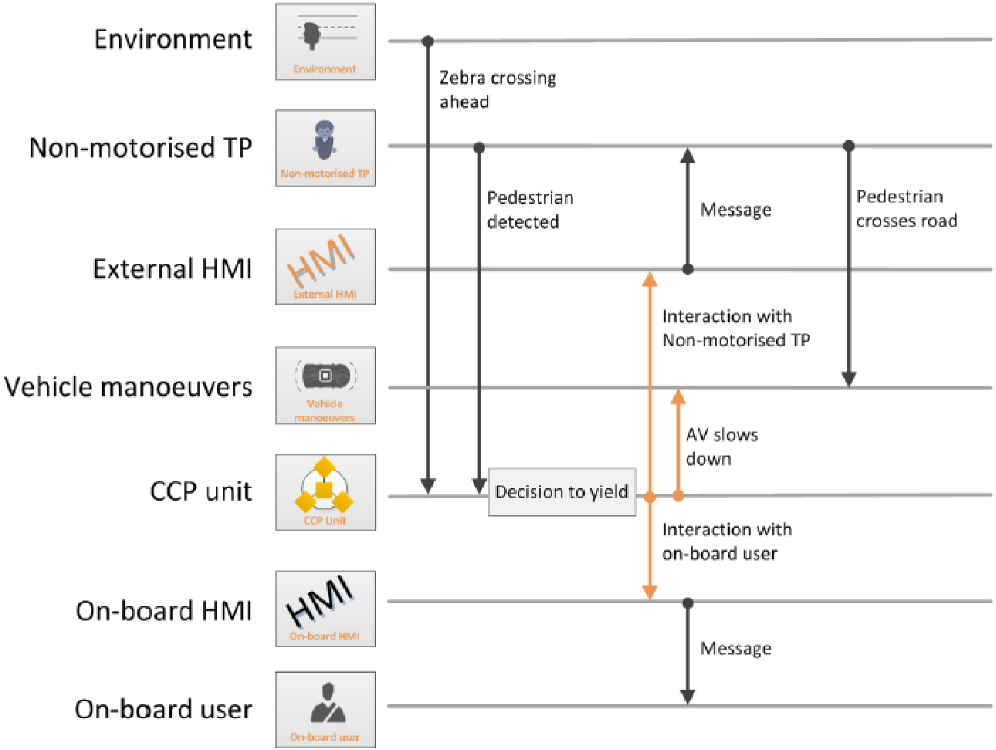
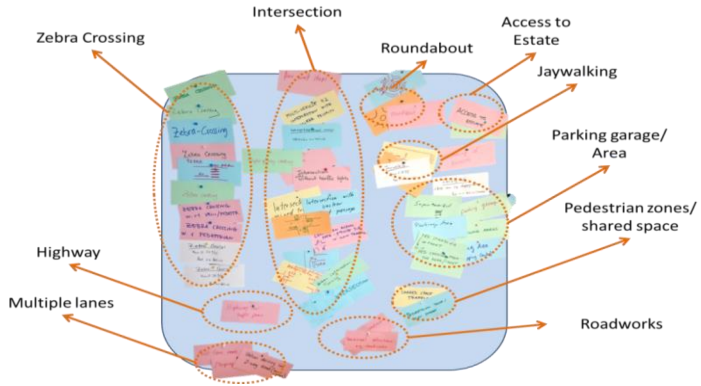


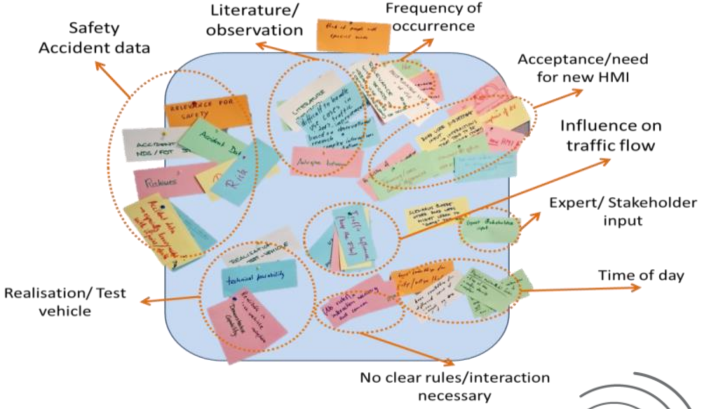
Figure 12: Sequence diagram for a zebra crossing scenario

https://www.interact-roadautomation.eu/wp-content/uploads/interACT_WP1_D1.1_UseCases_Scenarios_1.1_approved_UploadWebsite.pdf

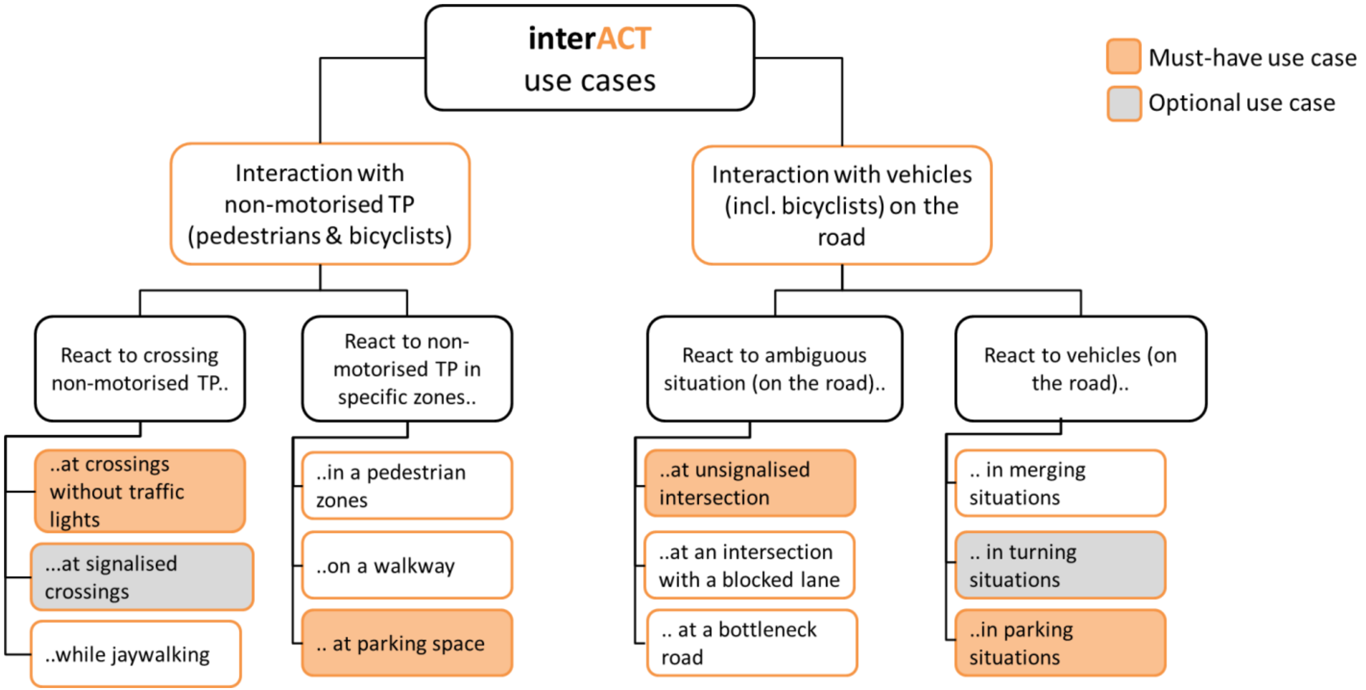
Selection of Use Cases

- Brainstorming workshop
- Criteria:
  - Relevance for safety
  - Frequency of occurrence
  - Relevance for traffic flow
  - Need for interaction with human road users
  - Effects on user acceptance
  - Realization in demo vehicles
  - Realization in simulators

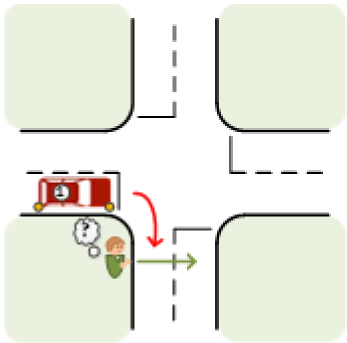


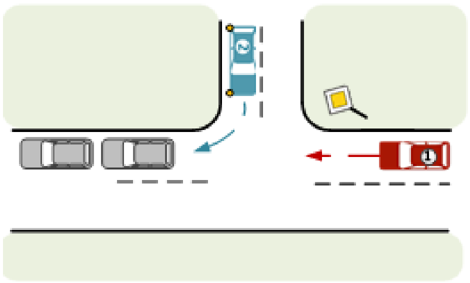


Selected Use Cases



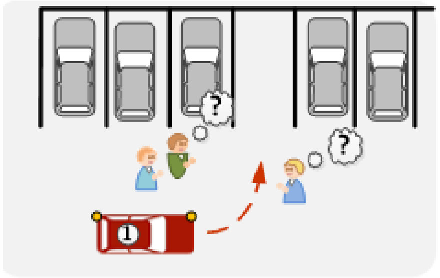
React to crossing non-motorised TP at crossings without traffic lights

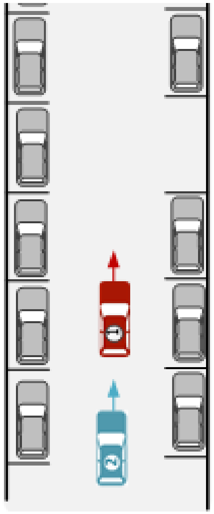




React to an ambiguous situation at an unsignalised intersection

React to non-motorised TP at a parking space





React to vehicles at a parking space

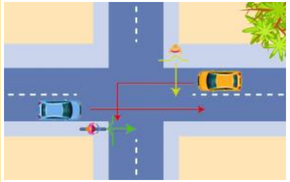
The challenge

5[th] Enabler
Methodology for assessing the quality of interaction

1[st] Enabler
Psychological models

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

4[th] Enabler
Novel HMI elements



2[nd] Enabler
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3[rd] Enabler
CCPU & safety layer

Use Case Implementation: Current traffic interactions

- Purpose of research:
  - Understanding and modelling current traffic to help identify **interaction-demanding situations** and how traffic participants resolve them using currently available **means of communication**

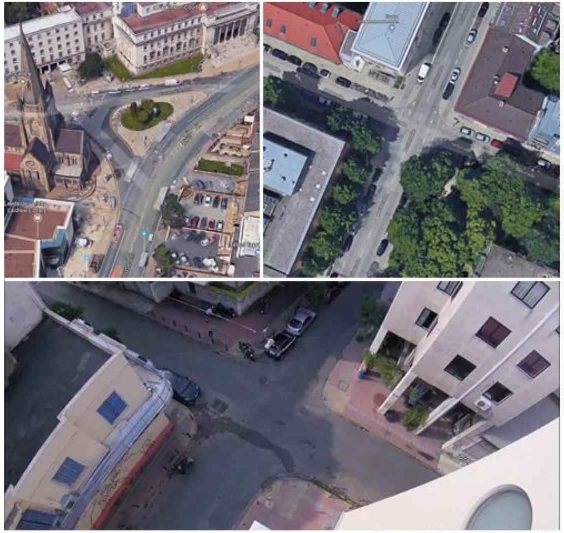

Figure 7: Pictures from the locations used for use cases 1 and 2. Top left: Google Maps image from Leeds (UK), top right from Munich (Germany), bottom picture from Athens (Greece)

Figure 11: Edited Google images from the locations chosen to observe use case 3 (left) and 4 (right) on a shared space in Germany

Use Case Implementation: Current traffic interactions

- Methods:
  - Naturalistic observations using protocols
  - Video data
  - LiDAR
  - Questionnaires
  - Commentary driving
- Overall results:
  - Few examples of explicit communication in use cases 1 and 2
  - More common in slow-moving situations captured in use cases 3 and 4

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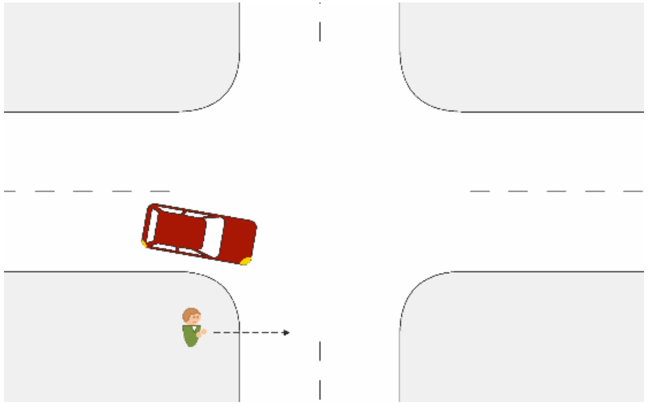
Adaptation & Specification of Use Cases for AV studies

- Providing a greater level of detail on the scenarios to enable the interACT AV's Coordination and Communication Planning Unit (CCPU) to evaluate how to progress

- For example in Use Case 1, the specification of different pedestrian behaviors, leading to:
  - **Scenario 1:** Pedestrian waiting for the vehicle to show action
  - **Scenario 2:** Pedestrian crossing the road and
  - **Scenario 3:** Pedestrian attempting to cross, but then noticing the AV and giving way to it (implicitly, e.g. stepping back, or explicitly, e.g. waving).



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Implementation of Scenarios

- Evaluating the interACT final solutions through:
  - Simulator based studies (Leeds, DLR)
  - Test-track studies / parking lot studies (CRF, BMW, ICCS, Leeds, TUM)
  - On-road studies (BMW and TUM)

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Capturing AV – Pedestrian Interactions (1)

- DLR: Simulator Studies:
- Comparison of pedestrians crossing behaviours in response to an AV with an eHMI, conventional vehicles, and AVs without an eHMI. Measures include:
  - Crossing decision point
  - Checking behaviour
  - Perceived certainty
  - Perceived safety

for information on HMI design see: https://www.interact-roadautomation.eu/wp-content/uploads/interACT_WP4_D4.2_Final_Human_Vehicle_Interaction_Strategies_v1.1_uploadWebsiteApproved.pdf

Capturing AV – Pedestrian Interactions (2)

- ITS Leeds, Cave Based Studies:
  - Evaluation of the effects of the interACT eHMI solutions on pedestrians' crossing decisions and behaviour
  - Effect of congruent and incongruent eHMI on pedestrians' crossing behaviour,
  - Effect of different speeds, deceleration rates, and deceleration onsets on crossing behaviour.
- Investigation of the interaction between drivers and pedestrians in real time at junctions
  - connecting HIKER with driving simulator

Capturing AV – Vehicle Interactions (1)

- Evaluation of interACT communication solutions (simulator study, DLR)
- Are there **learning effects** when drivers interact with a self driving vehicle with an external HMI?
  - Without signal, when it is braking, or braking with HMI
  - With small, medium or large gap size
  - When encountering different situations
- Does the driver
  - Turn earlier or more frequently?
  - Turn smoother?
  - Understand the intention of the automated vehicle better?
  - Accept smaller gaps?

Capturing AV – Vehicle Interactions (2))

- Test Track study (ICCS)
- AVs interactions with other drivers in no priority situations at urban intersections (AV yielding to a human driver in a left turn manoeuvere)
- **Objective:**
  - Study driver's interaction with an AV compared to an interaction with a conventional vehicle during a left turn
  - Study impact of eHMI on driver's interaction

Application of Scenarios using Demonstrator Vehicles (1)

- BMW Demonstrator
- Wizard-of-oz study to investigate three main research questions :

1. Do Pedestrians understand the vehicle’s intention, as conveyed through the eHMIs?
   – Learnability: Is there a behavioural adaptation/ adaptation of mental models from the first compared to following encounters?
   – Compliance: If the vehicle intention is understood, would pedestrians also act as intended?
2. Does the usage of eHMIs lead to faster crossing decisions?
   – Efficiency: Faster intention recognition of the AV and faster crossing initiation?
3. How does the eHMI influence pedestrians’ perception of AVs?
   – Perceived Safety
   – Technology Acceptance
   – Trust in Automation

Application of Scenarios using Demonstrator Vehicles (2)

- CRF Demonstrator
- Vehicle can travel autonomously in this dedicated area at a maximum speed of 15-20 km/h
- Focus on the parking area scenario. Evaluation of interaction with pedestrian moving within this space:
  - Crossing Decisions
  - Visibility of eHMI
  - Perception of vehicle movement
  - Understanding of AV communication

Conclusions and Lessons Learned (1)

- Helpful to agree to common use cases, documentation methods, and terminology at the beginning of a project
  - Influences all technical and research related work
  - Improves communication between WPs
- Higher complexity in observational studies needs to be reduced to lower complexity for experimental participant studies
  - Complexity increased again for real world studies

Conclusions and Lessons Learned

- Useful to differentiate between slow moving scenarios (e.g. shared space / parking lot) vs. urban scenarios
  - More examples of explicit interactions in slow moving scenarios
  - However, eHMI requirements similar
- Cross-cultural variations in traffic scenarios
- Important to agree on standardized scenarios including AV movements e.g. gap size, deceleration rate, to compare eHMI in standardized way in simulator and test track studies
  - Allows the comparison of data assessed at different test sites

interACT Final Event

1 April 2020
BMW Test Track Maisach, Munich, Germany

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

Learn more about the interACT projects results and experience our vehicle demonstrators in live demonstrations.

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Thank you

Any questions?

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