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Adapt/IVe

Automated Driving Applications and Technologies for Intelligent Vehicles

Emma Johansson
Driver Environment & Human Factors

Volvo Group Trucks Technology (GTT), Advanced Technology & Research

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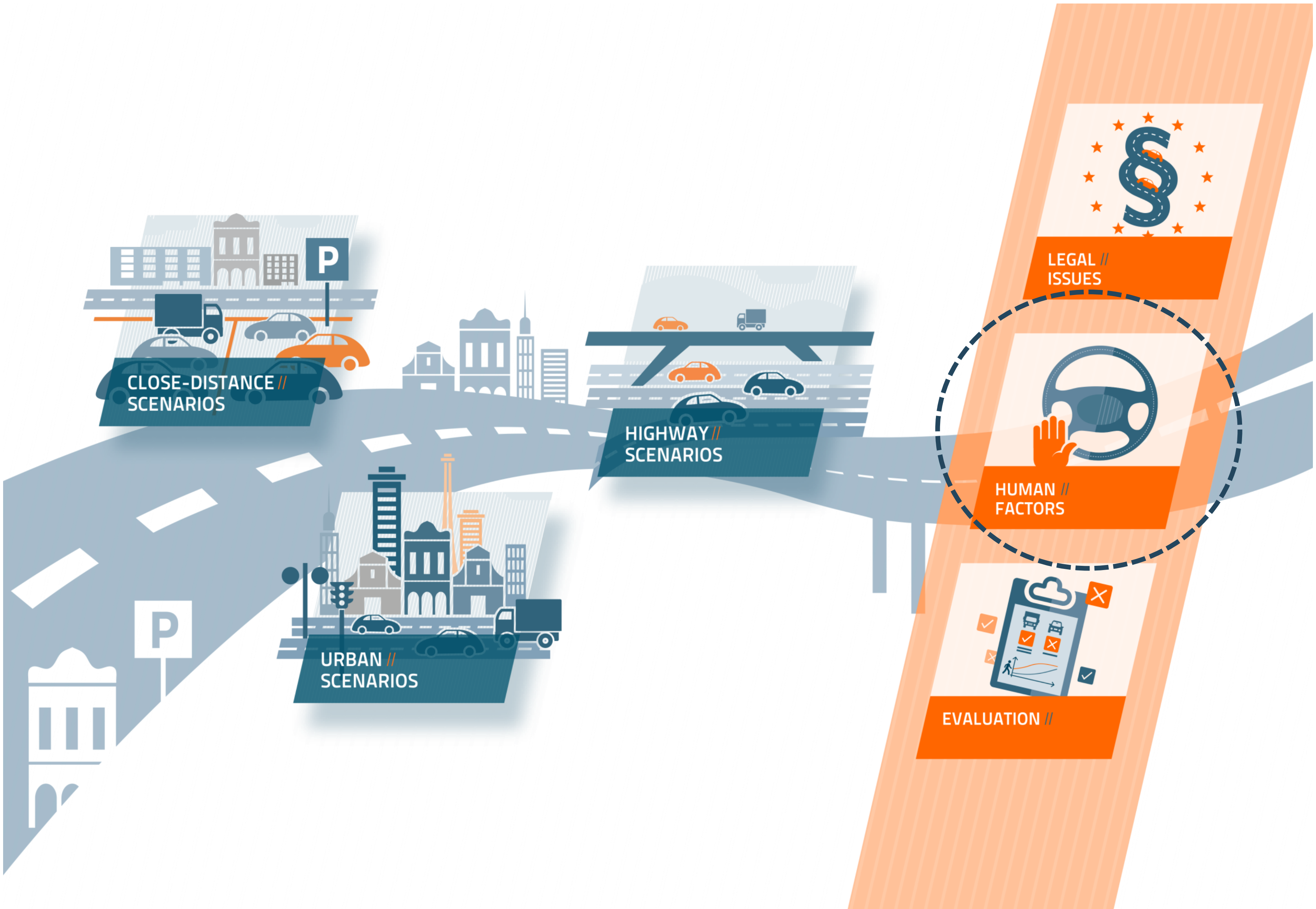
HUMAN FACTORS IN VEHICLE AUTOMATION

- Activities in the European project AdaptIVe

// AdaptIVe


CLOSE-DISTANCE // SCENARIOS
HIGHWAY // SCENARIOS
URBAN // SCENARIOS
LEGAL // ISSUES
HUMAN // FACTORS
EVALUATION //

//The overall goal

Increased safety

Reduction of human error/ weakness

Faster and stronger reactions

Increased comfort

More efficient use of time

Release of attentional resources

OBS - Human Error....vs Human Abilities...

//Human Factors challenges

Altered driver state

Drowsiness

Reduced situation awareness

Miscalibrated trust in Automation

Overreliance

"Misuse"

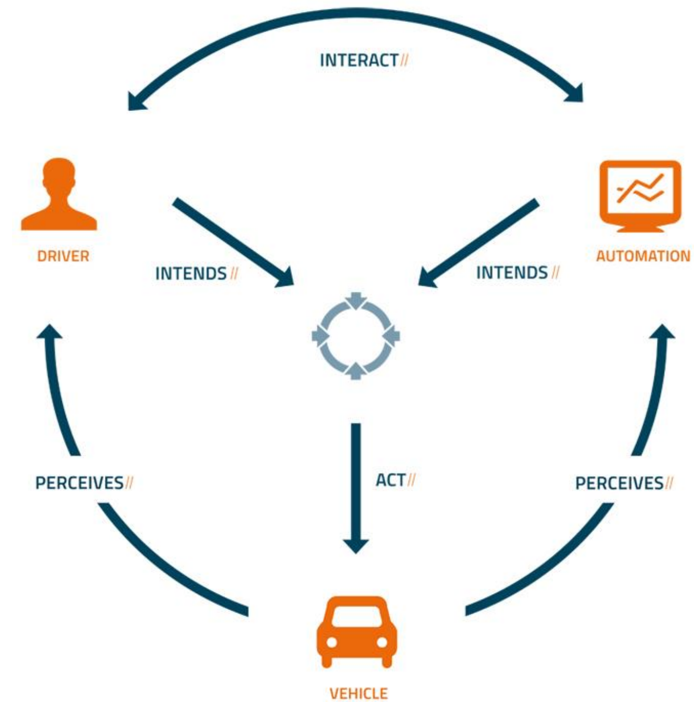
Unintended use

//Human Factors challenges & Human Error

- If nothing physically is broke in an accident, typically **human error** is what is searched for.
- With a simplified view on human error the solution has often been to **marginalise the driver/ operator by putting in more automation** or trying to remove the human being more or less completely.
- Instead of just replacing the driver, **human errors could be seen as a symptom, not a cause**, of a system which needs to be ***re-designed***.
- Important to look at both if the **indended effect** is reached and whether new automation induced errors are introduced (**unintended effects**).
- Also important to study **what the driver does "right"** (e.g. very able to adapt and respond to novel and unexpected scenarios)

//Can we design for collaborative automation?

- So far, there is no fail proof software. To replace the human behind the wheel being with a machine (designed by another human) only works if the task environment is very static and predictable and a priori controllable…
- Ensure intended effects of the functions are reached by taking both technology and driver's intent and actions into account as well as technical and human limitations.
- Implies the idea of complementary intentions, abilities, actions of human and automation that are used together to achieve one common goal.

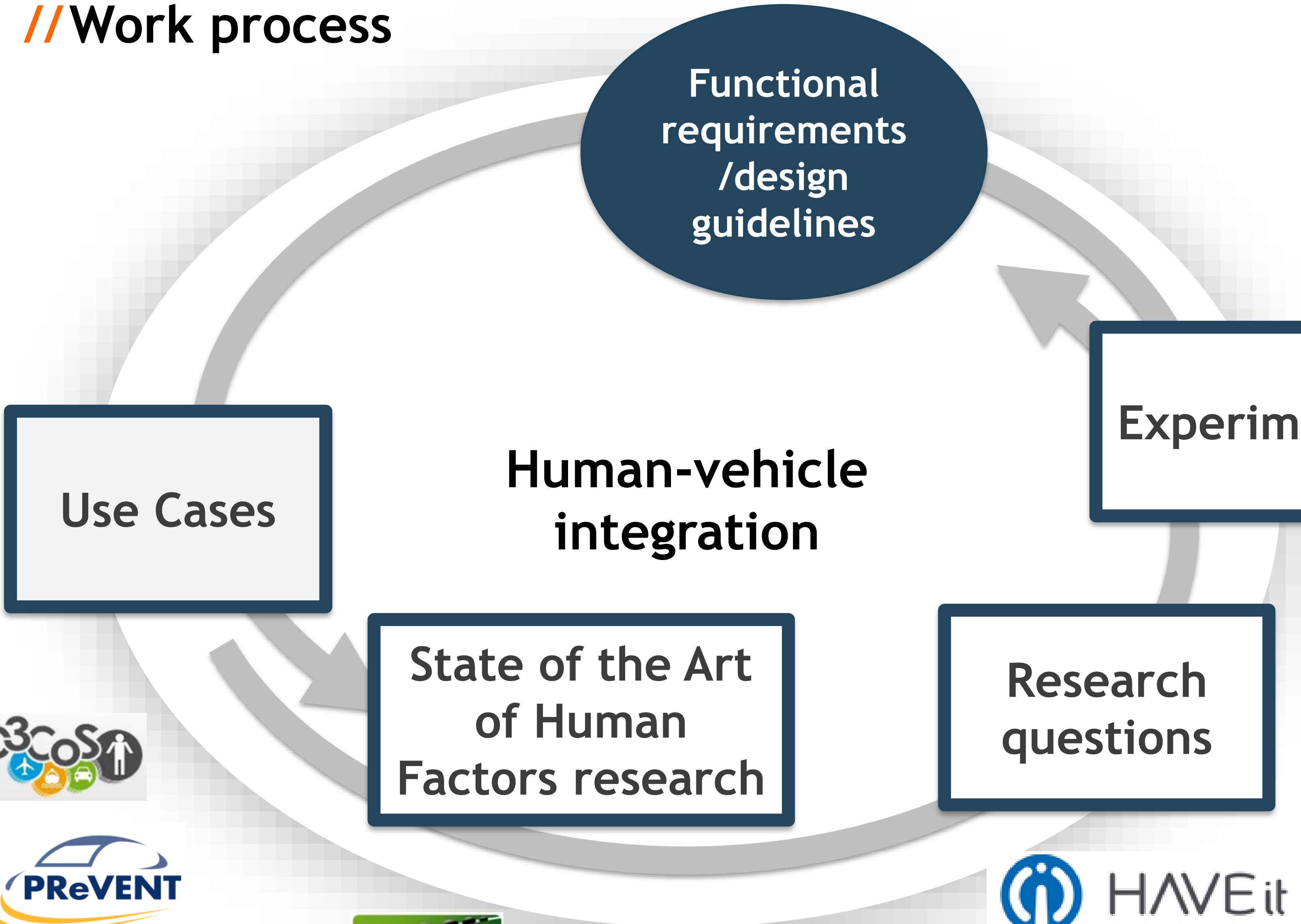


//From Human Machine Interface towards Interaction

System development work:

- …should
  - **define the actual function(s)** from a driver's perspective
  - explain the logic of the interaction, e.g. **how, when** and **where** information, warnings, interventions and continuous support should be present and study **compatibility and collaboration** between different agents (technical as well as human).
- …and cover the I/O components and the interaction with the driver through
  - visual,
  - auditory and
  - haptic output/input (e.g. as information and warnings) **including active vehicle steering, braking, acceleration** through actuators

//Work process



//Categorisation of Research Questions and Functional Human Factors requirements

- **Awareness problems**
  - Situation awareness
  - Mode awareness
  - Role and task awareness
  - ...

- **Aribitration**
  - Interaction & decision (e.g. visual, auditive, haptic, kinestetic communication, interaction, information, confirmation)
  - Meaning & Scheduling
  - Modes & Transitions
  - Modality
  - Adaptivity
  - Responsibility

- **Action problems**
  - Physical constraints
  - Motoric constraints
  - Lack of skills
  - Controllability
  - ...

- **Agent state problems (failure, limits)**
  - Driver state
  - Automation state
  - Environmental state
  - ...

***Based on SoA including work in e.g.:**

HAVEit

interactIVe

AdaptIVe

//Experiment facilities

Problem Areas			Leeds	DLR	Ford	WIVW	AB Volvo	Volvo CG
Agent State	Driver state	Drowsiness/Fatigue	X					
		Physiological/ Emotional state	X					
		Distraction	X		X	X		
		Workload	X		X			
		Cultural Differences			X			
		Acceptance	X	X	X	X	X	
	Automation State				X	X	X	
	Vehicle State						X	
	Environment state		X	X		X	X	
Awareness	Situation Awareness		X			X	X	
	Mode Awareness			X	X		X	
	Role & Task Awareness			X	X			X
Arbitration	Interaction & Decision			X			X	X
	Meaning & Scheduling			X				X
	Modes & Transitions		X	X		X	X	X
	Modality			X	X	X		X
	Adaptivity							
Action	Ergonomics			X				
	Controllability		X	X	X	X	X	

//Research questions and prel. results (examples)

- RQ 1: Does **traffic density** have any effect on the drivers' ability to detect and react to mode changes?
  - Yes. Traffic density affect **the time to automation activation** (high density → shorter time).
  - Possible explanation: **high traffic density → active glance behaviour** → a higher probability of detecting changes in the interfaces.

- RQ 2: What **behavioural measures** best capture **driver behaviour during automated driving**?
  - A number of potential behavioural measures were identified to predict out of the loop:
    - PRC of fixations/gaze, Gaze dispersion index, Percentage of glances towards non-driving task.
  - Driving related measures **after the transition** occurred:
    - Time to collision, Maximum lateral acceleration, Headway, Time to button press, Time to hands on steering wheel

//Research questions and prel. results (examples)

- RQ 3: Can **peripheral visual perception of ambient display** support drivers in different driving scenarios?
  - Peripheral visual perception of ambient display can support drivers in different driving scenarios.
  - Offers **slightly faster reaction times and higher acceptance** from the drivers.

- RQ 4: How does the **capability level of the automation** and a **timely announcement of a traffic situation** influence driver's monitoring behaviour and driving behaviour at take-over situations (planned transitions)?
  - Drivers becomes **more aware of approaching system limits**.
  - Information helps to **actively avoid uncomfortable transitions** to manual driving.
  - However, in this study an announcement that was 100% reliable led **to overreliance in the system** which might have negative effects in case of system failures.

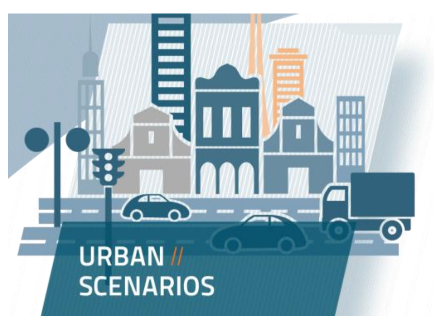
//Research questions and prel. results (examples)

- RQ 5: What kind of **parking support is desired** by the users?
  - **Generally favourable** opinions of novel parking support systems.
  - The usage frequencies and opinions indicate a **high desire for all parking systems** (visual and acoustic parking aids with rear-view camera & semi-automated parking).
  - **Demographic factors** hardly have an influence on the opinions.

- RQ 6: Does the **interface design** have any effect on the drivers' actions to the mode availability?
  - Yes. Effect on the time it took for the driver to **initiate automation** and **to take back control** after an automation failure.
  - **Shorter time with the two-mode design** compared to three-mode design.

//Research questions and prel. results (examples)

- RQ 7: What is the **most effective, yet least intrusive hand-over cue** we can design for unpredicted, immediate, non-critical pass backs?
  - Learning how to disengage automation is **not immediately intuitive** (the first time around, 30 % of drivers failed to disengage properly).
  - The **learning curve is fast** however.
  - Drivers **deeply engaged in a secondary task** while in automated mode are much **more sensitive to multimodal alerts and timing**, compared to drivers in manual driving.
  - Drivers who did not enjoy the secondary task **became bored** with automation mode very quickly.



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//Functional requirements/Design recommendations

- ’4 A structure’: Agent State, Awareness, Arbitration, Action.
- Continuation of work in e.g. HAVEit, interactIVe and SoA presented in literature.
- Final deliverable but should be considered a living document to be updated with new findings.

No.	4A-Sub-Category	Automation Level	Applicable to SP	Human Factors challenge	Human Factors recommendation (green = high importance recommendation)	Already existing approaches, examples	References
FR1 A01	Automation State Vehicle State Environment state Driver State	SAE1 SAE2 SAE3	SP6 SP5 SP4 (driver inside only)	The driver cannot project future states of the automation. If the driver is not informed in a timely manner about automation limits or failures he/she will get problems with taking-over the driving task	The automation should inform in advance about an upcoming automation limit, and if possible, about upcoming automation failures NFR1A01.6 If available, use a local visual feedback (red/blue-blinking transition button) and/or peripheral visual feedback (orange/blue pulsing on a 360° LED Stripe) to communicate system limits.	FR1A01.E3: Example of DLR local visual feedback on transition button and peripheral visual feedback on ambient display to communicate system limits. 	
FR1 A02	Driver state	SAE2 SAE3	SP6 SP5 SP4	The driver uses the automation in a non-intended way (e.g. driver is sleeping)	The automation should start a transition request to hand back control to the driver. If the driver wants to activate partial automation he needs to be capable of supervising the system all the time. Otherwise activation should not be possible.		

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//Future research challenges (examples)

- **Limited empirical experience from real driving** in real traffic environment with highly automated vehicles. E.g.
  - Humans ability to handle **non-planned take-over situations** (time, quality, type of action - automated vs. conscious).
  - Natural **driver engagement in secondary tasks** in real user scenarios (driver paced, real time sharing, …).
  - Long term effects such as actual system usage, drowsiness etc.
  - **Passive and integrated safety**. Driver moving out of normal passive safety seating position.
  - **Study real usage patterns** to assess assumptions on less congestion, reduced fuel consumption, increased comfort with automation
- From over-automation → appropriate feedback and interaction. E.g.:
  - Further investigate how to move from more traditional interaction patterns and I/O devices → **"ambient displays".** E.g. visual ambient displays, kinaesthetic feedback.
- Develop a real framework for **Out of the Loop** (on-going work in Trilateral HF group). Link to Driver State Monitoring and actual viable system design.

//Future research challenges (examples)

- **Wider systemic view**. E.g.
  - How automated vehicles and other road users, such as non-automated vehicles and vulnerable road users, interact in different traffic environments.
    - Unintended usage patterns including provoking/testing highly automated vehicles
    - Knowledge transfer possible from e.g. Automatic Ground Vehicles in production environment
- Further look into countermeasures for the automation irony of **deskilled operators/drivers**
  - Is training really an option? Driving manually in certain intervals? Transfer of knowledge possible from aviation and production or not?
- Change discussion from Human Error into looking at **situations drivers handle well today** (e.g. able to adapt to novel situations).
  - Benchmark systems so that they indeed can match the driver in quite complex situations.
  - Learn from how drivers behave.
  - Stress test the systems with naturalistic driving data.
- **Adapt level of automation to scenarios and business cases**.
  - High level of automation might be viable and a good solution in certain scenarios but not necessarily in all.

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Thank you.

Emma Johansson
emma.johansson@volvo.com

Adapt/IVe FINAL EVENT

SAVE THE DATE June 28 - 29, 2017
Aachen, Germany // www.AdaptIVe-ip.eu

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DLR Deutsches Zentrum für Luft- und Raumfahrt German Aerospace Center

Ford

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