HARMONISE - säker förarinteraktion med olika grad av automation i samma fordon

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Outline

- Overall project aim
- Theoretical background
  - Levels of Automation
  - Human Error
  - Mode understanding & confusion
  - Driver control
- Concept Design & Evaluation

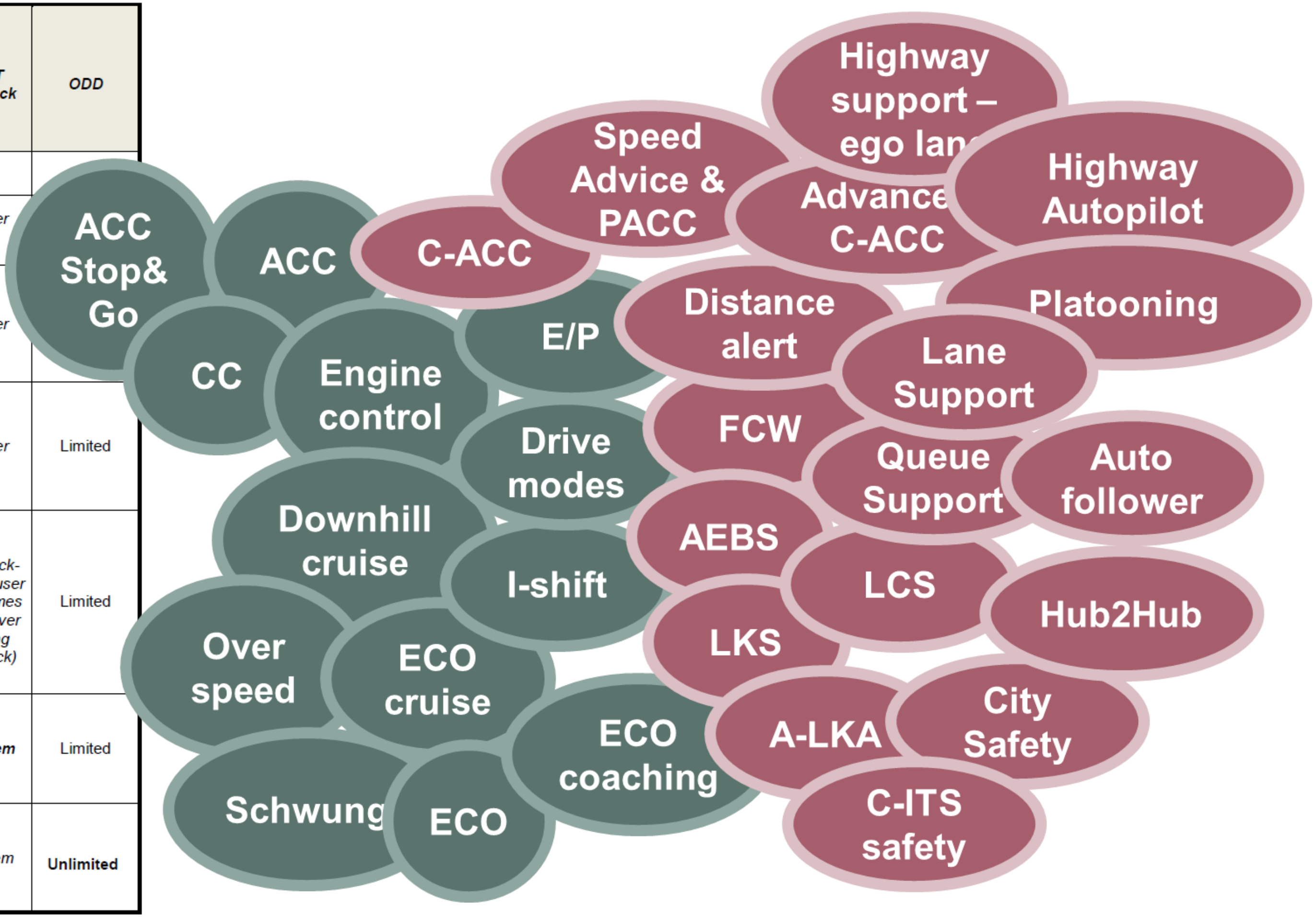
HARMONISE

- Overall aim:
  - Study the changing role of the driver when more and more support systems that operate at **different levels of automation** are introduced in vehicles in an evolutionary manner.
  - Investigate different means to **harmonize, simplify, manage and improve** how drivers interact with technical systems that automate parts of or the entire dynamic driving task in the vehicle.

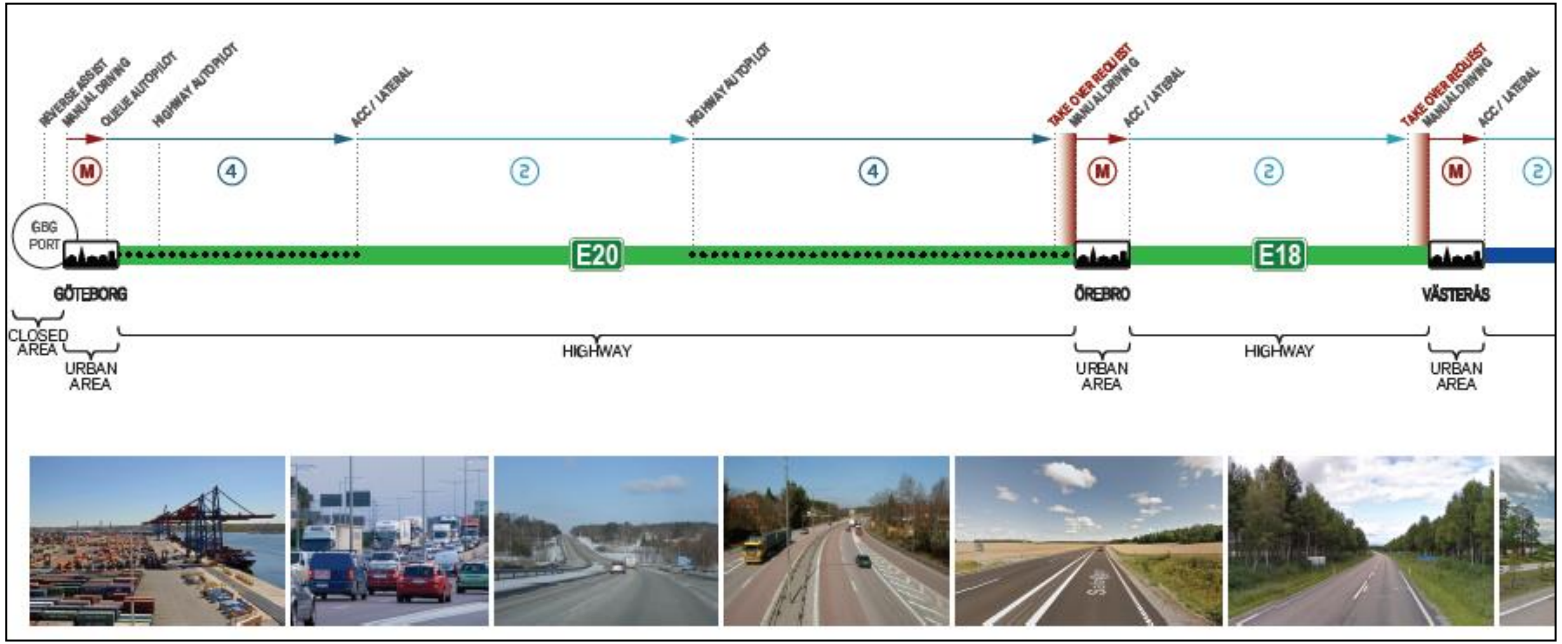
- Partners: Volvo Group Trucks Technology, Volvo Cars, RISE
- Coordinator: Volvo GTT
- Duration: 2017-2019
- Total project budget: 13,45MSEK, FFI reimbursement: 6,725 ('Trafiksäkerhet och automatiserade fordon')
- People: Emma Johansson, Ida Esberg, Christer Lundevall (Volvo GTT), Mikael Ljung Aust (Volvo Cars), Jonas Andersson Maria Klingegård, Azra Habibovic (RISE)

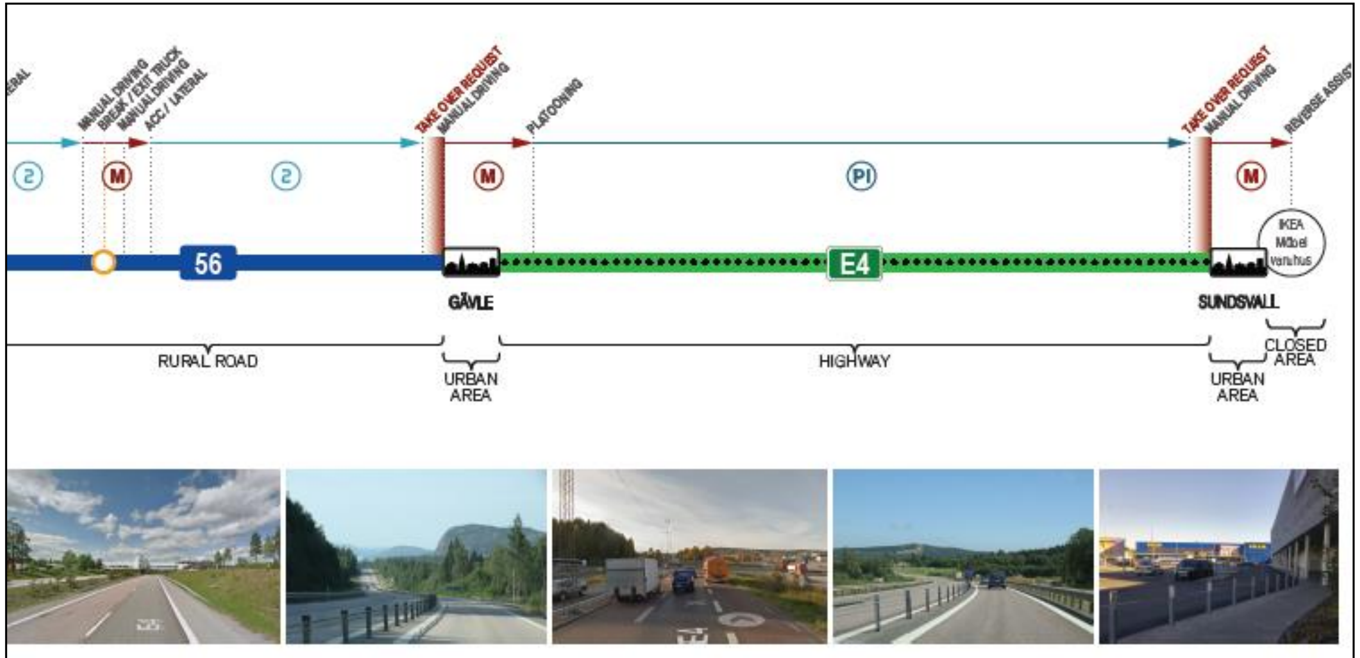
Levels of Automation

Level	Name	Narrative definition	DDT: Sustained lateral and longitudinal vehicle motion control	DDT: OEDR	DDT fallback	ODD
Driver **performs part or all of the** ***DDT***						
0	**No Driving Automation**	The performance by the *driver* of the entire *DDT*, even when enhanced by *active safety systems*.	*Driver*	*Driver*	*Driver*	
1	**Driver Assistance**	The *sustained* and *ODD*-specific execution by a *driving automation system* of either the *lateral* or the *longitudinal vehicle motion control* subtask of the DDT (but not both simultaneously) with the expectation that the *driver* performs the remainder of the *DDT*.	*Driver* and *System*	*Driver*	*Driver*	
2	**Partial Driving Automation**	The *sustained* and *ODD*-specific execution by a *driving automation system* of both the *lateral* and *longitudinal vehicle motion control* subtasks of the *DDT* with the expectation that the *driver* completes the *OEDR* subtask and *supervises* the *driving automation system*.	***System***	*Driver*	*Driver*	Limited
ADS **("*****System*****") performs the entire** ***DDT*** **(while engaged)**						
3	**Conditional Driving Automation**	The *sustained* and *ODD*-specific performance by an *ADS* of the entire DDT with the expectation that the *DDT fallback-ready user* is *receptive* to *ADS*-issued *requests to intervene*, as well as to *DDT performance-relevant system failures* in other *vehicle* systems, and will respond appropriately.	*System*	***System***	*Fallback-ready user (becomes the driver during fallback)*	Limited
4	**High Driving Automation**	The *sustained* and *ODD*-specific performance by an *ADS* of the entire *DDT* and *DDT fallback* without any expectation that a *user* will respond to a *request to intervene*.	*System*	*System*	***System***	Limited
5	**Full Driving Automation**	The *sustained* and unconditional (i.e., not *ODD*-specific) performance by an *ADS* of the entire *DDT* and *DDT fallback* without any expectation that a *user* will respond to a *request to intervene*.	*System*	*System*	*System*	**Unlimited**



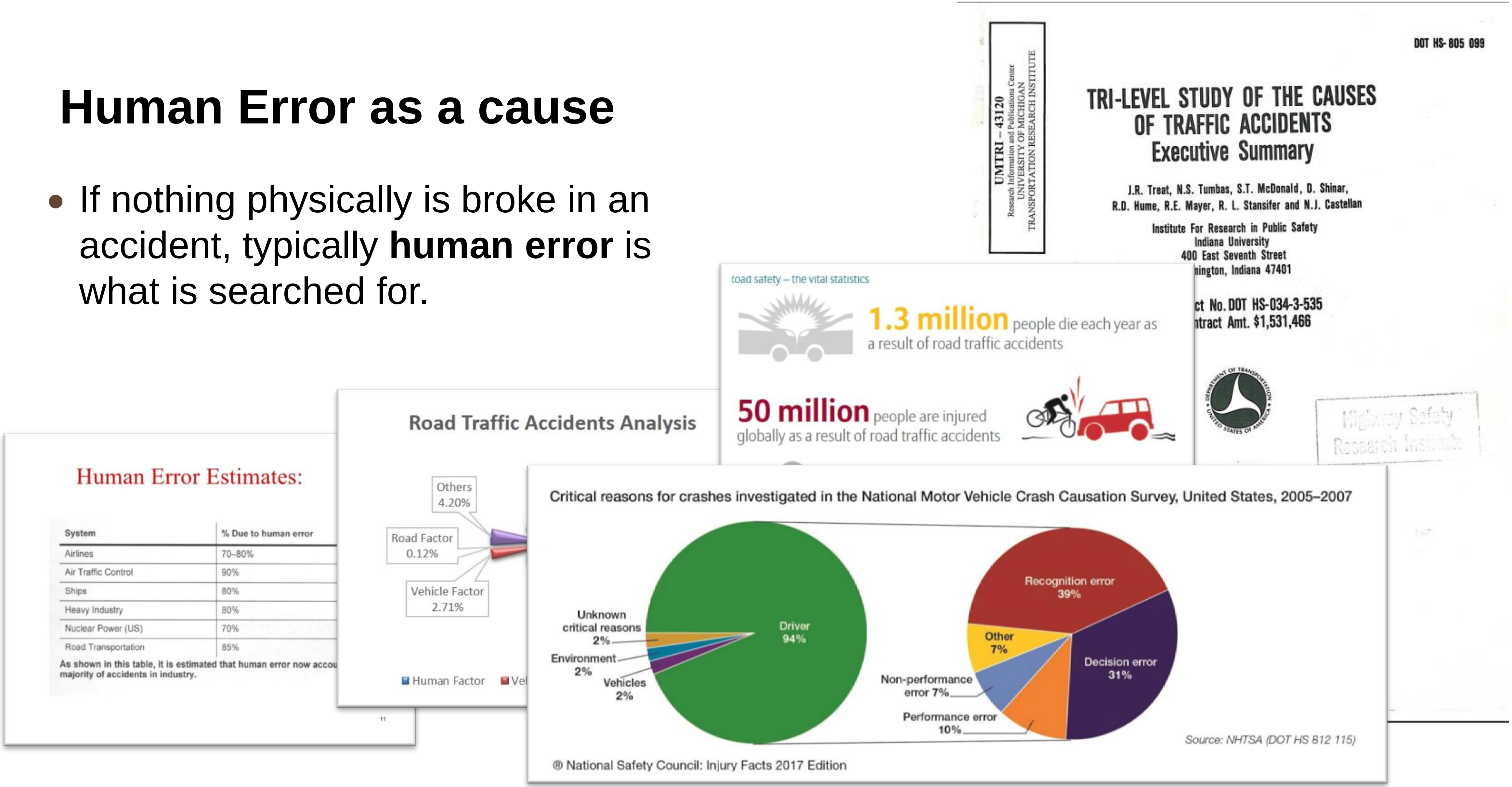
LoA & a driver's journey





Human Error as a cause

- If nothing physically is broke in an accident, typically **human error** is what is searched for.



Human Error as a symptom

- Human error could be seen as **a symptom, not a cause**, of a **system** which needs to be **re-designed**

- What caused the human error?

Leveson, 2011; Dekker, 2007

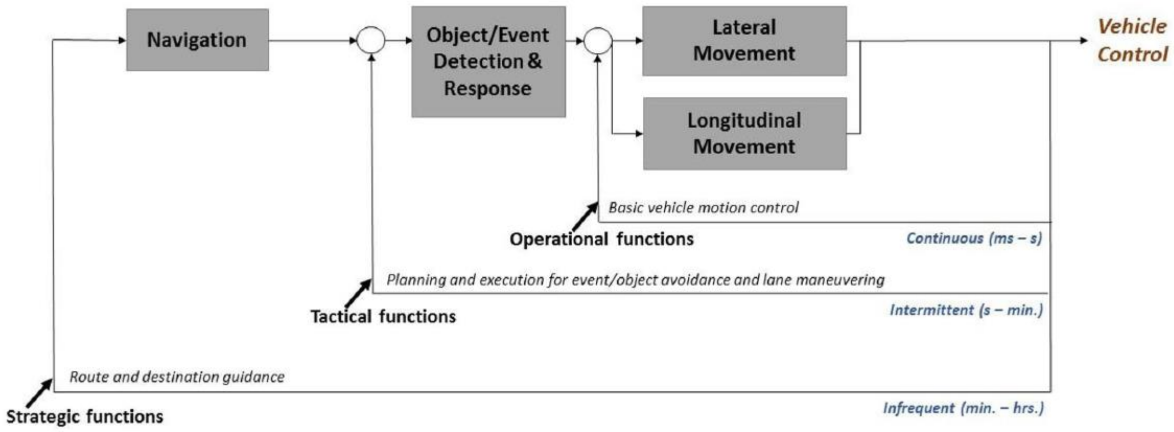
Mode understanding and mode confusion

- Customers and drivers **don’t think levels**.
- What matters is **affordance***.
  - The design itself needs to intuitively communicate ”am I in charge or are you?”
- **Create ‘mode understanding’ by design:**
  - Make sure drivers understand the *capability of individual functions* and what’s expected of the driver
  - Understanding develops and is modified **through the interaction with the system**.
- **Avoid ’mode confusion’:**
  - Design for clear understanding of *which function is operating* at a given point in time both during transitions as well as during ”steady state”

* Perceived and actual properties of an function/object/system that gives clues to its operation (Norman def.)

Driver control

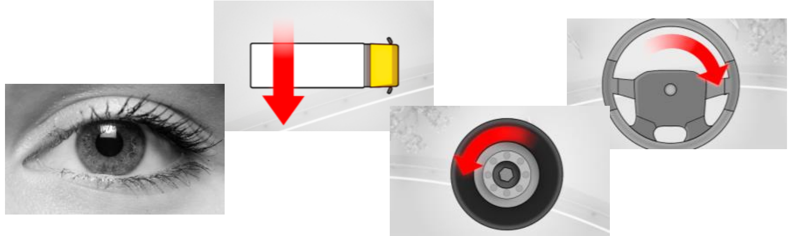
- What is meant by being in control/ ”in the loop”. Merat et al (2018):
  - **In the loop**: In physical control of the vehicle *and* monitoring* the driving situation
  - **On the loop:** Not in physical control of the vehicle, but monitoring the driving situation
- **Out of the loop:** Not in physical control of the vehicle, and not monitoring the driving situation, **OR** in physical control of the vehicle but not monitoring the driving situation



Driver control

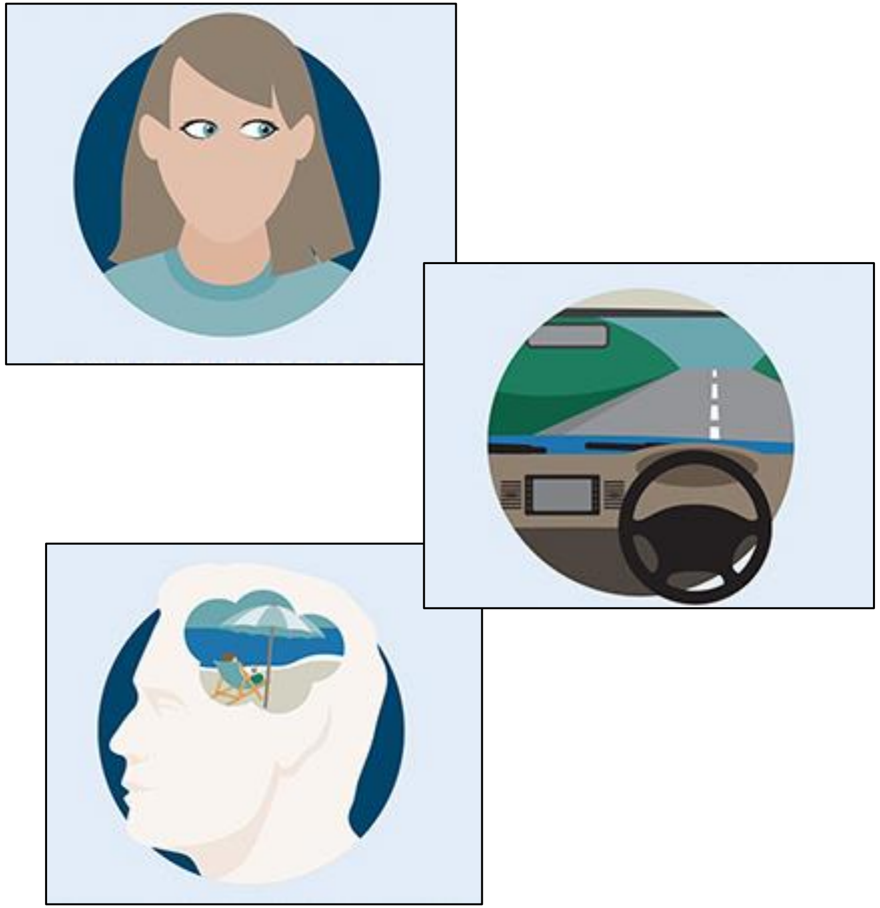
- Monitoring: not just eyes on road. Include **creating meaning** of dynamic changes in the environment
  - e.g. predict potential hazards ahead or movement of one's vehicle relative to other vehicles

- **Perceptual cues - not only visual** but also provided via acceleration/deceleration forces & lateral behavior etc.



Driver control

- What ensures the driver keeps his/her **mode awareness** for a prolonged period?
- Is it possible to avoid ”silent automation”?
- For SAE lvl 1-2:
  - Hands-on steering wheel (R79*)
  - Eyes on road
  - **Mind on task of driving/ keep ”making meaning** of dynamic changes in the environment”



* Upcoming regulation req. hands on detection for corrective steering functions (CSF) and lane centering lvl 2 functions (ACSF B1)

Driver control & system design - driver acceptance and adoption

- If a system is “too capable”, there is a risk of driver becoming less in the loop.

- If a system is “too simplistic”, system might be perceived as frustrating to use, and drivers won’t bother.

Human control – examples of Out of Control Loop in Aviation domain: visual displays vs. forward view and kinesthetic feedback

- “Pilots [...] described aspects of cockpit automation that were **strong but sometimes silent and difficult to direct when time is short**”.

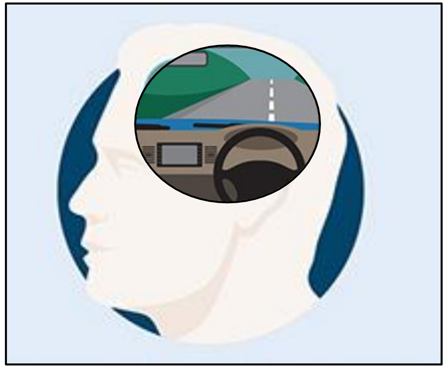
- “It seems that the crew generally **does not notice their misassessment from displays of data** about the state or activities of the automated systems”.

- “The misassessment is detected, and thus the point of surprise is reached, in most cases based on observations of **unexpected and sometimes undesirable aircraft behaviour**”.

(Woods & Sarter, 1998)

Concept Design & Evaluation –
for mode understanding & control

- Research questions:
  - How can the driver **maintain control and remember his/her role** even when longitudinal and lateral control are partially or fully delegated to the vehicle?



- Possible solutions:
  - Alter the frequency of hands-on requests
  - Create less dominant steering performance/manipulate stiffness in steering?
  - Introduce ’deadband’ in the lateral performance or other types of haptic feedback:
    - Continously or
    - In certain intervals

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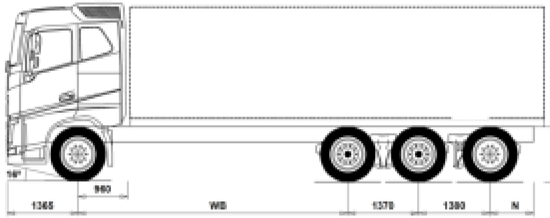
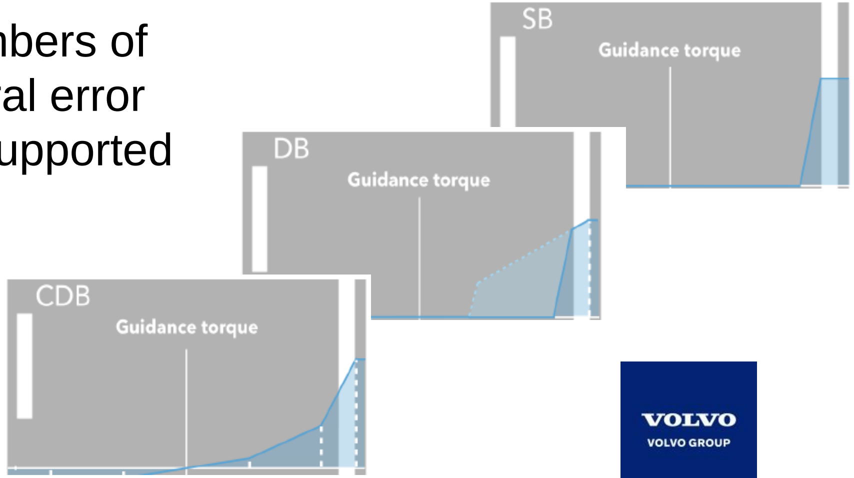
Concept Design & Evaluation: Truck Experiment 1 - Haptic shared control



- 4 main conditions: ACC + no lateral support (”Baseline”), ACC + ’single bandwidth’, ACC + ’ double bandwidth’, ’conditional double bandwidth’
- 16 subjects with C/CE driving licence
- Test track (Hällered). 1,5 hrs/test subject
- Measurements: Lane keeping/Lane exeedences during support, Rated driving performance (HASTE scale), Rated acceptance (van der Laan)
- Results:
  - All support types (including manual driving) yielded equal numbers of lane departures, however the duration and the maximum lateral error of a lane departure are significantly lower when the driver is supported by DB or CDB systems compared to manual driving.
  - SB rated lower wrt acceptance.



Concept Design & Evaluation: Truck Experiment 2 – haptic shared control

- 3 main conditions; ACC + no lateral support (”Baseline”), ACC + ’Low gain’, ACC + ’High gain’
- 18 subjects with C/CE driving licence
- On-road (E6 + E45). 2 hrs/test subject
- Measurements:
  - Eye scanning behaviour (Seeing Machines’ dashboard mounted mono camera), Lane keeping/Lane exeedences during support and when support is temporarly unavailable, Grip behaviour (conductive sensor), Perceived degree of control
- Analysis on-going. Challenges: Large individual diffrences for preferred shared control settings, Difficult to establish good measurement of ”being in control” which has true safety relevance

General mid-term conclusions

- Further investigate the application of controllers that adapt to
  - individual driver preferences,
  - to specific road characteristics and to
  - driver state/engagement/activity level.
- "Scrutinize" the tools and measurement of Out of the Loop/ in the loop behavior.

Questions?

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