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

Emma Johansson, Volvo Group Trucks Technology, september 2018
Outline

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

<table>
<thead>
<tr>
<th>Level</th>
<th>Name</th>
<th>Narrative definition</th>
<th>DDT</th>
<th>ODD</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Sustained lateral and longitudinal vehicle motion control</td>
<td>OEDR</td>
<td>DDT fallback</td>
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<tr>
<td>0</td>
<td>No Driving Automation</td>
<td>The performance by the driver of the entire DDT, even when enhanced by active safety systems.</td>
<td>Driver</td>
<td>Driver</td>
</tr>
<tr>
<td>1</td>
<td>Driver Assistance</td>
<td>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.</td>
<td>Driver and System</td>
<td>Driver</td>
</tr>
<tr>
<td>2</td>
<td>Partial Driving Automation</td>
<td>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.</td>
<td>System</td>
<td>Driver</td>
</tr>
<tr>
<td></td>
<td>ADS (&quot;System&quot;) performs the entire DDT (while engaged)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Conditional Driving Automation</td>
<td>The sustained and ODD-specific performance by an ADS of the entire DDT with the expectation that the DDT fallback-ready user is responsive to ADS-issued requests to intervene, as well as to DDT performance-relevant system failures in other vehicle systems, and will respond appropriately.</td>
<td>System</td>
<td>System</td>
</tr>
<tr>
<td>4</td>
<td>High Driving Automation</td>
<td>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.</td>
<td>System</td>
<td>System</td>
</tr>
<tr>
<td>5</td>
<td>Full Driving Automation</td>
<td>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.</td>
<td>System</td>
<td>System</td>
</tr>
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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)
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
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 exceedences 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 exceedences during support and when support is temporarily unavailable, Grip behaviour (conductive sensor), Perceived degree of control
- Analysis on-going. Challenges: Large individual differences 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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