Are you Ready to Take-over? – Driver State During Automated Driving

Jonas Radlmayr, TU Munich – Chair of Ergonomics  
Dennis Befelein, University of Würzburg – Center for Traffic Sciences (IZVW)  
Claus Marberger, Robert Bosch GmbH  
Svenja Paradies, BMW Group
Content

- Transition Process and Model
- Test Scenarios
- Requirements for a generic HMI
- Catalogue of non-driving related tasks (NDRTs)
- Metrics and TOC-Rating
- Wizard of Oz method
In Work Package 3, we conducted a total of **33 empirical studies**, with **1723 participants**, in over **1750 hours**, resulting in **30 publications**.

Common methodology to allow comparison of experiments and results.

- Transition model for take-overs
- Definition of take-over situations
- Generic HMI requirements
- Catalogue of NDRTs
Transition Process and Model

Transition Process and Model

Transition Process and Model

Automated driving → Manual driving

Current driver state
- Sensory state
- Motoric state
- Cognitive state

Driver state transition process

Target driver state
- Sensory state
- Motoric state
- Cognitive state

Driver intervention process

Type of current (non driving related) activity

Type/Design of Request to Intervene

Requirements of take-over scenario

Driver training / education / system experience
**Definition of take-over situations**

<table>
<thead>
<tr>
<th></th>
<th>Urgency of situation</th>
<th>Predictability of RtI</th>
<th>Criticality of situation</th>
<th>Complexity of driver response</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Human performance limits</strong></td>
<td>How much time is available to intervene?</td>
<td>How likely is the driver prepared about a future take-over requirement?</td>
<td>How severe are the consequences if the driver does not take-over in time?</td>
<td>How complex is the required driver intervention?</td>
</tr>
<tr>
<td></td>
<td>high</td>
<td>low</td>
<td>high</td>
<td>medium-high</td>
</tr>
<tr>
<td><strong>Time demand for unplanned transitions</strong></td>
<td>medium</td>
<td>low</td>
<td>low</td>
<td>low-high</td>
</tr>
<tr>
<td><strong>Driver comfort for planned transitions</strong></td>
<td>low</td>
<td>high</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>
Definition of take-over situations

Identification of six possible and reasonable take-over situations for the workpackage 3 experiments.
Transition Process and Model

Automated driving

Current driver state
- Sensory state
- Motoric state
- Cognitive state
- Arousal level
- Motivational conditions

Driver state transition process

Target driver state
- Sensory state
- Motoric state
- Cognitive state

Driver intervention process

Manual driving

Type of current (non driving related) activity

Type/Design of Request to Intervene

Requirements of take-over scenario

Driver training / education / system experience

September 19th & 20th, 2018
Ko-HAF – Are you Ready to Take-over? Driver State During Automated Driving

Ko-HAF – Are you Ready to Take-over? Driver State During Automated Driving
HMI – Minimal requirements

- Messages concerning the status of the automation
  - System not available and not activated (Off)
  - System available but not activated (Ready)
  - System available and active (On)
  - System soon not available but active (Request to Intervene, RtI)

- Modalities of the status of automation
  - Continous system status: visual
  - Request to Intervene/Warnings: at least dual modalities (e.g. acoustic + visual, visual + haptic)
Transition Process and Model

Automated driving → Manual driving

Current driver state
- Sensory state
- Motoric state
- Cognitive state

Motivational conditions

Driver state transition process

Target driver state
- Sensory state
- Motoric state
- Cognitive state

Driver intervention process

Type of current (non driving related) activity

Type/Design of Request to Intervene

Requirements of take-over scenario

Driver training / education / system experience
Task switching

Requirements for driver
1. General availability (e.g. being awake)
2. Perception of task switching necessity and allocating driver availability for take-over process
3. NDRT-disengagement planning and executing
Catalogue of NDRTs

Depending on step of the task switching process

→ What is affected by the NDRT?
→ List of **16 features** (e.g. over-/underload, modalities, involvement, effort of disengagement)
# Catalogue of NDRTs

<table>
<thead>
<tr>
<th>HAF-Stage</th>
<th>Natural Environment</th>
<th>HAF Engagement</th>
<th>Driver State</th>
<th>Literature Link to NDRT</th>
<th>TAF</th>
<th>HAF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engaged</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Degraded</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
<td>0.50</td>
</tr>
<tr>
<td>Degradation</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
<td>0.30</td>
</tr>
<tr>
<td>Manual</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Measures for human performance (see ISO TR21959 Part 1)

▪ Type of driver intervention, e.g.
  ▪ Deactivation by steer/brake,..

▪ Time related measures, e.g.
  ▪ Take-over time
  ▪ Remaining action time

▪ Quality related measures, e.g.
  ▪ Single (objective) performance measures
    ▪ Collision (speed)
    ▪ Minimum time to collision
    ▪ SDLP
  ▪ Driver subjective assessment
  ▪ Expert assessment of traffic safety
Take-over controllability rating (TOC)

**Controllability:** Different, potentially safety-relevant aspects when drivers need to react to system limits or failures.

The TOC-Rating is a scientifically based expert method for assessing the controllability of take-over situations in conditionally automated driving (level 3).
Take-over controllability rating (TOC)

**Assessment criteria**

- **Uncontrollable events** (e.g. leaving the road)
- **Endangerments** (e.g. near-accidents with other road users)
- **Driving errors** (e.g. failure to secure): Poor quality of take-over
- **Imprecision in vehicle guidance** (e.g. imprecise lane keeping): Good quality of take-over with minor impairments.
Take-over controllability rating (TOC)

- Integration of multiple (single) performance measures into one global metric.
- Raters are trained to ensure high inter-rater reliability.

The TOC adds a holistic, flexible, efficient and comparable method for assessing the controllability of take-overs.
Wizard-of-Oz (exemplary BASt)

- Second seat in the back, used to simulate automated driving by a human (wizard)
- Concealed and unrecognizable for participants
- Can be used on public roads
- Specific HMI concept to allow transitions between manual driving and automated driving
- Data acquisition of driving data, eye-tracking, physiological data, reaction times
- Other Wizard-of-Oz-Approaches at Audi, BMW and Bosch
Are you Ready to Take-over?

- Methodological common ground as basis for the empirical experiments.

- Results, nomenclature and understanding were integrated into the ISO discussion and standardization.
Thank you for your attention!

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