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

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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

Motivation

In Work Package 3, we conducted a total of **33 empirical studies**, with **1723 participants**, in over **1750 hours**, resulting in **30 publications**.

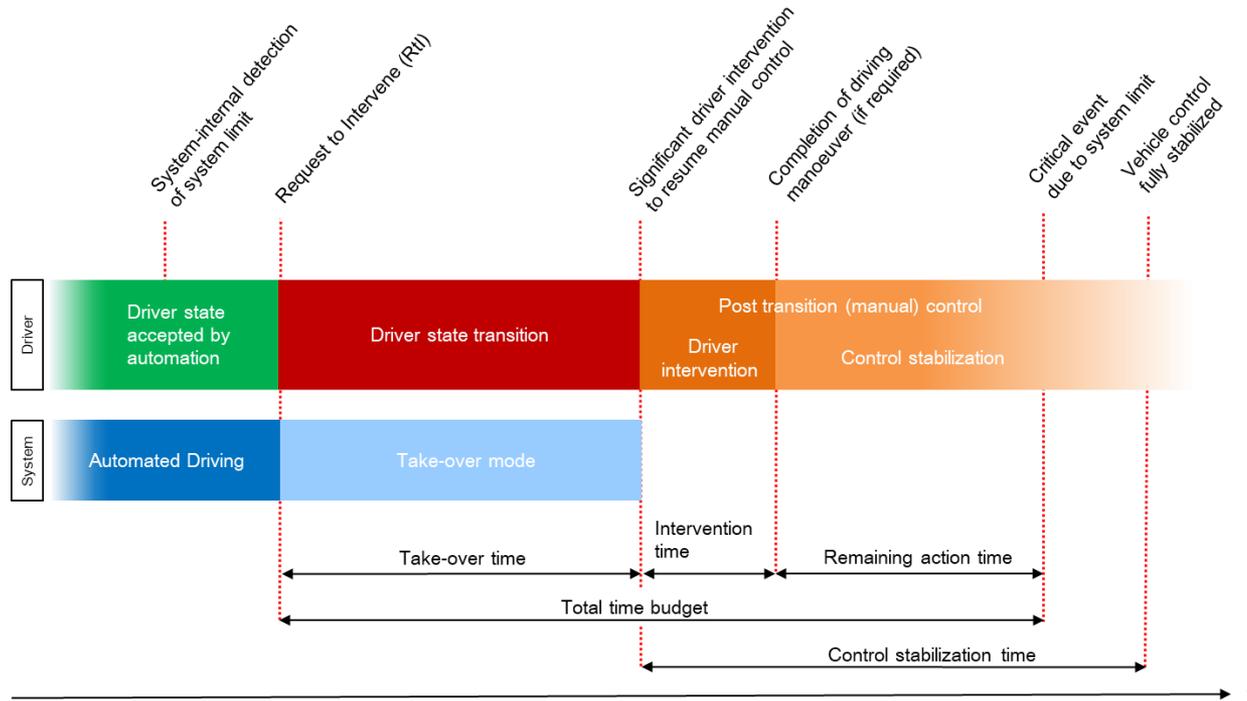**Common methodology to allow comparison of experiments and results.**

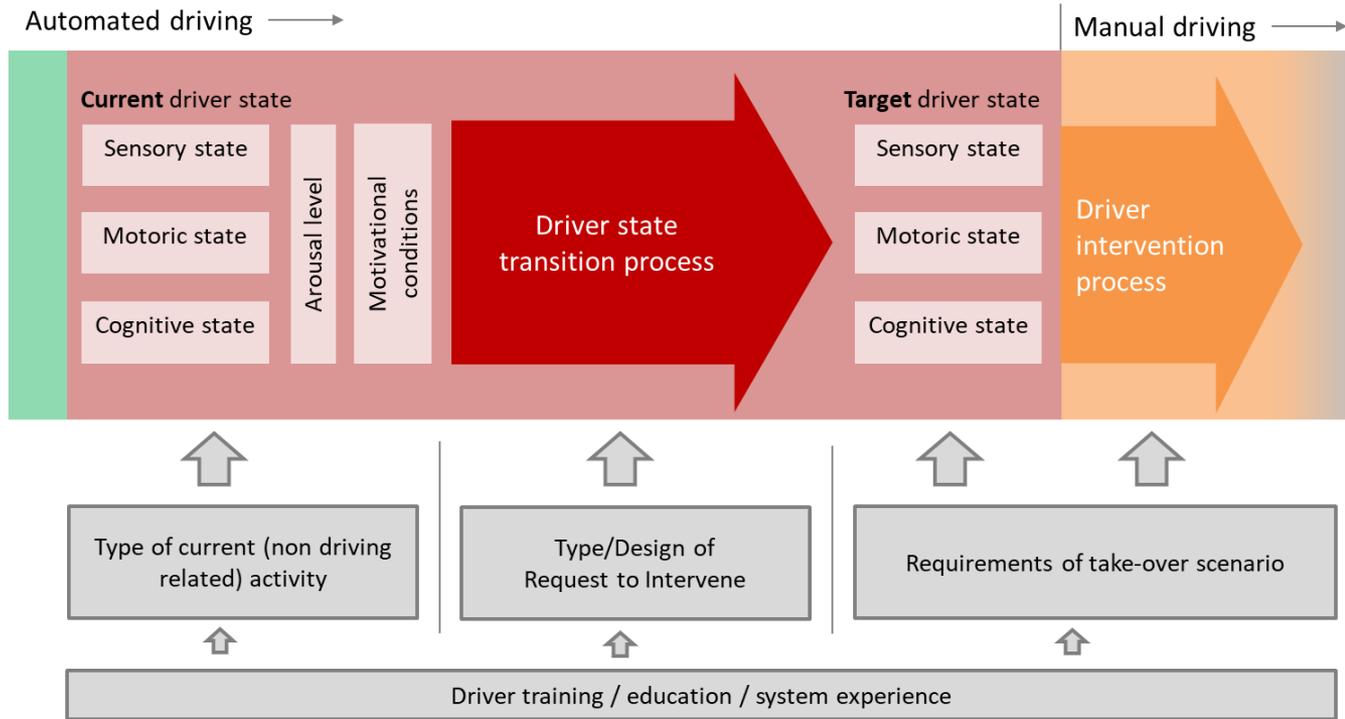| **Transition model for take-overs** | **Definition of take-over situations** | **Generic HMI requirements** | **Catalogue of NDRTs** |

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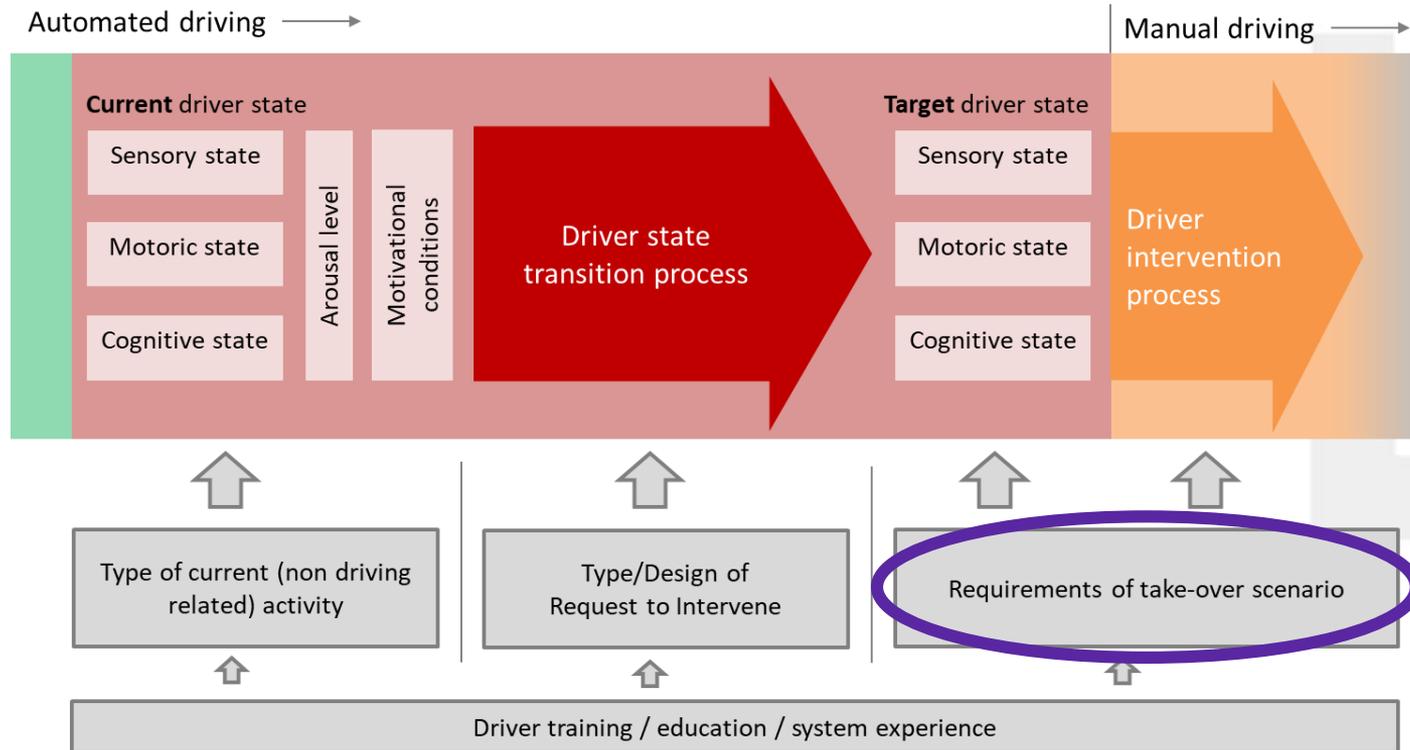
Transition Process and Model

Marberger, C., Mielenz, H., Naujoks, F., Radlmayr, J., Bengler, K., & Wandtner, B. (2017). Understanding and Applying the Concept of "Driver Availability" in Automated Driving. In N. A. Stanton (Ed.), *Advances in Human Aspects of Transportation: Proceedings of the AHFE 2017 International Conference on Human Factors in Transportation*

Transition Process and Model

Automated driving →

Manual 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

Type of current (non driving related) activity

Type/Design of Request to Intervene

Requirements of take-over scenario

Driver training / education / system experience

Marberger, C., Mielenz, H., Naujoks, F., Radlmayr, J., Bengler, K., & Wandtner, B. (2017). Understanding and Applying the Concept of "Driver Availability" in Automated Driving. In N. A. Stanton (Ed.), *Advances in Human Aspects of Transportation: Proceedings of the AHFE 2017 International Conference on Human Factors in Transportation*

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Transition Process and Model

Definition of take-over situations

	Urgency of situation	**Predictability of RtI**	**Criticality of situation**	**Complexity of driver response**
	How much time is available to intervene ? Corresponds to "Total time budget".	*How likely is the driver prepared about a future take-over requirement?*	*How severe are the consequences if the driver does not take-over in time?*	*How complex is the required driver intervention?*
Human performance limits	high	low	high	medium-high
Time demand for unplanned transitions	medium	low	low	low-high
Driver comfort for planned transitions	low	high	low	low
…	…	…	…	…

Definition of take-over situations

			Prädizier-barkeit	Dringlich-keit	Kritika-lität	Fahrer-reaktion	
Normalfahrt	Sensorausfall "Total": alles fällt aus	Sensorausfall vor Kurve					2
		Sensorausfall auf Gerade					2
Abfahren von der AB	Spurwechsel auf den Verzögerungsstreifen nicht möglich	Dichter Verkehr					3
Durchfahren eines AB-Kreuz	Spurwechsel im AB-Kreuz nicht mgl.	Dichter Verkehr					3
Auffahren auf die AB	Spurwechsel beim Auffahren auf die AB nicht möglich	Dichter Verkehr					
Engstelle	Engstelle erst durch Umfeldsensorik erfasst						2
Passieren von Gefahrenstellen	Taktische Gefahrenstelle klassifizierbar, aber nicht umfahrbar (Bsp.: Fußgänger, Tiere...) / nicht klassifizierbar	Objekt auf dem eigenen Fahrstreifen (z.B. Unfall)					1
		Objekt auf einem anderen Fahrstreifen (z.B. Unfall)					

1: alles worst case: hoch dringlich, kritisch und komplexe Fahrerreaktion

2: niedrigere Komplexität der Fahrerreaktion, teilweise geringere Kritikalität

3: höhere Prädizierbarkeit, geringere Kritikalität, Komplexität der Fahrerreaktion hoch

In den empirischen Studien zu Einflussvariablen der Fahrerverfügbarkeit auf die Übernahme sollten mind. je eine Situation der Gruppe 1 und 2 enthalten sein, optional eine Situation der Gruppe 3.

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

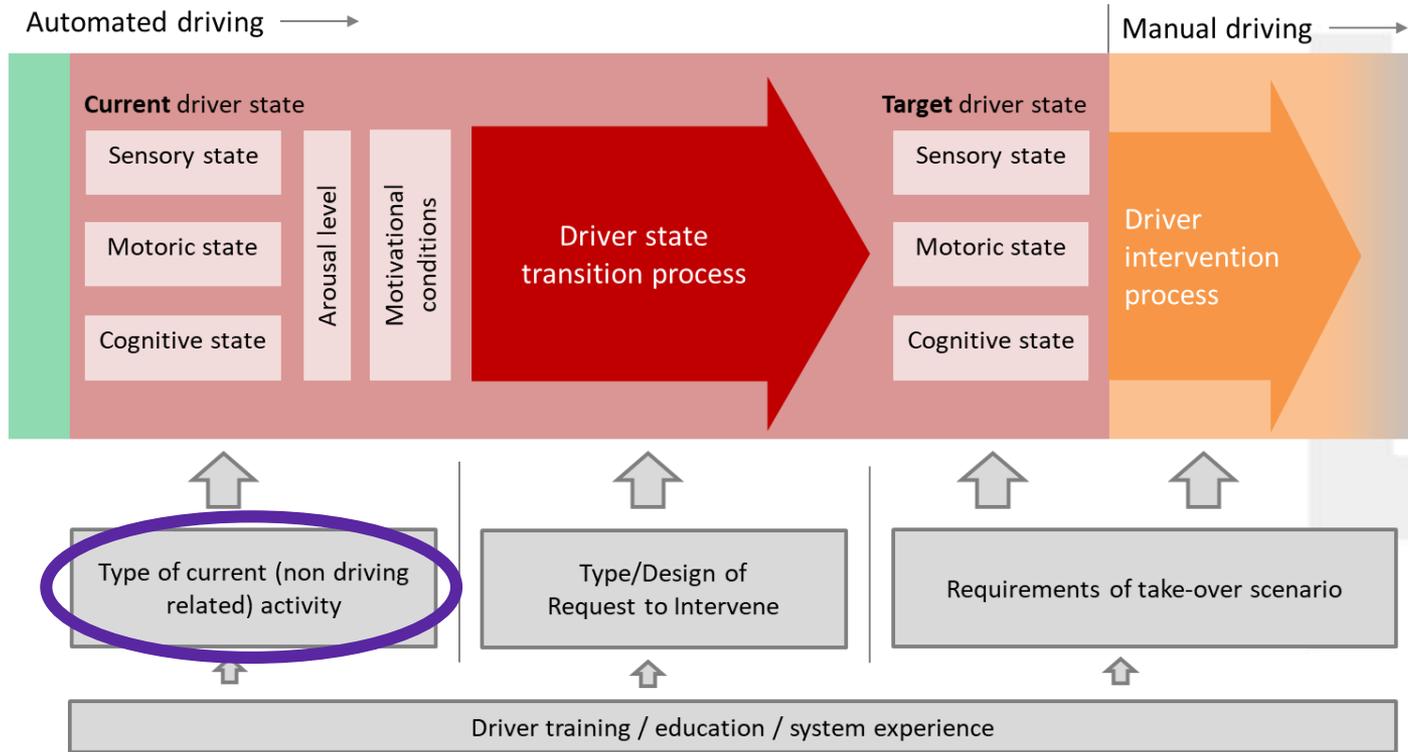| Construction Site			
Urgency	**Predictability**	**Criticality**	**Complexity**
high	low	low – medium	low – medium

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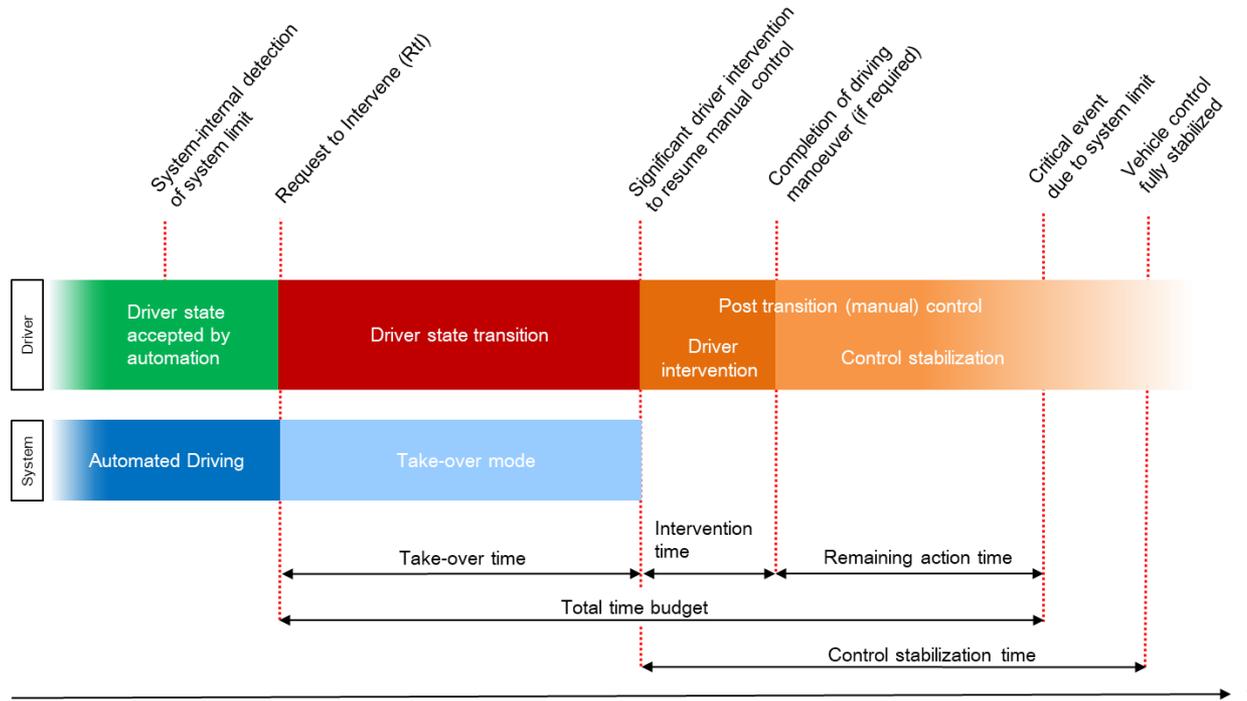# Transition Process and Model
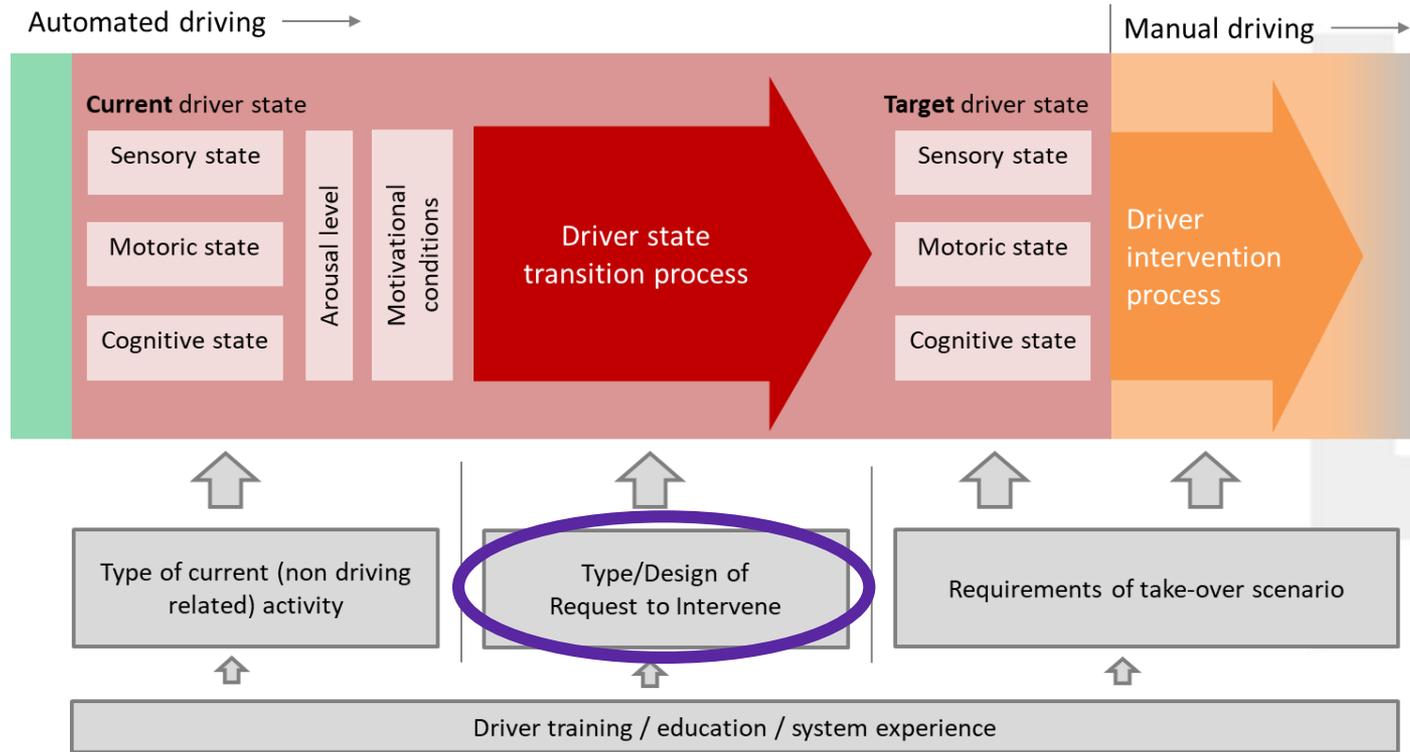
HMI – Minimal requirements

- 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)

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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**

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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)

Naujoks, Befelein, & Neukum. 2016.

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Catalogue of NDRTs

Naujoks, Befelein, & Neukum. 2016.

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Metrics and TOC-Rating

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).

| Research question | Driving simulator study | Video sequences of take-over situation | TOC-Rating | Controllability under condition 1/2 |

Condition 1 Condition 2

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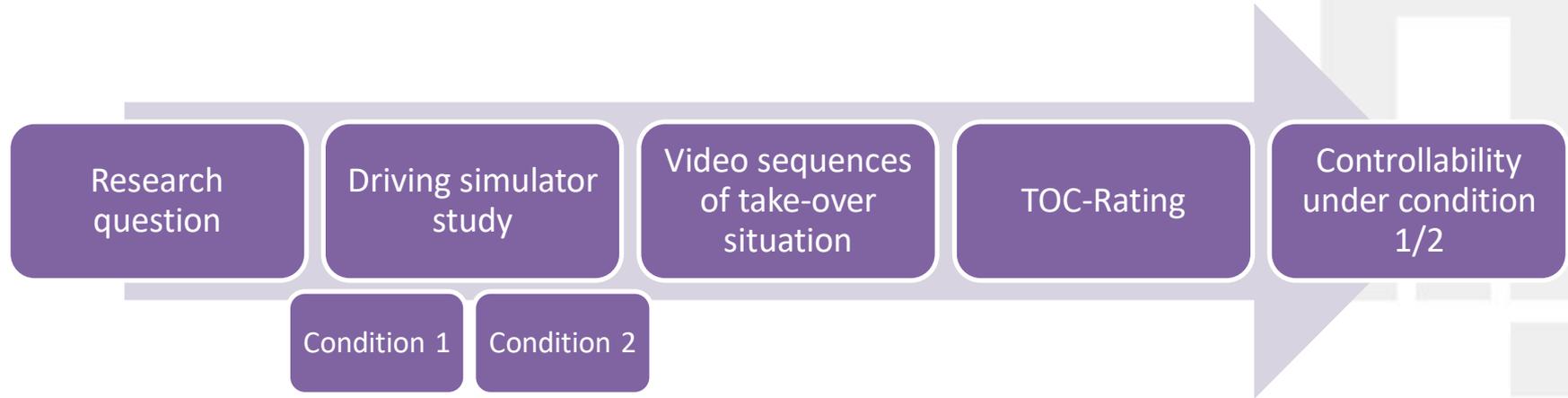
Take-over controllability rating (TOC)

Assessment critera

- **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.
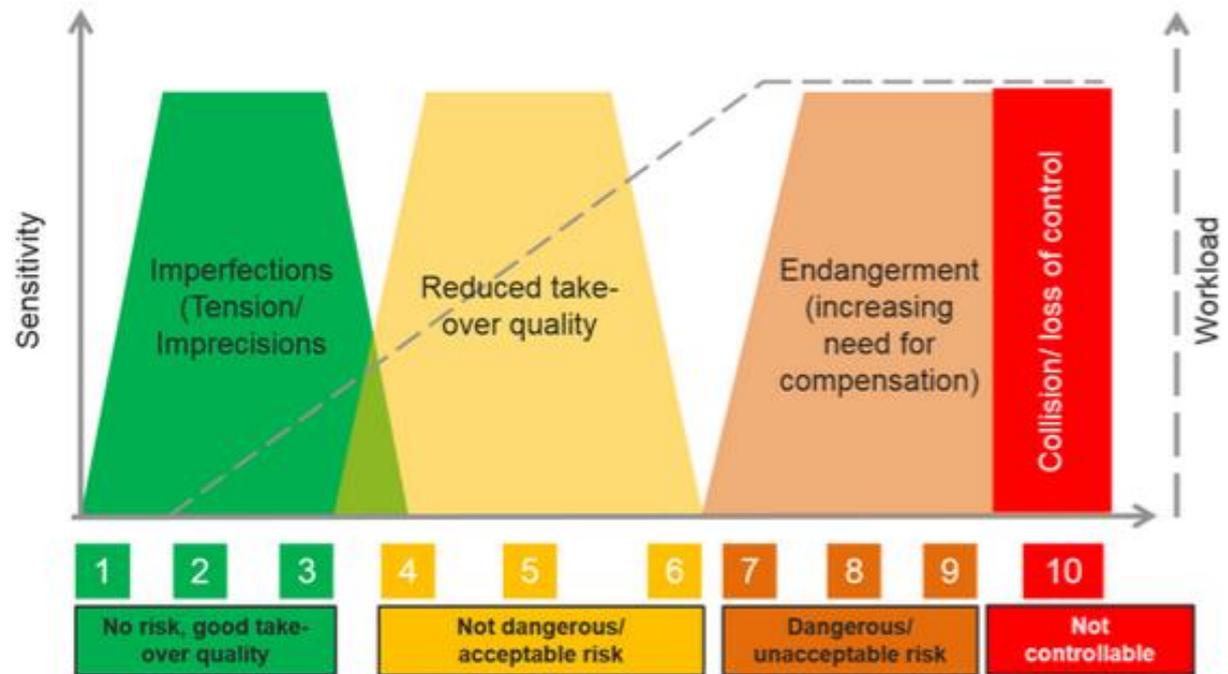
Take-over controllability rating (TOC)

- 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.

Coding sheet for take-over situations

	Fault-less	Imprecisions	Driving Errors	Endangerment	Not controllable Event
Braking response			too strong / too weak / too late / missing	endanger others / endanger self	collision / lane departure/ leaving road / loss of vehicle control
Longitudinal vehicle control			safety-distance too low / inadequate speed		
Lateral vehicle control		jerky steering event / imprecise lane keeping	safety-distance too low / strong oscillation / crossing lane markings		
Lane change/ lane choice			hesitant/ interrupted / too late / missing / wrong lane		
Securing/ communication		unnecessary/ wrong use of indicator	missing/ too late use of indicator / missing/ too late control glance		
Vehicle operation		imprecisions	problems		
Driver facial expression		visible emotions			
	1	2 3	4 5 6	7 8 9	10

comment:

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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

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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**.

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Thank you
for your attention!

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