



Fahrermodell für das virtuelle Testen von Level 3 Systemen

ASAM-Tagung, 2017, Dresden

Dr. Helmut Schittenhelm,
06/07.12.2917

Mercedes-Benz
The best or nothing.

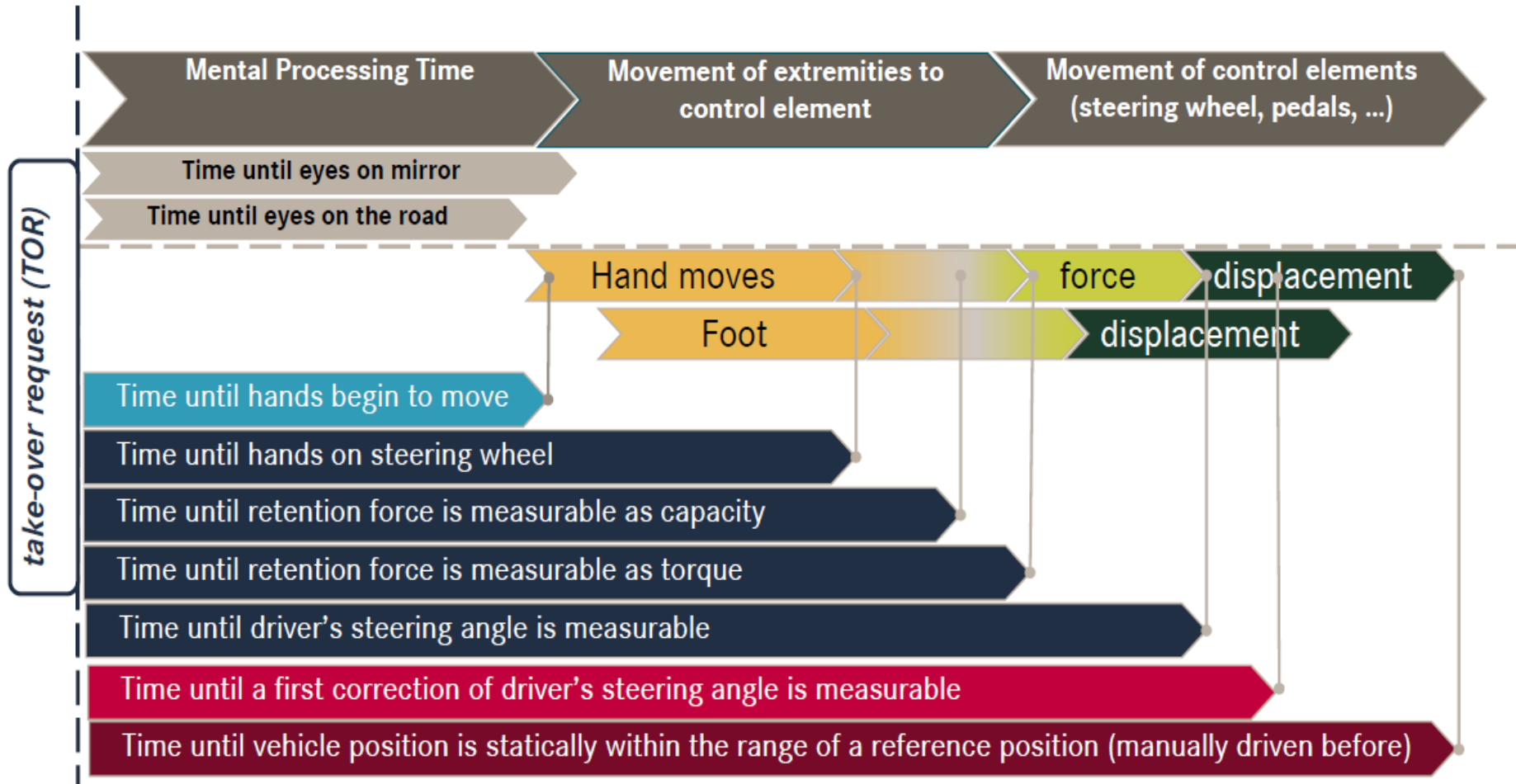
Extract only





Different „take-over times“ defined along the event chain

crucial point: they are all **Take-over reaction time(s)** – but they are not all the same





Daimler driving simulator

360° visibility



<https://www.youtube.com/watch?v=qSYs5PgZhDY>



Testing – how drivers interact with a Level 3 system

Daimler driving simulator

• Focus on driver & vehicle interaction

- high repeatability
- with a large number of test persons
- representative results
- interior & exterior of a W222 (complete vehicle)
- close to vehicle implementation avoids artefacts resulting from simulator research





System indication

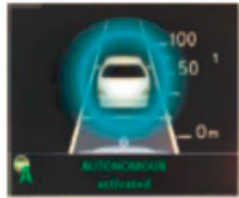
Take-over request



- ACC is activated



- **Available** Requirements for activating the systems are fulfilled. System can be activated by the driver. System is yet not active.



- **Activated** System is active and controls longitudinal and lateral vehicle guidance.



- **Take-over-request** Activated system has detected a system limit and requires the driver to take-over.

Take-over Request (TOR)

- Visual warning in instrument cluster (IC) and head unit (HU)
- Acoustic warning
- Secondary task blocked





Integration of secondary task in vehicle interior

All regulation, requirements and specifications in force are fulfilled



Secondary task

- high workload, NASA-TLX controlled
- long glance duration to secondary tasks
- performed over a period of 20-25 minutes before TOR

The **secondary task** consists of a mixture of

- Arithmetic problems
- Brain teasers
- Personal questions
- attentiveness endurance test (Test d2)
- Text input of given texts of 100-200 characters
- Receiving and writing text messages [SMS]
- Quiz questions
- riddles

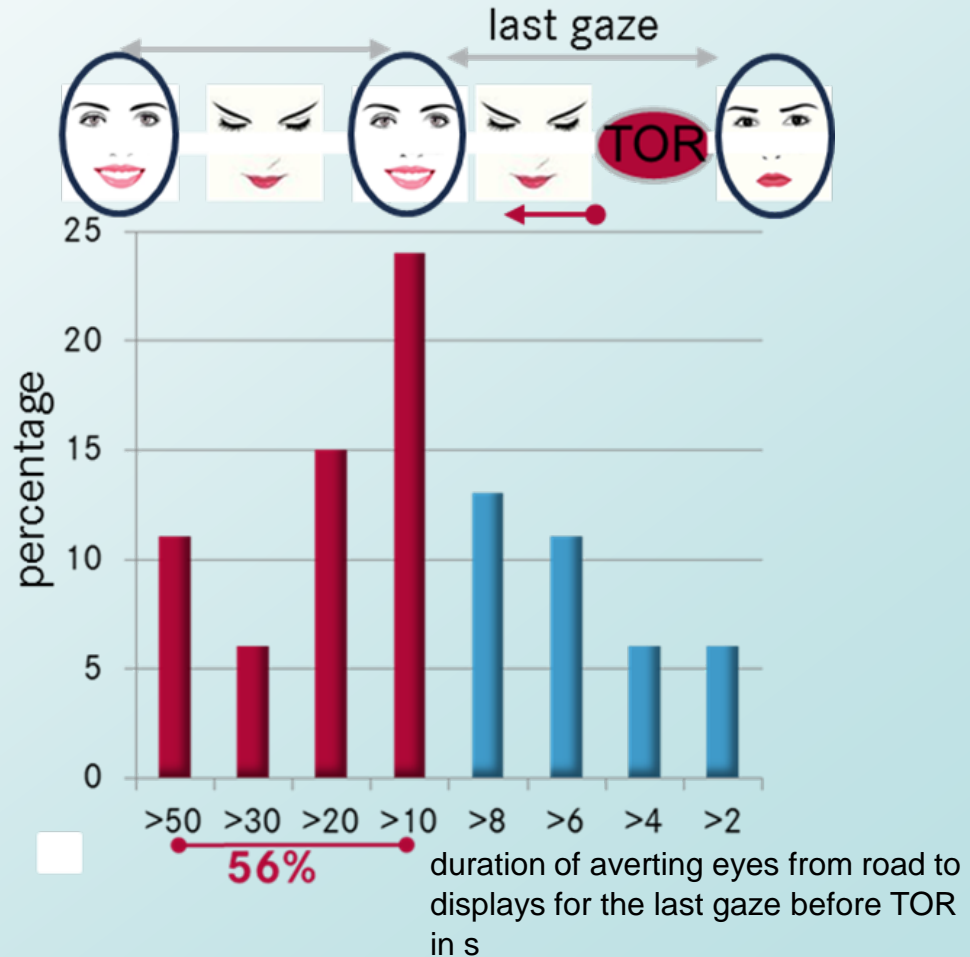
Task set contains visual, acoustic (speak and listen), manual, motoric and cognitive components. The speed of receiving new tasks is controlled by the test person by their processing time. Fixed type of task before take-over request.



Setup secondary task

Quality of distraction: criterion last gaze before TOR

- **100%** of all participants turned their eyes on the display (not on the road) for **more than 2 sec.** before TOR
- More than **50%** of all participants turned their eyes on the display (not on the road) for **more than 10 sec.** before TOR

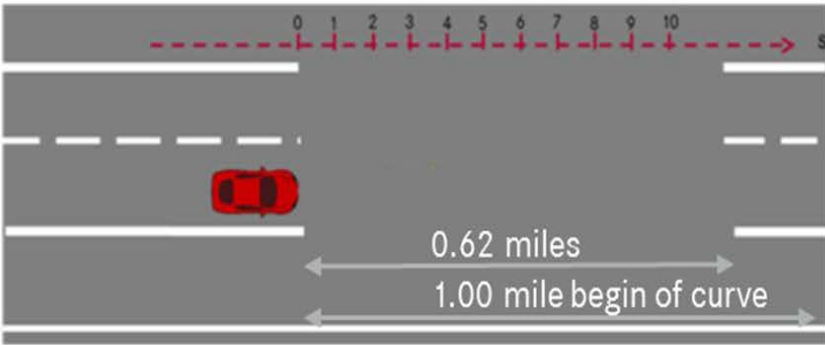




Impact on Take-over Time: analyzed situation containing **no urgency, no criticality, no self-protection**

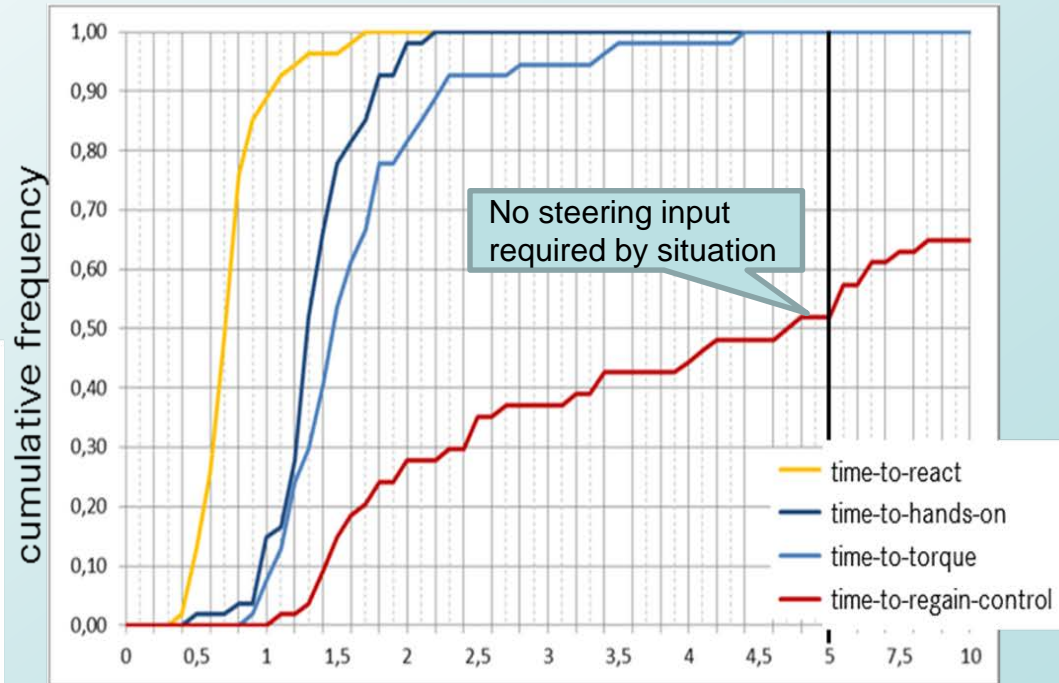


Performed with / without lead car



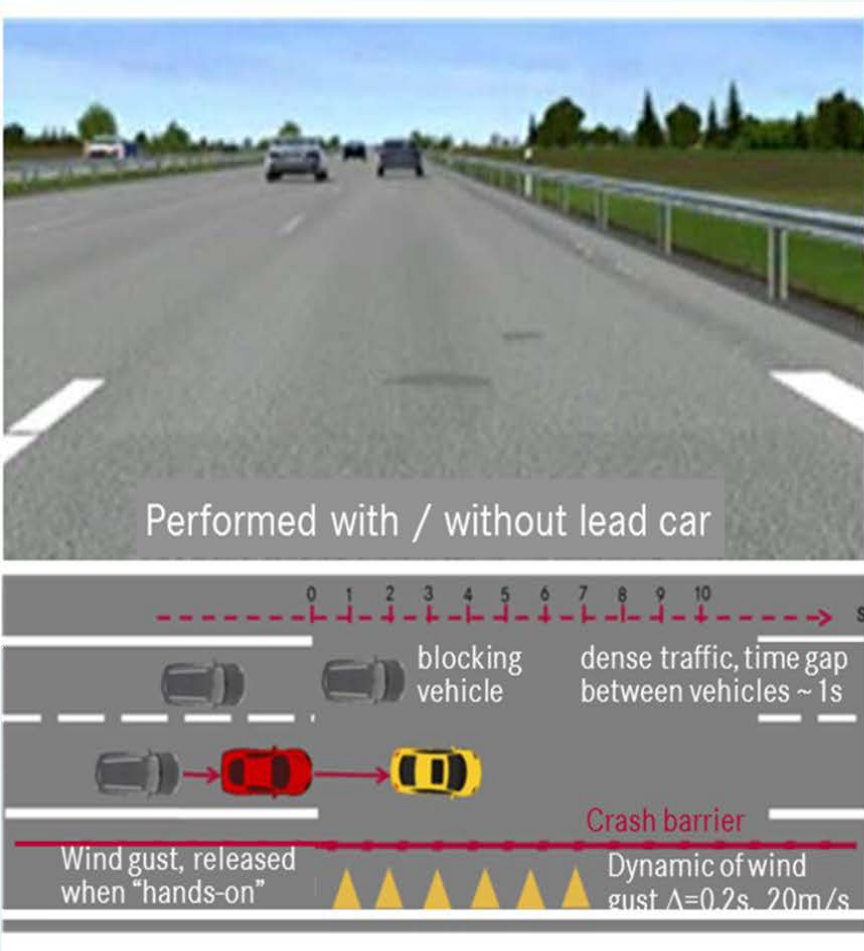
Take-over Scenario – missing lane markings (n = 54)

- Straight road section
- Low density of traffic



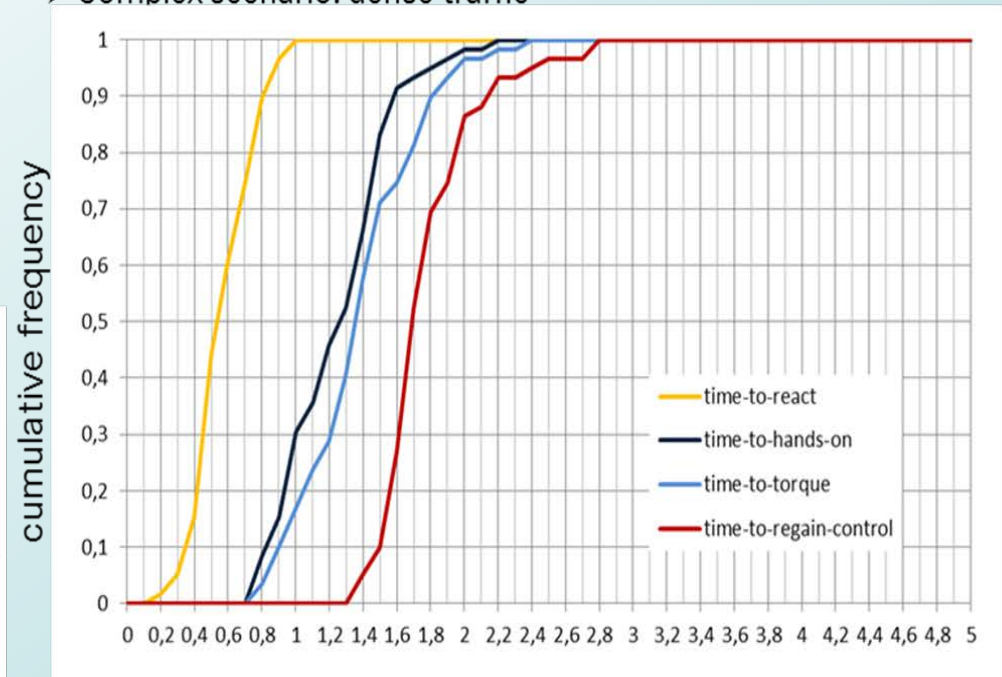


Impact on Take-over Time: analyzed situation containing urgency (pressure to react), criticality, **no** self-protection



Revised take-over Scenario – missing lane markings (n = 46)

- Disturbance (while taking over control): wind gust from the right
- Requirements for lateral control: Blocked lane left, crash barriers
- Complex scenario: dense traffic



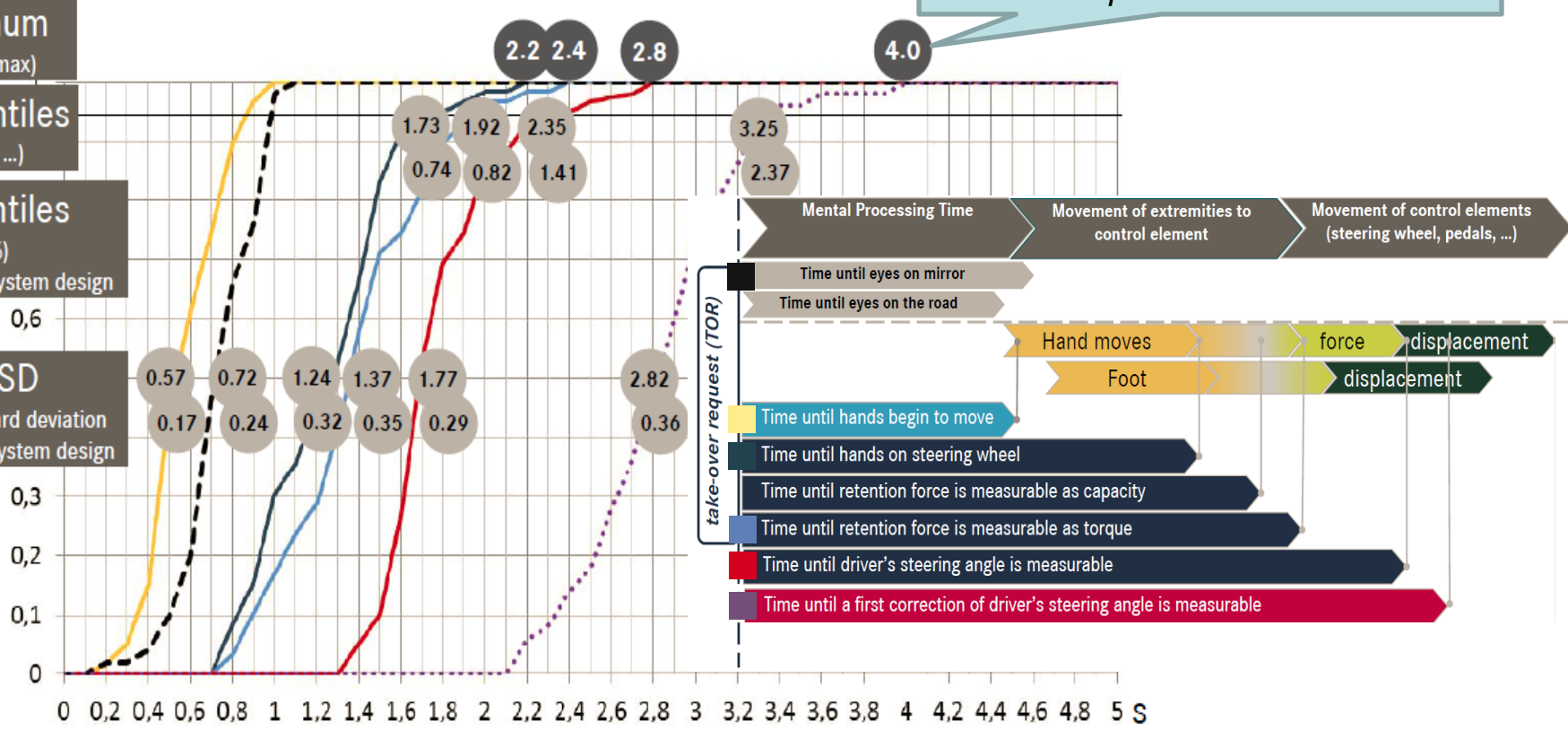


Take-over reaction times

Determination of the « VALUE » of take-over reaction time – which should be used?

100% of test persons have *corrected* their first *impulse reaction* within 4.0s

- 1. Maximum
(min, median, max)
- 2. Percentiles
(95%, 50%, 5%; ...)
- 3. Percentiles
(75%, 50%, 25%)
Irrelevant for system design
- 4. MV & SD
Mean & standard deviation
Irrelevant for system design

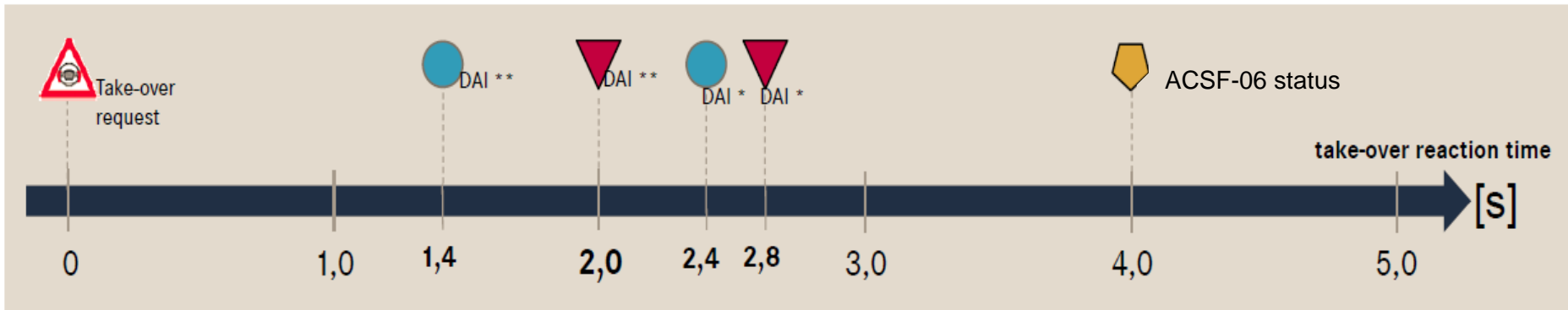






Summary: take-over reaction times presented here

Our studies show:

Within a short period of time, drivers are able to switch back from the role of a "passenger", who is performing a secondary task, back into the role to that of a "driver" and can resume control of the vehicle and drive stable and accident-free in manual control.



 time until driver's hands-on steering wheel (maximum of times that appeared in the trials)

 time until driver's steering angle is measurable (maximum of times that appeared in the trials)

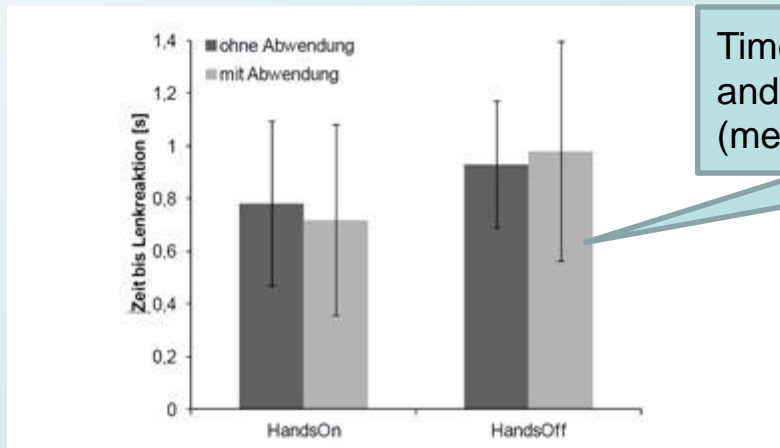
**very urgent situation (emergency maneuvers)

*normal urgency of the situation, but urgent need for action after takeover



Investigation of the drivers' behavior after semi-automatic hands-free driving

- Project supported by FAT and BAST
- Results are comparable.
- Daimler values even more conservative (Meanvalue of first steering 1.77s vs. 0.95s).



Time of first steering correction with and without secondary task (meanvalue)

FAT: Forschungsvereinigung Automobiltechnik
 Research Association Automotive Technology
 BAST: Bundesanstalt für Straßenwesen

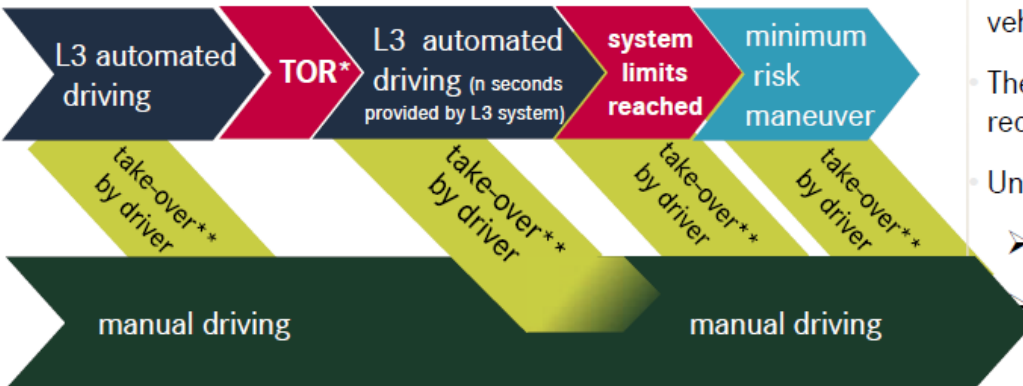


BACK UP

The exemplary Level 3 System here: Highway Chauffeur (VDA definition)

System performs driving task – driver stays alert and takes over if requested

Design of L3 system under test



*take-over request (TOR)

**There is always the possibility to „take-over“ for the driver.
(Naturally, the driver can “take-over” before TOR.)

- The System that is analyzed here is comparable to Highway-Chauffeur (VDA) with the following exceptions:
- The system takes over longitudinal and lateral control on multi-lane roads with parallel traffic system (additionally)
- The driver may perform **certain** secondary tasks limited to the vehicle’s infotainment/functions
- The driver must take-over again within a certain time frame after a request by the system
- Until the driver takes over, the system remains in control
 - The system avoids collisions
 - The system knows its limitations and hands over to the driver before these are reached
 - If the driver does not take-over the system starts decelerating moderately (Active Emergency Stop Assist) until he takes over or vehicle is stopped
 - Failures by the system are handled by the system

Classification remarks about the „*take-over times*“ defined before
 ... to avoid comparing apples and oranges.

	Special expression of „take-over reaction time“	Measurement	Threshold value for classification	Normal use	Problems / Dependencies
All referred to as: take-over reaction time	time until hands begin to move	acceleration sensors and laser sensors,	movement of a hand	performance indicator for UI & ability of driver	-
	time until (first) hand on steering wheel	video denotation	clasping the steering wheel with the first hand	performance indicator for UI & ability of driver	-
	time until retention force is measurable as capacity	capacitive steering wheel	capacity (hand clasping steering wheel)	detection hands-on, assessment criticality	scenario: subjectively felt criticality, complexity
	time until retention force is measurable as torque	torque Sensor,	torque for retention force performed by driver	detection hands-on, assessment criticality	scenario: subj. felt criticality, complexity, human property
	time until driver's steering angle is measurable	steering angle sensor	steering angle is performed by driver	detection driver input	scen.: subj. felt criti., urgency, complexity, human property
	time until a first correction of driver's steering angle is measurable	steering angle sensor	steering angle & condition for correction	differentiation between reflex & willfully / intentional driv. action	scen.: subj. felt criti., urgency, complexity, human property, dynamics, need for correction
	time until vehicle position is statically within the range of a reference position	statistical model for lane position & steering angle	parameters that describe the quality of statistical model	time it needs to come back to an initial state	not a time until s.th. starts, function of time and quality



Driving Simulator test: setup participants

figures that were approximately met in later discussed tests

Group size	at least 35 analyzable subjects
Group profile	representative to Statistics
• age	mean ~ 49 years; range 23-78 years, balanced
• gender	40% female, 60% male
• Driving experience	
➤ Classification of own car	at least a subcompact car
➤ driving exposure (owned driver's license)	mean ~ 30 years; range 1-60 years
➤ miles travelled per year	mean~12,500 miles; range 3,000-65,000 miles
➤ experience with ADAS (built-in own cars)	about 25% of subjects used a Level 2 system once a week in their own car; about 50% had no experience L1/L2 syst.
➤ Experience Driving simulator	first experiences but no undergoing of accidents



Some remarks concerning the secondary task used

The secondary task used generated among the test persons:

- high **acceptance** due to a wide and varied range of tasks (there was always something for everybody),
- a high level of **work load** was achieved by addressing their visual, acoustic (speak and listen), motoric/manual and cognitive capabilities test persons and the integration of small d2-tasks,
- a **self-reinforcing steady demand for new tasks**. (difficult of getting rid of them)

At a certain point before TOR, the participants received the task of reading a text (140-160 characters) in the display and re-entering it two lines below. This corresponds to a high level variant of the reference task “**manual destination entry**” suggested in the NHTSA Guidelines (2012). Test persons who completed the task quickly received new texts until TOR was triggered. As a result, long gaze distractions could be generated. Text messages were chosen as a task-before TOR because many studies show that they have a great distraction potential.

The turn-push control used for secondary tasks is a demanding input medium. Rotate to pre-select a character from a character string, which is then transferred to the input window by pressing it. For the selection of lowercase and capital letters as well as special characters and numbers, it was necessary to switch between several selection strings.



Quality of manual control after TOR and wind impulse (gust)

Performance of L3 driver is comparable with the performance of L2 driver

Performance L3 and L2 group:

- No collision with crash barrier on the right side or vehicle in the left lane
- Everyone stays in the “freespace”

Group driving L3-system conducting secondary task before TOR

Leaving the (non-visible) lane

- 97%: no leaving of the lane
- 3%: leaving the lane (max. 5 cm in other lane)

Reference group (driving L2, no secondary task)

Leaving the (non-visible) lane

- 95%: no leaving of the lane
- 5%: leaving the lane (max. 5cm in other lane)