Driving Automated.
Looking Back - Looking Ahead

Automotive User Interfaces 2023

Ingolstadt

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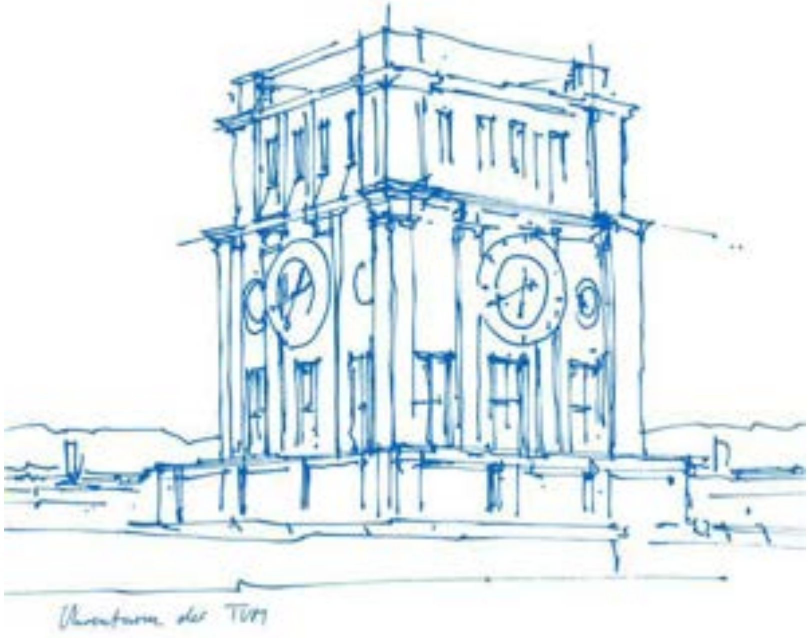


with contributions of LfE Doctorates

Benefits of Higher Levels of Automation

- **Improved Traffic Flow**
- **Efficient Usage of Infrastructure**
- **Fuel Savings**

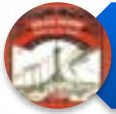
- **Comfort**
- **More Lifetime**
- **More Quality of Life**

- **More Safety ?**

Welt online, 2011

Welt online, 2011

Autonomous Car History (selected)



1863

- Paris au XX^{ème} Siècle (Verne, 1863)

20’s & 30’s

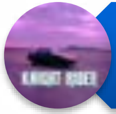
- ”Iinrrican Wonder”, (The Milwaukee Sentinel, 1926)
- Futurama exhibit, (O’Toole, 2009)

50’s

- RCA Labs demonstration on public Highway, Lincoln, Nebrasca, USA.(Quigg, 1958)

60’s & 70’s

- “Electonic Roads” (Jenks, 1961)
- UK’s Transport and Road Research Laboratory driverless car (Waugh, 2014)



80’s

- Prometheus Project, **Ernst Dickmanns.** (Ernst Dickmanns, 2002 & 2011)
- Autonomous Land Vehicle Project, DARPA (Kanade, Thorpe, & Whittaker, 1986)

Autonomous Car History (selected)

90's

- VaMP project, driving in Paris highway 1000Km (Ernst Dickmanns, 2002 & 2011)
- Navlab Project, driving in the USA 5000Km (Thorpe & Hebert, 1988)
- Mille Miglia in Automatico, driving in Italy(Broggi, Bertozzi, & Fascioli, 2000)

2000's

- Demo I, II, III for the US Government. Driving off-road. (Albus, 2002)
- Parkshuttle, in Netherlands, a public driverless transport system (Parent, 2004)
- DARPA Grand Challenge, DoD (Thrun & Montemerlo, 2006)
- Commercial application, Rio Tinto, Australia (Mcnab & Garcia-vasquez, 2011)

2010's

- VisLab International Autonomous Challenge (Broggi, Medici, & Cardarelli, 2010)
- Spirit of Berlin and MadeInGermany, AutoNOMOS (Göhring, Latotzky, Wang, & Rojas, 2013)
- Leoni Braunschweig
- Leaf Advance Driving Assistance System Prototype, Nissan (Santos, 2013)
- Google Car allowed to circulate in Nevada, USA. (Knapp, 2011)

Joel Gonçalves, 2014
HF Auto

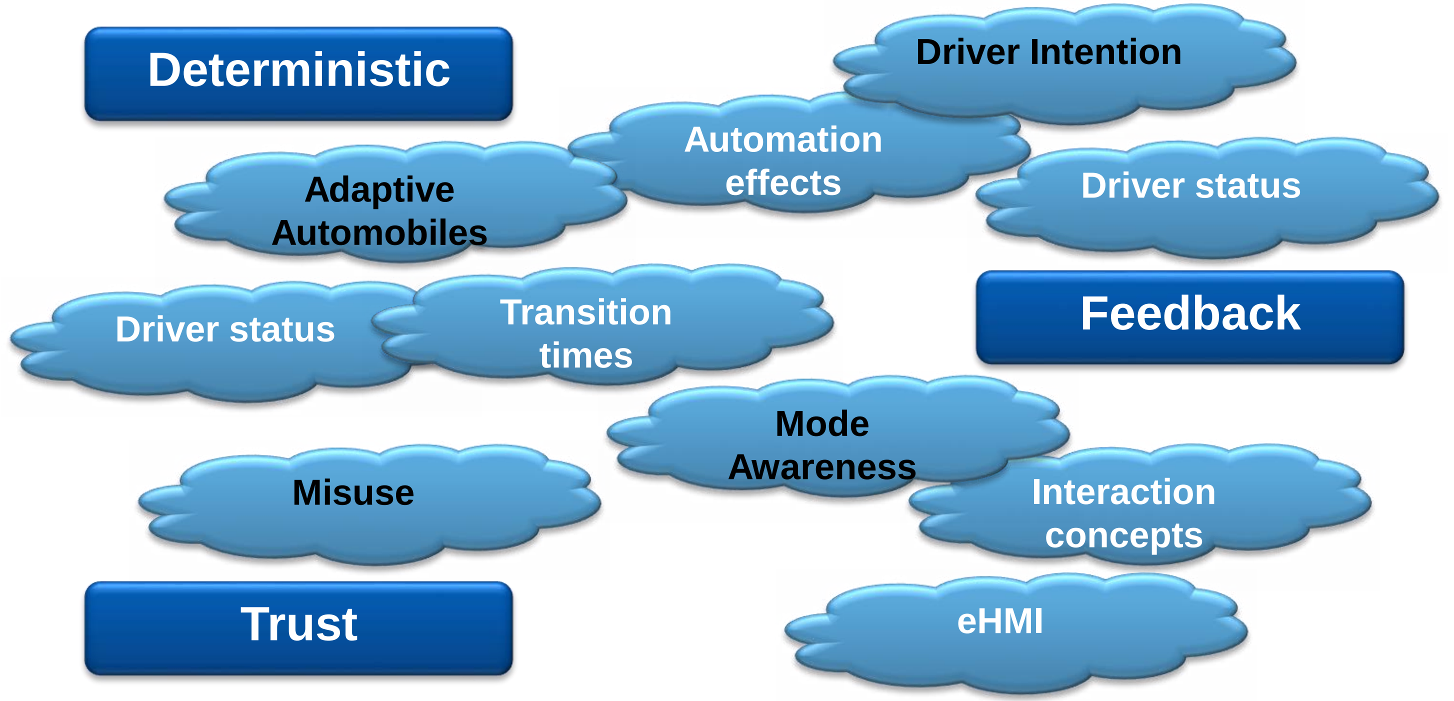
Why Are We Able to Drive the Automobile

Because ..

August Horch (1908)

- it is deterministic
- it provides instant feedback
- we trust in it and the system

Research Questions



Automated Vehicles …

Thank Heaven …

Reduced Questions on Human Factors and Ergonomics

For Heaven‘s Sake –
Even more Questions on Human Factors and Ergonomics

Translation

Report on the Need for Research

Round Table on Automated Driving – Research Working Group

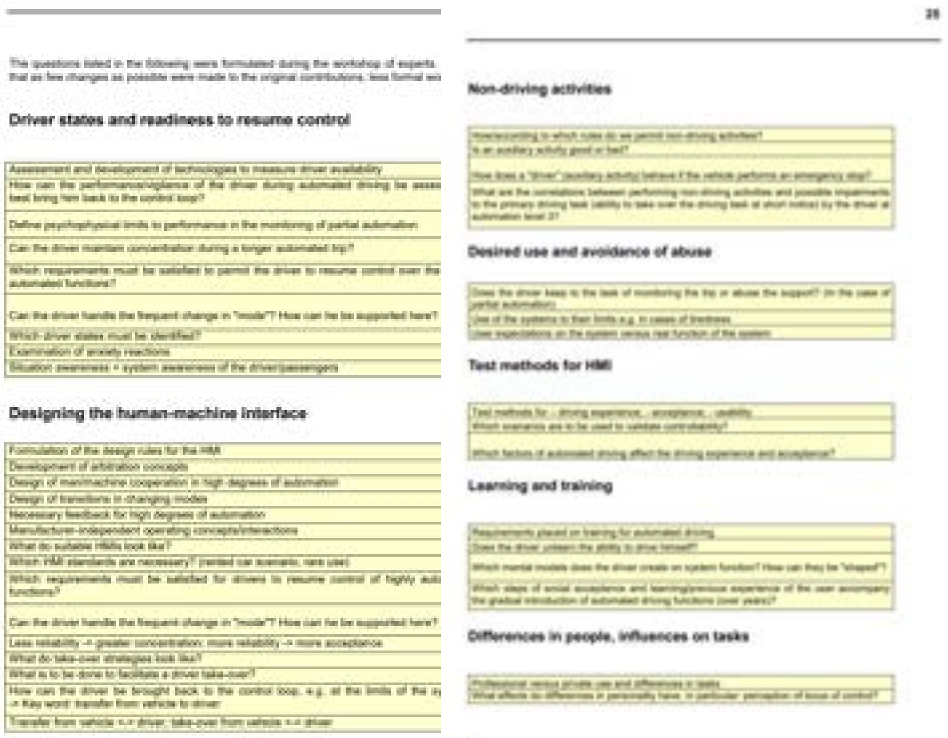
by

Tom M. Gasser/ Eike A. Schmidt (Working Group Lead)

Klaus Bengler
Frederik Diederichs
Frank Flemisch
Erich Fuchs
Robert Hoyer
Meike Jipp
Matthias Kühn
Christine Lotz-Keens
Michael Meurer
Nina Möller
Andreas Reschka
Jan Ritter
Wolf Stankowitz
Eberhard Zeeb
Ulrich Chiellino
Lutz Eckstein
Eva Fraedrich
Marko Gustke
Michael Hüttinger
Frank Köster
Barbara Lenz
Markus Maurer
Siegfried Meuresch
Christian Reitter
Gerd Riegelhuth
Karl-Heinz Siedersberger
Rüdiger Trimpop

Round Table on Automated Driving

Level 3 Research Questions


Driver states and readiness to resume control

Designing the human-machine interface

Non-driving activities

Desired use and avoidance of abuse

Test methods for HMI

Learning and training

Differences in people, influences on tasks

Report on the Need for Research Round Table on Automated Driving – Research Working Group

Level 3 Research Questions

Driver states and readiness to resume control

Assessment and development of technologies to measure driver availability
How can the performance/vigilance of the driver during automated driving be assessed to best bring him back to the control loop?
Define psychophysical limits to performance in the monitoring of partial automation
Can the driver maintain concentration during a longer automated trip?
Which requirements must be satisfied to permit the driver to resume control over the highly automated functions?
Can the driver handle the frequent change in "mode"? How can he be supported here?
Which driver states must be identified?
Examination of anxiety reactions
Situation awareness + system awareness of the driver/passengers

Designing the human-machine interface

Formulation of the design rules for the HMI
Development of arbitration concepts
Design of man/machine cooperation in high degrees of automation
Design of transitions in changing modes
Necessary feedback for high degrees of automation
Manufacturer-independent operating concepts/interactions
What do suitable HMIs look like?
Which HMI standards are necessary? (rented car scenario, rare use)
Which requirements must be satisfied for drivers to resume control of highly automated functions?
Can the driver handle the frequent change in "mode"? How can he be supported here?
Less reliability -> greater concentration; more reliability -> more acceptance
What do take-over strategies look like?
What is to be done to facilitate a driver take-over?
How can the driver be brought back to the control loop, e.g. at the limits of the system? -> Key word: transfer from vehicle to driver
Transfer from vehicle <-> driver; take-over from vehicle <-> driver

Report on the Need for Research Round Table on Automated Driving – Research Working Group

Level 3 Research Questions

Non-driving activities

How/according to which rules do we permit non-driving activities?
Is an auxiliary activity good or bad?
How does a "driver" (auxiliary activity) behave if the vehicle performs an emergency stop?
What are the correlations between performing non-driving activities and possible impairments to the primary driving task (ability to take over the driving task at short notice) by the driver at automation level 3?

Desired use and avoidance of abuse

Does the driver keep to the task of monitoring the trip or abuse the support? (In the case of partial automation)
Use of the systems to their limits e.g. in cases of tiredness
User expectations on the system versus real function of the system

Test methods for HMI

Test methods for – driving experience; - acceptance; - usability
Which scenarios are to be used to validate controllability?
Which factors of automated driving affect the driving experience and acceptance?

Learning and training

Requirements placed on training for automated driving
Does the driver unlearn the ability to drive himself?
Which mental models does the driver create on system function? How can they be "shaped"?
Which steps of social acceptance and learning/previous experience of the user accompany the gradual introduction of automated driving functions (over years)?

Differences in people, influences on tasks

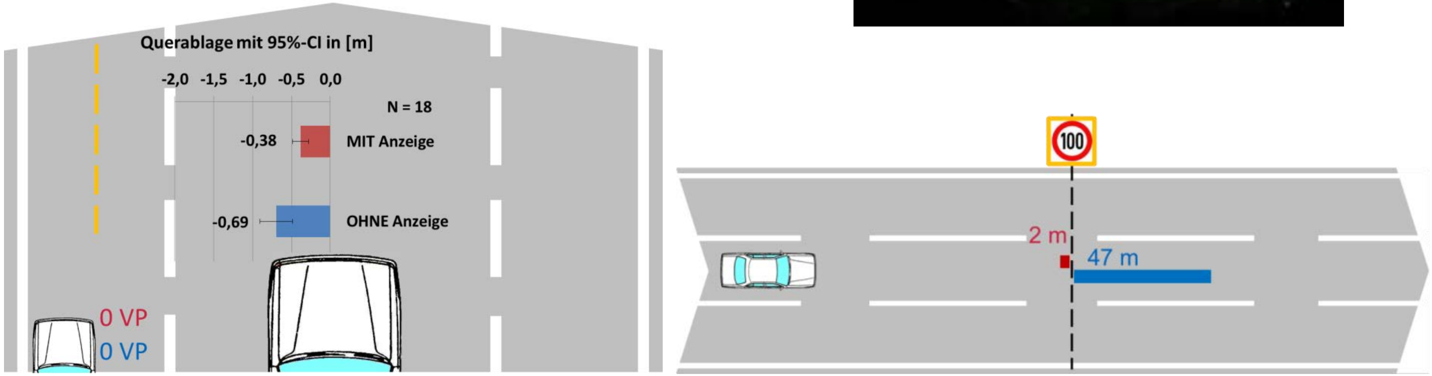
Professional versus private use and differences in tasks
What effects do differences in personality have, in particular: perception of locus of control?

Report on the Need for Research Round Table on Automated Driving – Research Working Group

Controllability / Visual Information

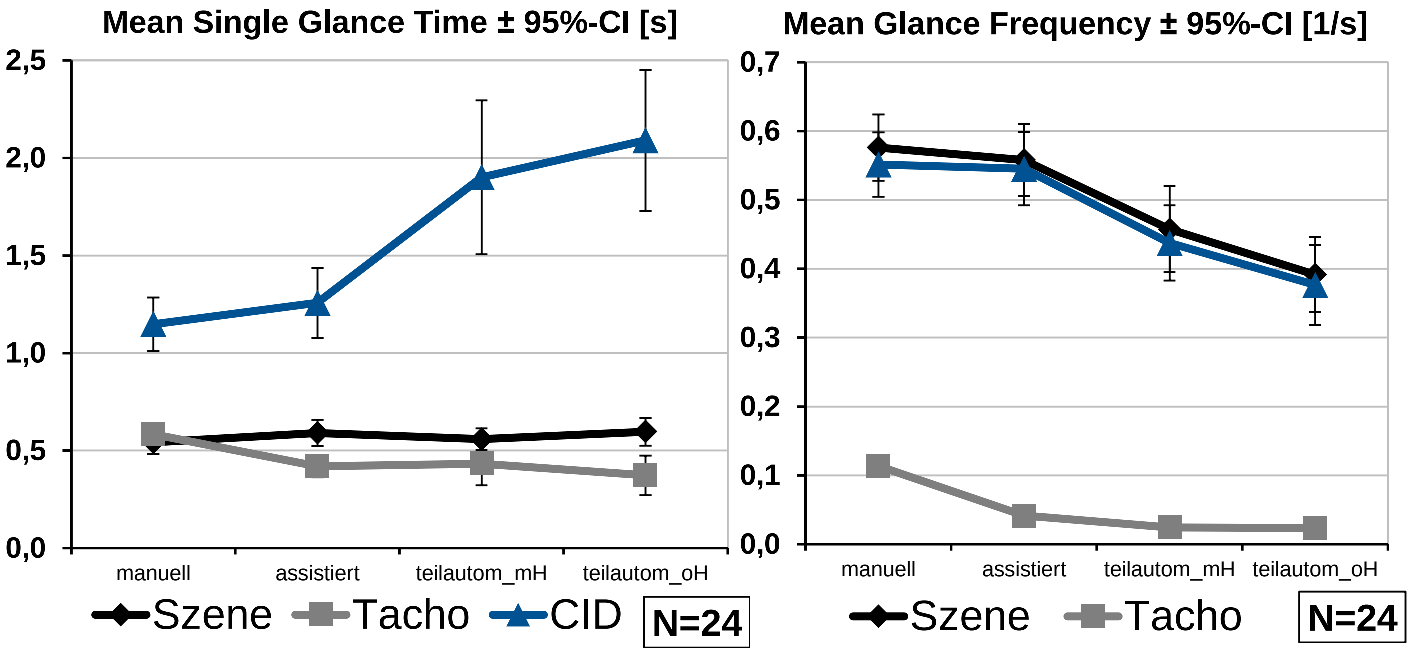
Preview of system behavior leads to

Quicker responses and
better learnability by visualisation
But still to total misses of traffic signs
while automated driving



Weissgerber, T.; Damböck, Daniel; Kienle, Martin; Bengler, Klaus: Erprobung einer kontaktanalogen Anzeige für Fahrerassistenzsysteme beim hochautomatisierten Fahren. 5. Tagung Fahrerassistenz, TÜV SÜD Akademie GmbH, 2012

Visual Behavior During Tertiary Task (Damböck 2012)

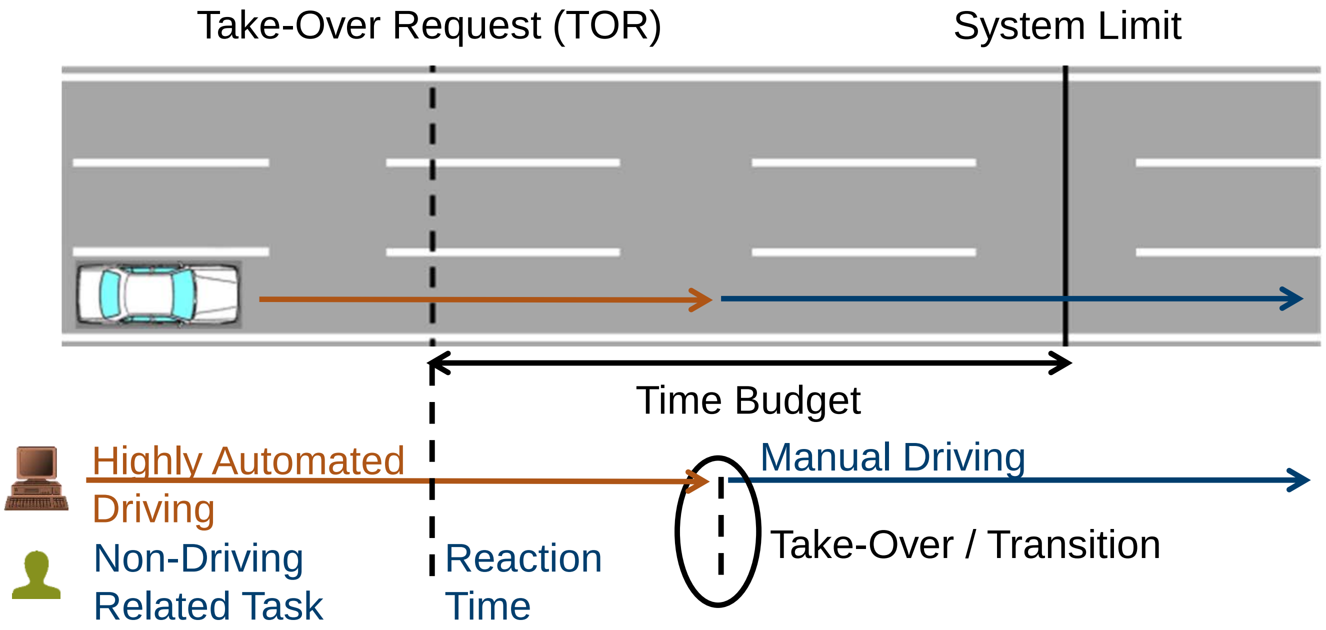


- **Higher LOA lead to more visual divertion**
- **Haptic information is used to reducte glances to speedometer**
- **Visual behavior can be used as an availability metric for cooperation [H-M-S]**

(Dissertation D. Damböck 2013)

Take-Over in Automated Vehicles

Take-Over (here): Machine initiated transition from automated to manual driving.



Take-Over in Automated Vehicles

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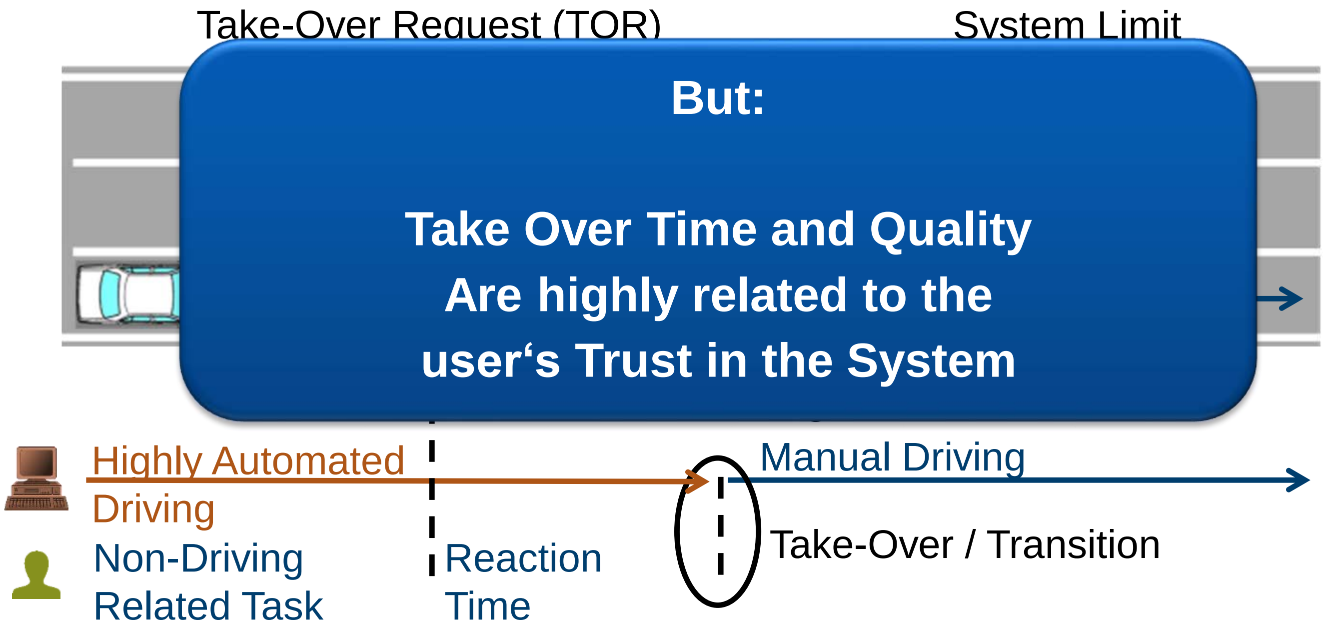


But:

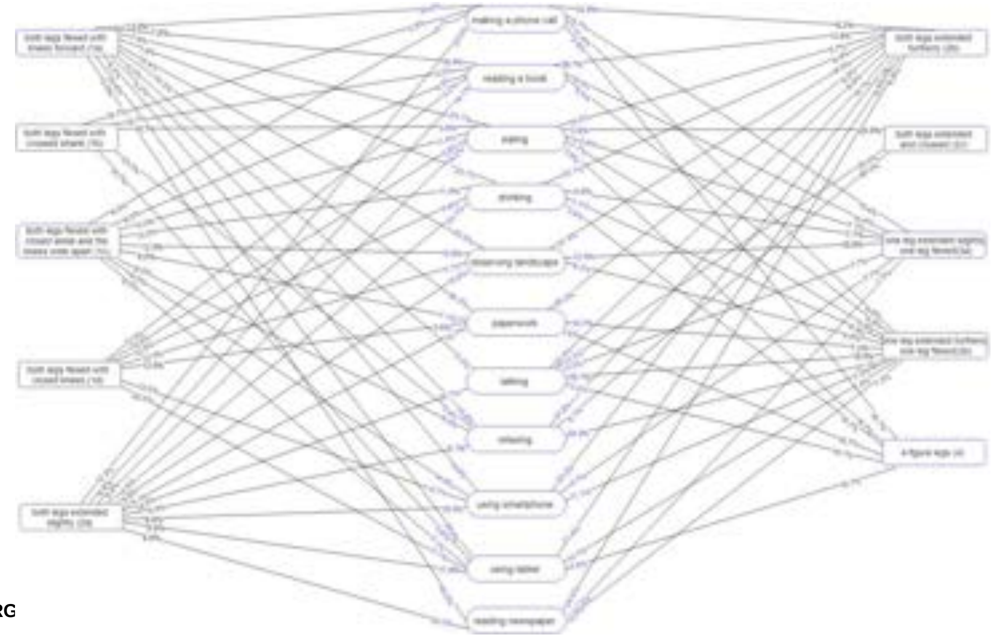
Take Over Time and Quality
Are highly related to the
user‘s Trust in the System

Yes – we have the

10 seconds

but ..

Non Driving Related Activities



Digital Human Models for Future Interiours

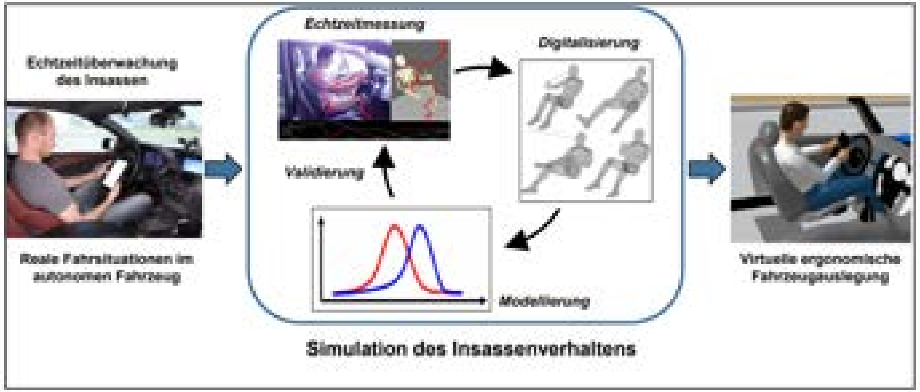


Abbildung 5-1 Vorgehen im INSAA Projekt

Fleischer, M., Chen, S.: How Do We Sit When Our Car Drives for Us? In: Duffy, V.G. (ed.) Digital Human Modeling and Applications in Health, Safety, Ergonomics and Risk Management. Posture, Motion and Health. Lecture Notes in Computer Science, vol. 12198, pp. 33–49. Springer International Publishing, Cham (2020). doi: 10.1007/978-3-030-49904-4_3

Fleischer, M., Li, R.: Spatial Needs for Non-Driving Related Activities. In: Proceedings AHFE 2021 International Conference (2021)

Relaxed

Kinotosis

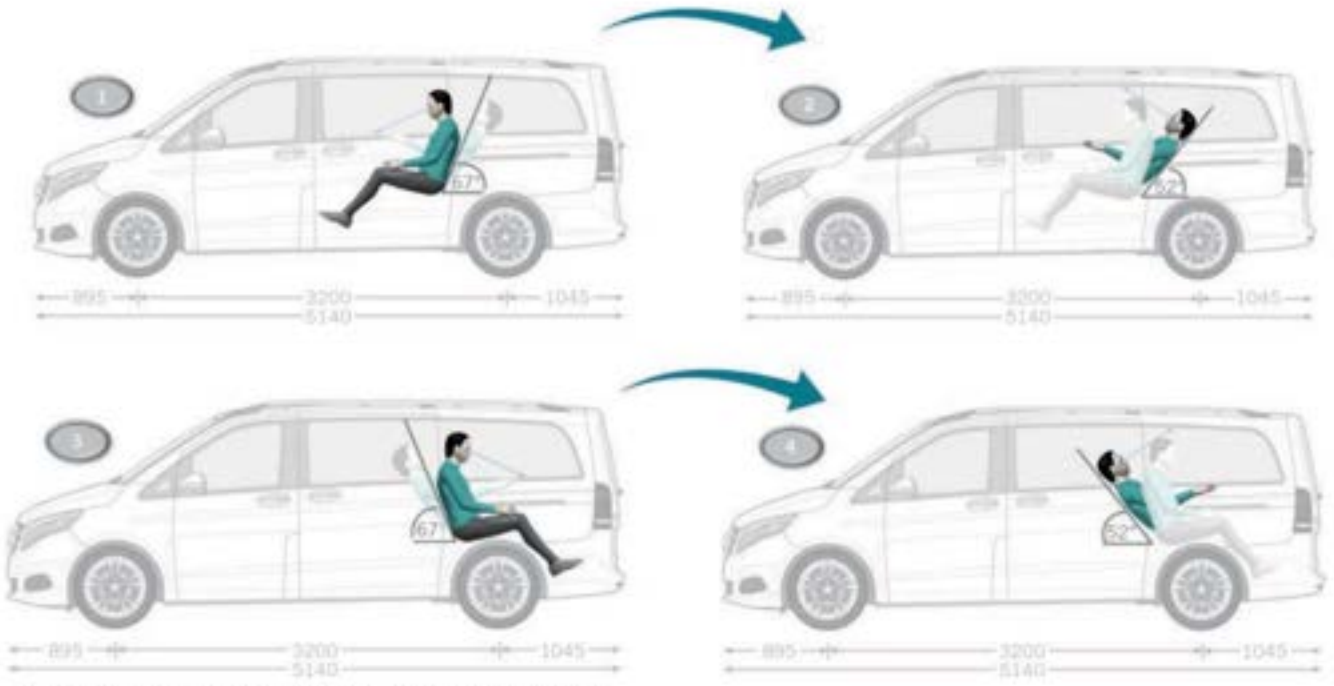


BILD 1 Schematische Darstellung der Experimentalbedingung (© Daimler)

Bohrmann, Dominique: Probandenstudie - Vom Fahrer zum Passagier. ATZextra 24 (S1), 2019, 36—39
Bohrmann, Dominique; Bruder, Anna; Bengler, Klaus: Effects of Dynamic Visual Stimuli on the Development of Carsickness in Real Driving. IEEE Transactions on Intelligent Transportation Systems 23 (5), 2022, 4833-4842

Pedestrian Simulator – Research Questions

How do pedestrians perceive different types of automated vehicles?

What **implicit** and **explicit** communication strategies of automated vehicles are intuitive and comprehensible for pedestrians?

Design

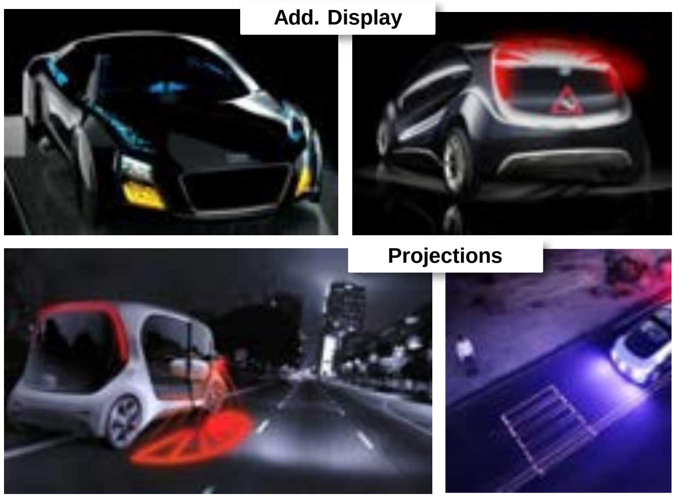
Timing

Message

Position

Lighting

Current OEM Concepts



Motion as THE Language

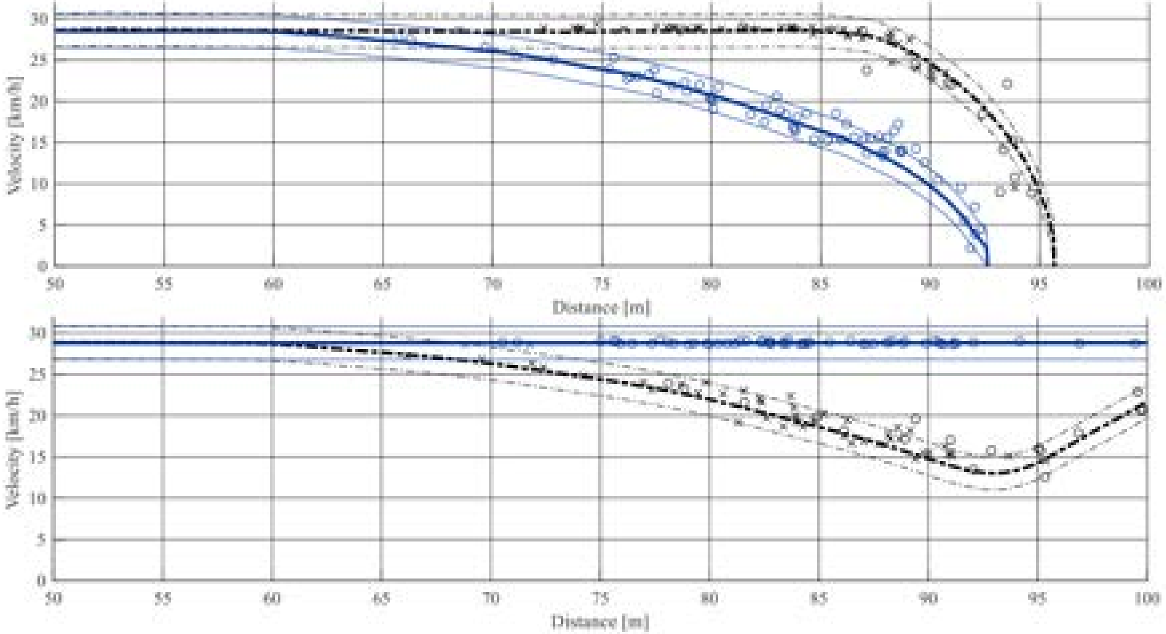
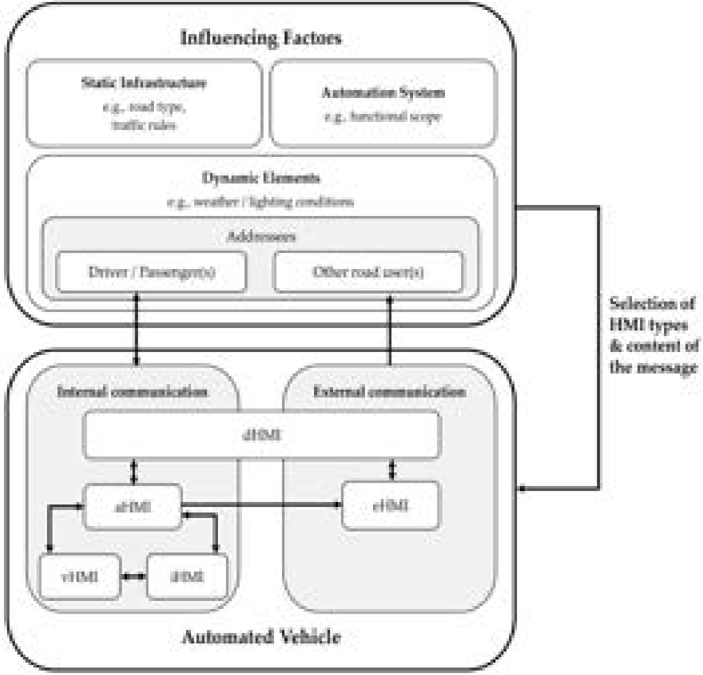


Figure 3. Unambiguous (solid blue line) and ambiguous (dasched black line) target trajectory for the intentions *Let the HRU go first* (top) and *Go first* (bottom), each with the ±2 km/h tolerance limit; the markers show the end of the actual driving profile for all correct (o) and incorrect (x) recognitions, at the moment the participants understood the intention

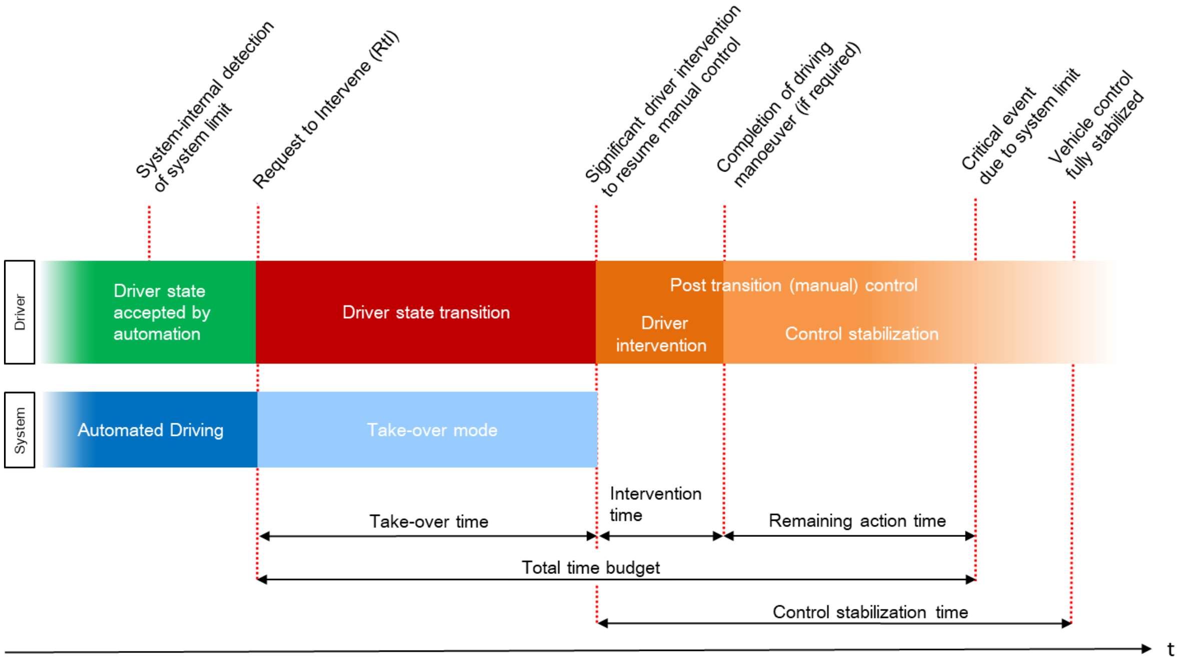
Fuest, T.; Michalowski, L.; Schmidt, E.; Bengler, K.: Reproducibility of Driving Profiles -- Application of the Wizard of Oz Method for Vehicle Pedestrian Interaction. Proceedings of the 22st International Conference on Intelligent Transportation Systems (ITSC), IEEE, IEEE Xplore, 2019Auckland, New Zealand

Systematic Helps



Bengler, Klaus; Rettenmaier, Michael; Fritz, Nicole; Feierle, Alexander: From HMI to HMIs: Towards an HMI Framework for Automated Driving. Information 11 (2), 2020, 61

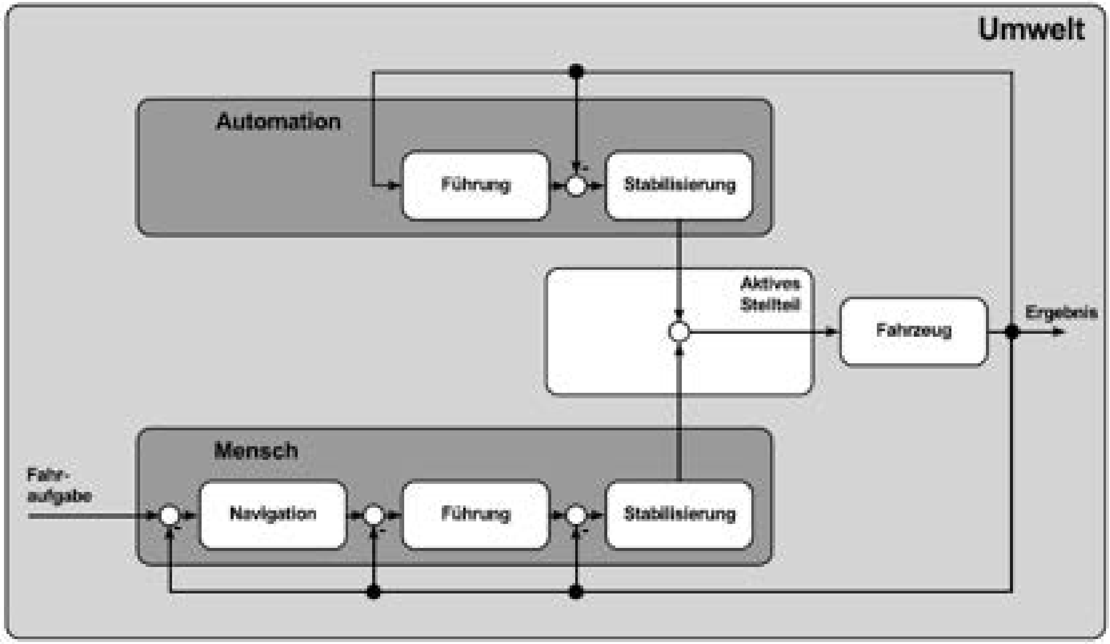
Transition Process and Model



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

Looking Ahead - Rethink

Haptic Shared Control – Active Systems



Vehicle guidance following the H-Mode (Dissertation Martin Kienle, 2015)

Haptic Shared Control – Active Devices

Steering wheel

YOKE
Wittenstein

SIDESTICK
Stirling Dynmaics

Vehicle guidance following the H-Mode (Dissertation Martin Kienle, 2015)

Autonomous Driving

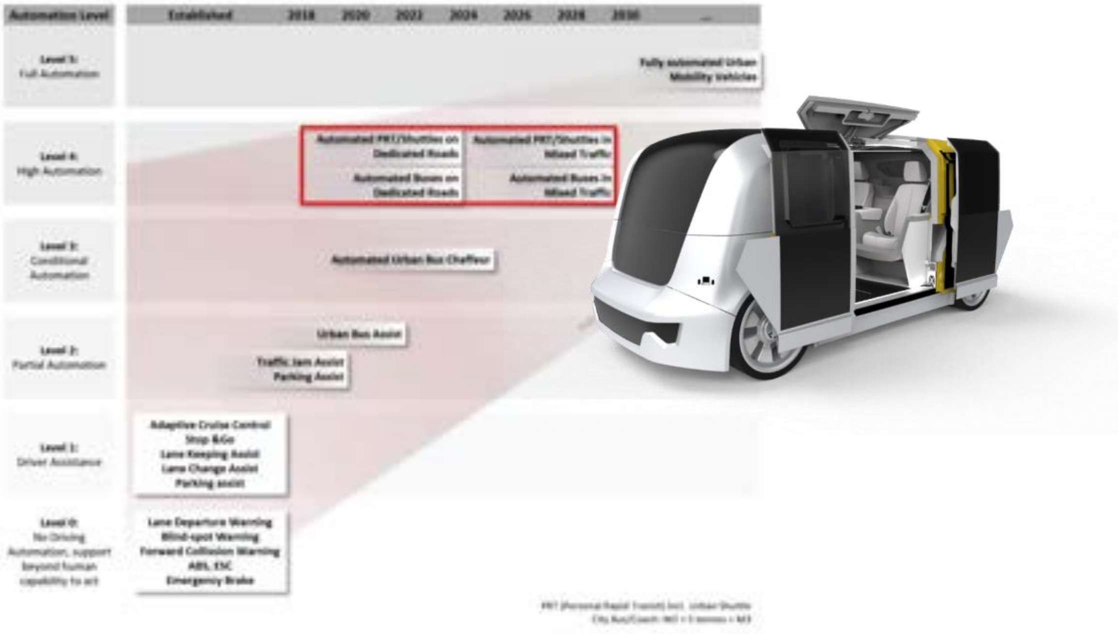
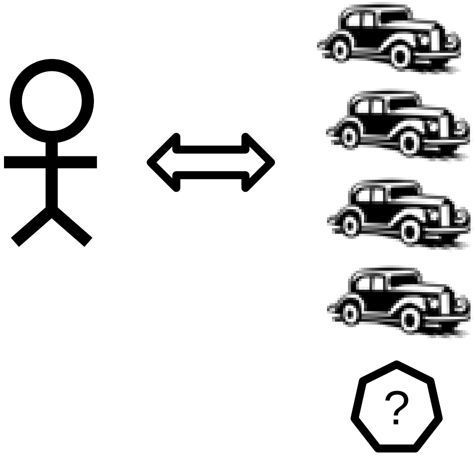
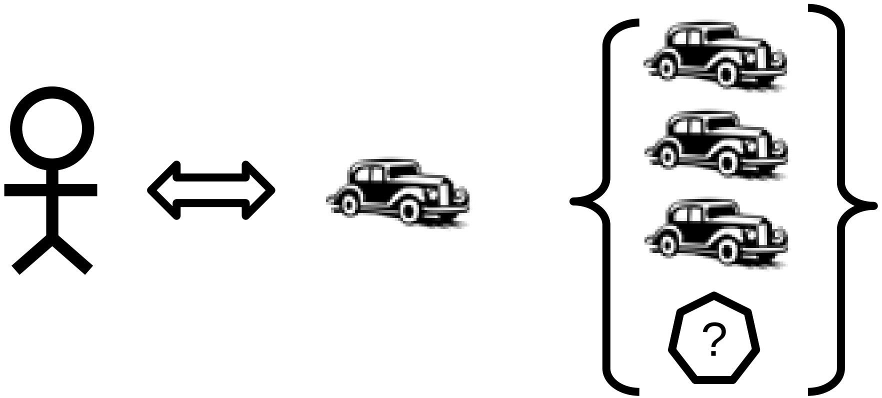


Figure 9: The Automated Driving development path for urban mobility vehicles

Defining the Working Situation





Yet – Another Usecase.

Support for Visually Impaired Drivers

Christian Lehsing, 2018

FIGURE 1 | The study was conducted in a static driving simulator, which consists of a BMW mock-up and a 180° frontal field of view. Complete homonymous hemianopia on the left and right side was simulated on large screens with a semi-transparent transition toward the seeing side and a match of color and luminance of the occluding mask to the road surface and surrounding housing.

Biebl, Bianca; Arcidiacono, Elena; Kacianka, Severin; Rieger, Jochem W.; Bengler, Klaus: Opportunities and Limitations of a Gaze-Contingent Display to Simulate Visual Field Loss in Driving Simulator Studies. Frontiers in Neuroergonomics 3, 2022

doi:10.3389/fnrgo.2022.916169

https://www.stadtup-online.de/


STADT:up
Solutions and Technologies for Automated Driving in Town:
an urban mobility project
Federal Ministry
for Economic Affairs
and Climate Action

STADT:up

Teilprojekt 1

Perspektives urban Mobility

Goals and Innovations

Concepts for sustainable, multimodal urban mobility

- Dialogforum cities and technology stakeholders
- Digital twin urban mobility
- Analysis and evaluation of mobility scenarios

DZ Modellstadt Braunschweig

Motiontag Tracking-App

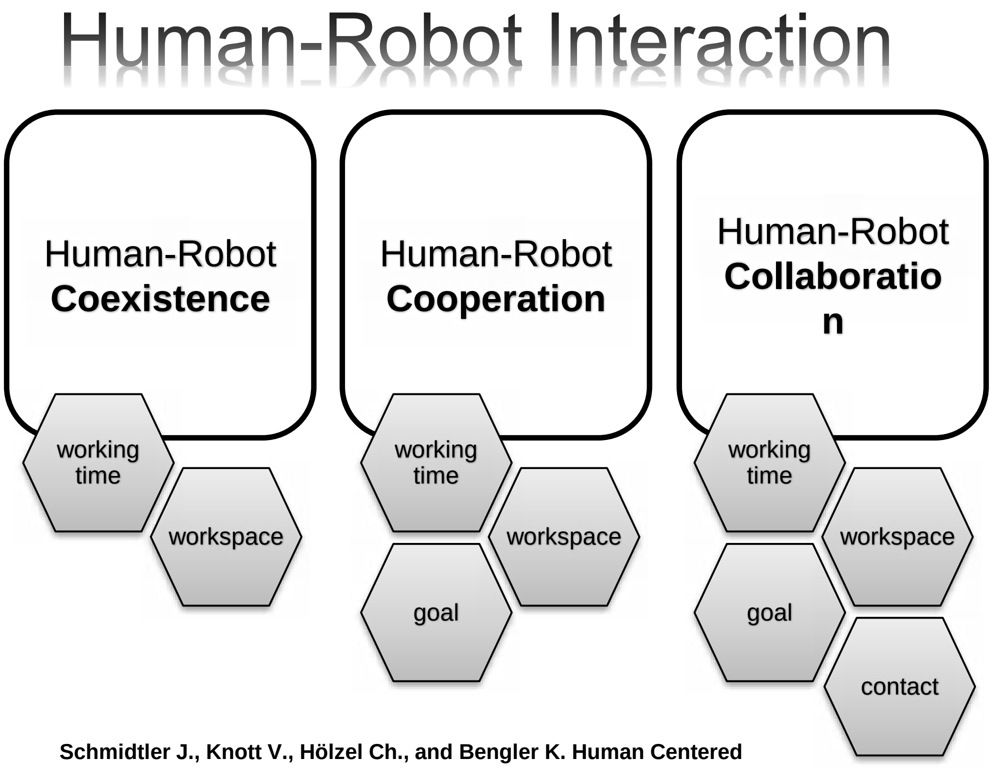
LoA (Sheridan 1992)

Beschreibung der Automationsstufe		Systemfunktion: Alternativen-generierung	Alternativen-reduzierung	Handlungs-auswahl	Handlungs-umsetzung
Involvierung des Menschen	Vollständige Kontrolle durch den Menschen.	M	M	M	M
	Handlungsauswahl durch den Menschen aus einem kompletten Satz möglicher Alternativen.	A	M	M	M
	Handlungsauswahl durch den Menschen aus einem vorausgewählten Satz von Alternativen.	A	A	M	M
	Durchführung der vom Automaten vorgeschlagenen Handlung durch den Menschen.	A	A	A	M
Einfluss des Menschen	Durchführung der Handlung durch den Automaten nach Genehmigung durch den Menschen.	A	A	A	A
	Durchführung der Handlung durch den Automaten, wenn ein Veto des Menschen ausbleibt.	A	A	A	A
Informierung des Menschen	Informierung des Menschen.	A	A	A	A
	Durchführung der Handlung durch den Automaten. Eine Information des Menschen findet nur statt, wenn diese angefordert wird.	A	A	A	A
	Durchführung der Handlung durch den Automaten. Der Automat entscheidet, ob der Mensch informiert wird.	A	A	A	A
	Informierung des Menschen.	A	A	A	A

Sheridan, T.B. (1992). Telerobotics, Automation and human Supervisory Control. The MIT Press: Cambridge.

Using Alternative Taxonomies

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*	n/a
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*	Limited
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**



Schmidtler J., Knott V., Hölzel Ch., and Bengler K. Human Centered Assistance Applications for Manufacturing Systems of the Future, to appear in Occupational Ergonomics (special issue), 2015.

Looking Ahead

We should

- **see the value of highly assisted driving**
- **dare to rethink usage scenarios**
- **migrate to other human centered taxonomies**
- **change the relation of Analytics and Empirics more modeling and calculation**