



Teleoperation: research needs and human factors challenges

September 26 | Lena Plum | BAST

Agenda

- ▶ Working Group "Research Needs in Teleoperation"
 - ▶ Problem description und approach
 - ▶ Joint Definition of "Teleoperation"
 - ▶ Use cases
- ▶ Human Factors Challenges
 - ▶ Why consider human factors?
- ▶ 5 angles of analysis
 - ▶ Exemplary research questions
 - ▶ Project conclusion

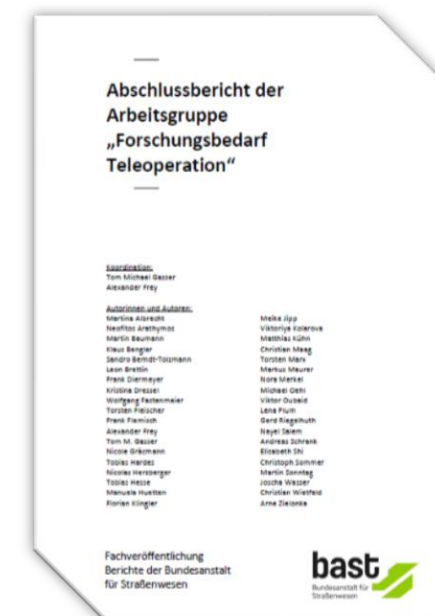


Who of you is working (in any way) on the subject of Teleoperation/Remote Operation?

Working Group "Research Needs in Teleoperation"

Who is this Working Group?

- ▶ 38 (mostly scientific) experts
- ▶ Coordination by BAST
- ▶ Kick-off: July 28, 2022
- ▶ Pre-publication of the technical report in German:
March 25, 2024
 - ▶ Available here for download in English:
www.bast.de/teleoperation-en



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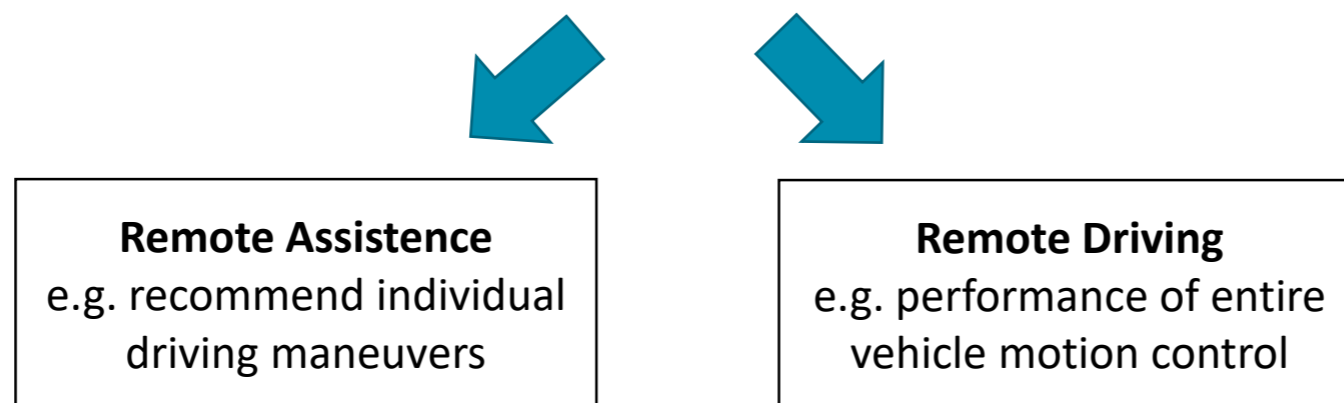
Problem description und approach

- ▶ Teleoperation as an innovation in road traffic
- ▶ Integration into road safety considering safety, security, usability and efficiency
- ▶ Early identification and structuring of research needs
- ▶ Structuring of research needs into 5 cluster + interdisciplinary (cross-cluster) research needs
- ▶ Identified research questions are categorized according to priority in time

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Joint Definition of "Teleoperation"

Teleoperation is an umbrella term that includes both the provision of information or advice to an ADS-equipped vehicle to facilitate trip continuation, and the performance of vehicle motion control from outside the vehicle.



The L4/L5 function retains final authority over the execution of the maneuver.

Teleoperation is another form of vehicle motion control alongside driving automation systems and human drivers.

Use Cases

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Considered use cases of teleoperation



- ▶ Remote assistance on demand



- ▶ Continuous Remote Driving
- ▶ Event-based Remote Driving

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Considered use cases of teleoperation

- ▶ Remote assistance on demand
 - ▶ Assumption: vehicle operated by ADS of Level 4 or Level 5
 - ▶ Remote assistance does not directly influence vehicle guidance
 - ▶ Remote assistance provides ADS with information or advice on demand
 - ▶ The Level 4 or Level 5 ADS decides on the execution of the respective piece of advice or information



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Considered use cases of teleoperation

- ▶ Continuous remote driving
 - ▶ Remote driving from beginning to the end of a trip
 - ▶ The individual trip is entirely performed by remote driving
 - ▶ During remote driving no sustained driving automation system is active or available in the vehicle



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Considered use cases of teleoperation

- ▶ Event-based remote driving
 - ▶ Assumption: vehicle is operated by an ADS of Level 4 or 5 before and after the event-based remote driving phase
 - ▶ The in-vehicle available ADS of Level 4 or 5 requests a remote driver
 - ▶ Remote driving for a limited period of time, and for a specific section of the trip



Human Factors Challenges

Why consider Human Factors?

1. Ensure user-friendly design
 2. Prevent post-implementation issues
 3. Maximize technology effectiveness
 4. Enhance safety and reliability
-
- ▶ **Parallel consideration of technology AND human from the start!**

Human Factor Challenges?

- ▶ Event-based remote driving
 - ▶ Assumption: vehicle is operated by an ADS of Level 4 or 5 before and after the event-based remote driving phase
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 - ▶ Remote driving for a limited period of time, and for a specific section of the trip



What challenges do we face regarding the human operator?

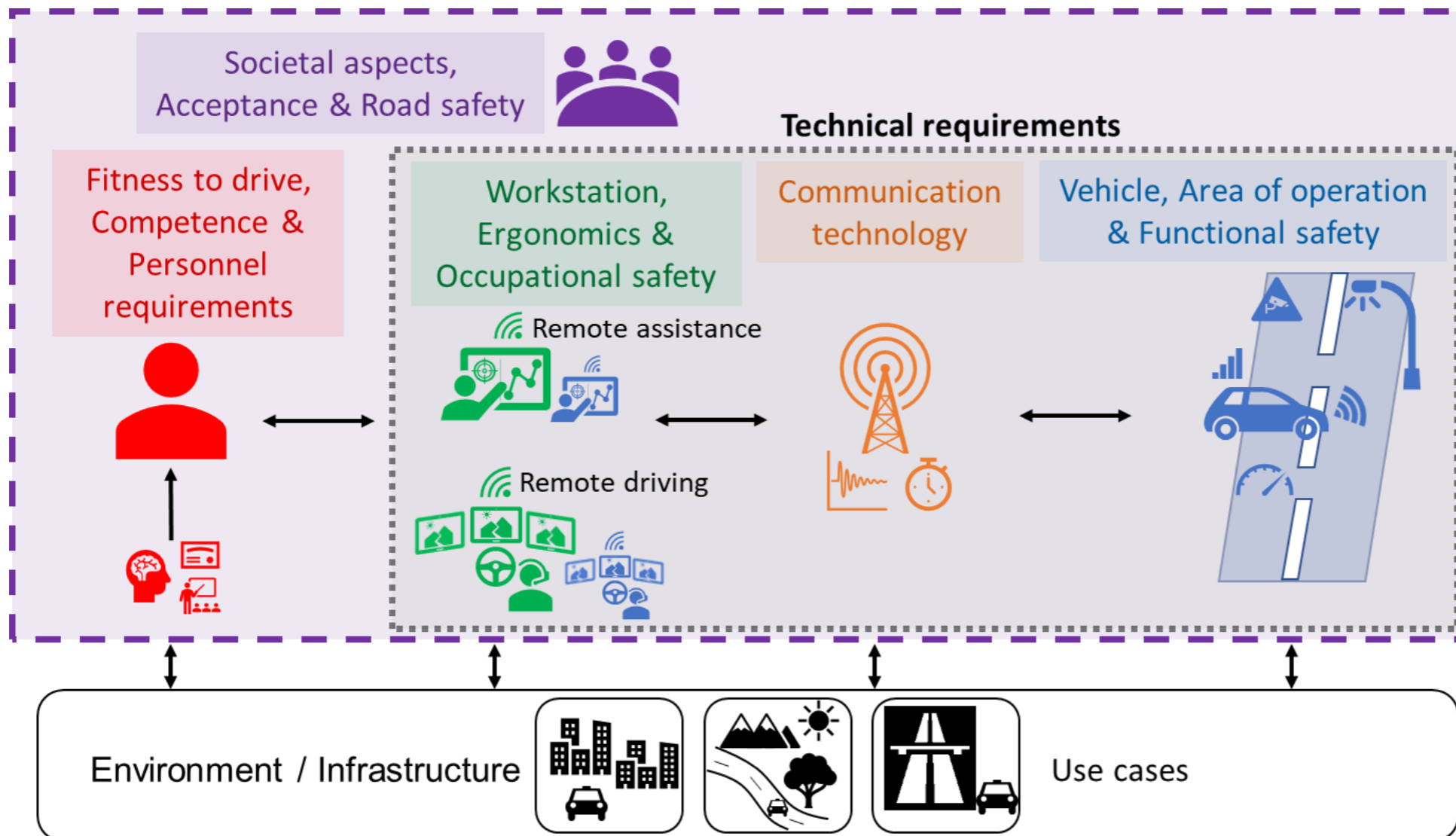
Human Factor Challenges?

- ▶ Scan the code to participate or go to [menti.com](https://www.menti.com). and enter the code **5960 2335**



5 angles of analysis

The Socio-technical System



5 cluster of the
working group

Cluster: Work station, Ergonomics & Occupational safety

Exemplary research questions*

- ▶ How is the system designed and used not only for the normal operation, but also for system limits and system failures?
- ▶ Which evaluation criteria are relevant for the design of a control centre and workstation (display and usability concept, transitions, monitoring etc. of the teleoperator)?
- ▶ How can the requirements for basic ergonomic principles, such as usability, joy of use, transparency and controllability, be incorporated into the R&D process? How can they be measured? Which methods, already known from other domains, can be transferred?
- ▶ Which design is required in particular for transitions, i.e. handovers and takeovers of vehicle control?
- ▶ ...

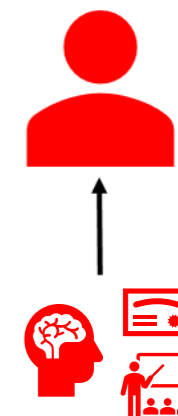
*complete overview on research question in chapter 4.2 of the working group's technical report



Cluster: Fitness to drive, Qualification & Personnel requirements

Exemplary research questions*

- ▶ Which job-related characteristics can be derived from a tasks and requirements analysis with regard to teleoperators' qualifications and fitness to drive?
- ▶ Does spatial separation of a teleoperator from the vehicle site and the driving task lead to reduced orientation?
- ▶ What are the effects of latencies on teleoperators' performance?
- ▶ Does mixed or hybrid traffic require increased requirements for teleoperators? What are the consequences if teleoperators' compliant behaviour meets irregular or informally enforced driving behavior?
- ▶ ...



*complete overview on research question in chapter 4.4 of the working group's technical report

Cluster: Societal aspects & Road safety

Exemplary research questions*

- ▶ What factors influence the individual acceptance of remote assistance and remote driving in general?
- ▶ What factors influence the perceived safety of users and other road users?
- ▶ What does a cost-benefit analysis look like for society?
- ▶ What requirements for the design of communication between individuals and teleoperated vehicles can be derived from the analysis of acceptance conditions?
- ▶ ...



*complete overview on research question in chapter 4.5 of the working group's technical report

Cluster: Vehicle, Area of operation & Functional safety

Exemplary research questions*

- ▶ What are requirements for teleoperation to ensure traffic flow is not impaired but improved?
- ▶ What are the effects of a communication link necessary for teleoperation on the concept of a teleoperated vehicle?
- ▶ How does a data interface between vehicles and control stations need to be designed?
- ▶ What security mechanisms need to be implemented to minimise attacks on teleoperation systems?
- ▶ ...



*complete overview on research question in chapter 4.1 of the working group's technical report

Cluster: Communication technology

Exemplary research questions*

- ▶ How can coverage gaps in existing technologies (e.g. 3GPP) be closed without compromising performance?
- ▶ How can the goals of performance and security be harmonised with privacy protection goals?
- ▶ Can the concept of ODDs be extended to the requirements for the available communication services?
- ▶ How can communication data be safely and securely recorded and stored (in a black box for accident research)?
- ▶ ...



*complete overview on research question in chapter 4.3 of the working group's technical report

Interdisciplinary research questions

Exemplary research questions*

- ▶ What data does the teleoperator need and in which quality? What gradation, what prioritisation is there? Does this depend on the use case or the speed?
- ▶ What are the effects of latency etc. on the teleoperator? How high is the mental workload?
- ▶ Do remotely assisted and remotely driven vehicles have to be labelled and, if so, what should the vehicle labelling look like?
- ▶ To what extent does the place of work of teleoperators (Germany vs. abroad) influence the acceptance of remote assistance and remote driving in society?
- ▶ ...



*complete overview on research question in chapter 5 of the working group's technical report

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Conclusion

- ▶ 174 research questions (individual questions and system-related questions)
- ▶ Priorisation according to temporal relevance (short-, medium-, long-term)
- ▶ Basis for research funding to advance the subject in an **interdisciplinary** and holistic manner – consider human from the start!
- ▶ Opens up the discussion about a broader application

**Thank you for your kind
attention!**

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Link to technical report

