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Federal Highway Research Institute

Remote work station and human factors

Findings and research needs

16.03.2023| Tom M. Gasser | BASt

Terms and definitions – SAE J3016/2021

Remote Assistance

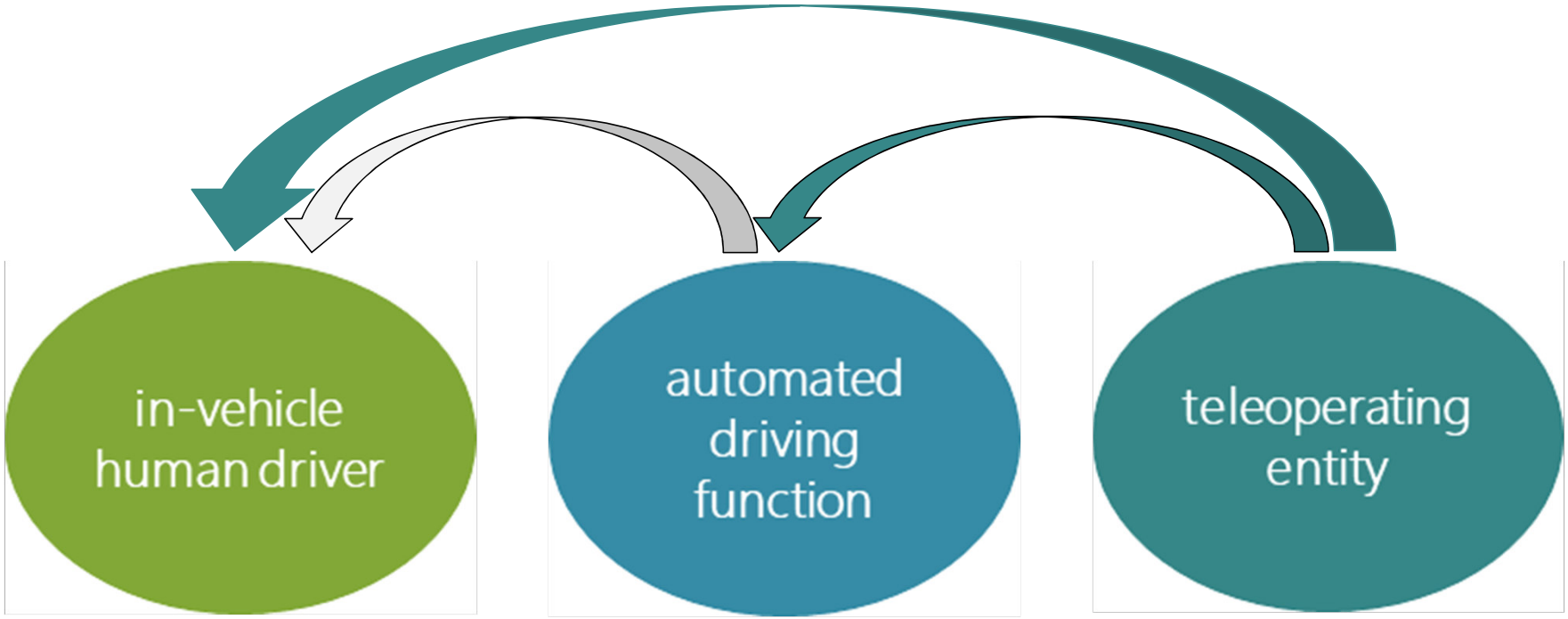
- *"Event-driven provision, by a remotely located human […] of information or advice to an ADS-equipped vehicle in driverless operation in order to facilitate trip continuation when the ADS encounters a situation it cannot manage."*

Remote Driving

- *"Real-time performance of part or all of the DDT and/or DDT fallback (including, real-time braking, steering, acceleration, and transmission shifting), by a remote driver."*

Teleoperation – how to classify?

Theoretical Substitution Model for Teleoperation



Shi & Frey (2021)

HMI: Research questions

Support and compensation

- *How can the teleoperator be supported in the best possible way in carrying out his activity?*
- *What compensatory measures with regard to ergonomics can promote (traffic) safety during teleoperated vehicle operation (e.g. reduction of jitter, predictive displays, visualisation of the vehicle environment)?*
- *How can the teleoperator be supported in quickly forming an adequate picture of a traffic situation and building up situation awareness?*

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Gary, Maag, Merkel & Neukum (in prep.)

What do we know about latency?

Time delay between a control input and the display of its effects.

- *Physical and technical*
- *Depends on network technology used, amount of data to be transmitted, connection quality, ...*
- *The higher the latency, the higher the workload and the lower the situation awareness*
- *Small, variable latencies less favourable for humans than large, constant latencies*

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Gary, Maag, Merkel & Neukum (in prep.)

What do we know about latency?

Latency reduces driving performance of teleoperators.

- *Perception threshold: 17 ms*
- *Influence threshold: 170 ms*
- *Effects non-linear on task performance*

Threshold: 300 ms (remote driving)

- *Otherwise: Move-and-wait strategy!*

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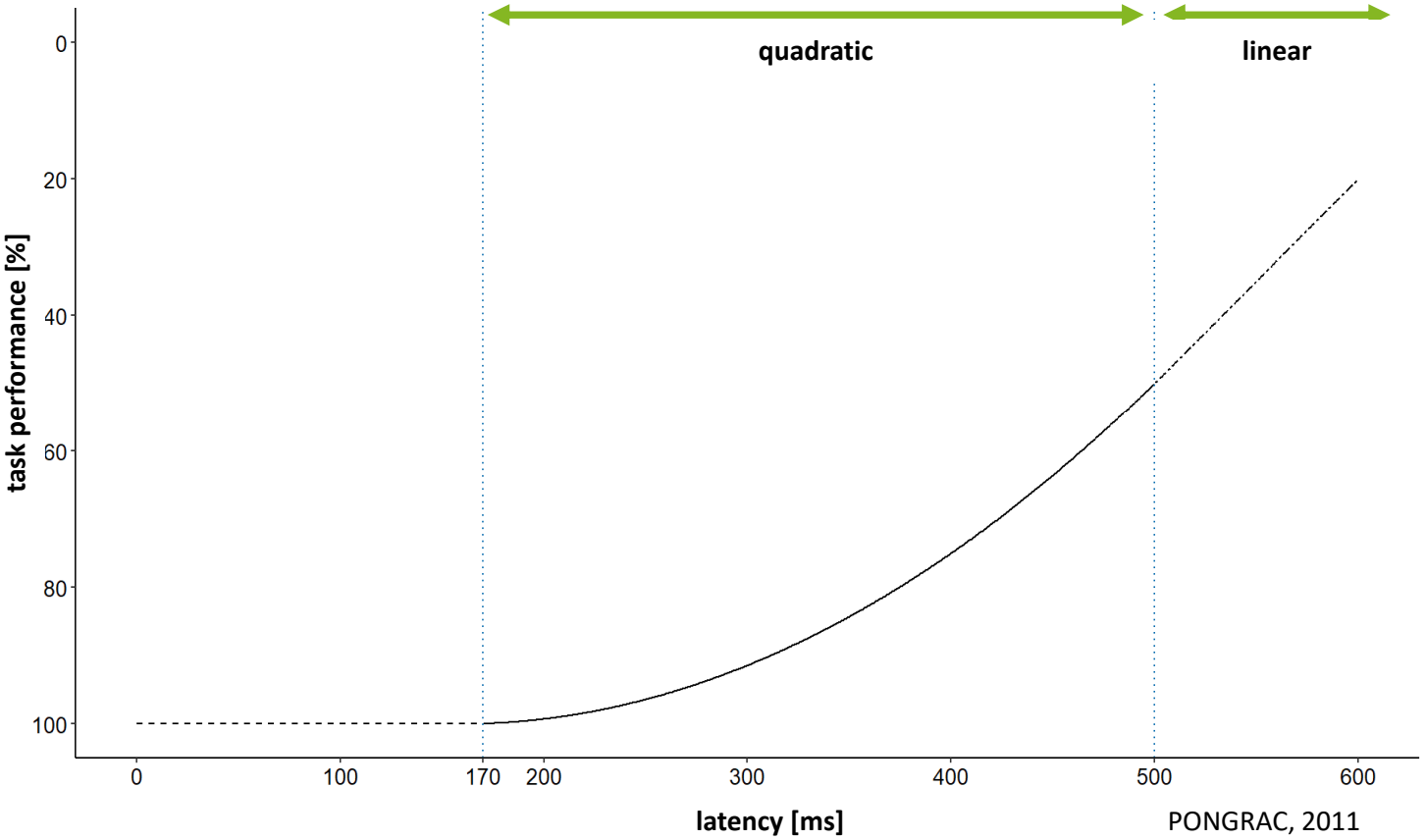
What do we know about latency?



PONGRAC, 2011

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What do we know about video quality?

Perceived quality of the visual representation of the driving situation

- *is dependent on frame rate (fps), resolution…*
- *the lower the video quality, the higher the workload and the lower the situational awareness*
- *the lower the video quality → the lower the driving performance*

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What do we know about video quality?

Limit value: 10 fps

- *Below: reduced driving performance*
- *Negative influence still remains measurable above 10 fps*

Subjective evaluation

- *Teleoperators will prefer lower video quality in favour of lower latencies*

BODELL & GULLIKSON, 2016

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Compensatory measures

Measures	Findings	Sources
Predictive displays	• *Improve driving performance* • *Improvement of situational awareness* • *Inconsistent findings regarding workload*	• CHUCHOLOWSKI, 2015 • CHUCHOLOWSKI ET AL., 2013 • DYBVIK ET AL., 2021 • GRAF, ABDELRAHMAN ET AL., 2020 • TANG, 2015
assistance systems (supporting prediction)	• *Improve driving performance*	• HOSSEINI, 2018 • HOSSEINI & LIENKAMP, 2015 • MATTS & STERNER, 2020

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Compensatory measures

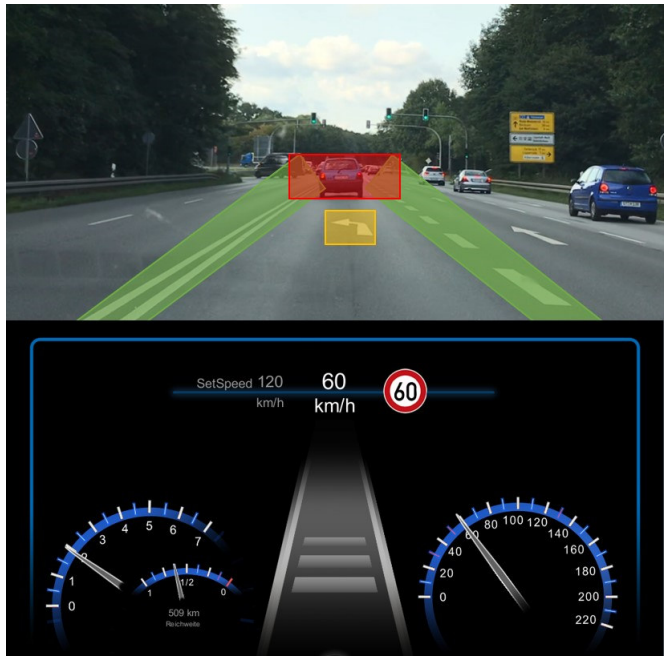
Predictive displays – examples and effects

- *Display of predicted conditions and information*
- *Position of the ego-vehicle and other road users*
- *Display of a "free corridor”*

Predictive assistance systems

- *Combination of predictive displays and classical ADAS*

  →Reduction of effects by latency



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(cp.: CHUCHOLOWSKI ET AL., 2013)

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Compensatory measures

Measures	Findings	Sources
Presentation of additional information	• *inconsistent findings* • *Methodological critiscm: partial confounding with display technologies*	• BODELL & GULLIKSON, 2016 • CHEW ET AL., 2021 • MATSS & STERNE, 2020 • NEUMEIER ET AL., 2019 • THOMASON ET AL., 2017
Training	• *Improves driving performance* • *Partial reduction of workload*	• HOSSEINI, 2018 • SILVA ET AL., 2018 • SUOMELA, 2001
Algorithm-based latency compensation	• *Improves driving performance* • *Reduction of workload*	• LU ET AL., 2019

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Assessment of compensatory measures

Promising approaches

- *First evidence of effectiveness for individual predictive display and assistance approaches*
- *Inconsistent findings regarding individual measures*
- *Early stage: few empirical studies on individual measures*

Overall high need for research on influencing factors and compensatory measures!

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BASt working group on research needs

5 pillars of expertise currently involved:

1. *Vehicle, ODD & functional safety*
2. *Working station, ergonomics & occupational safety*
3. *Communication technology*
4. *Fitness to drive, competence & personnel requirements*
5. *Social aspects & traffic safety*

→ Final Report currently planned for in 2023!

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Thank you!

I look forward to the joint discussion.