TELEOPERATION AND REMOTE DRIVING – REQUIREMENTS FOR SUITABILITY AND COMPETENCE OF REMOTE DRIVERS

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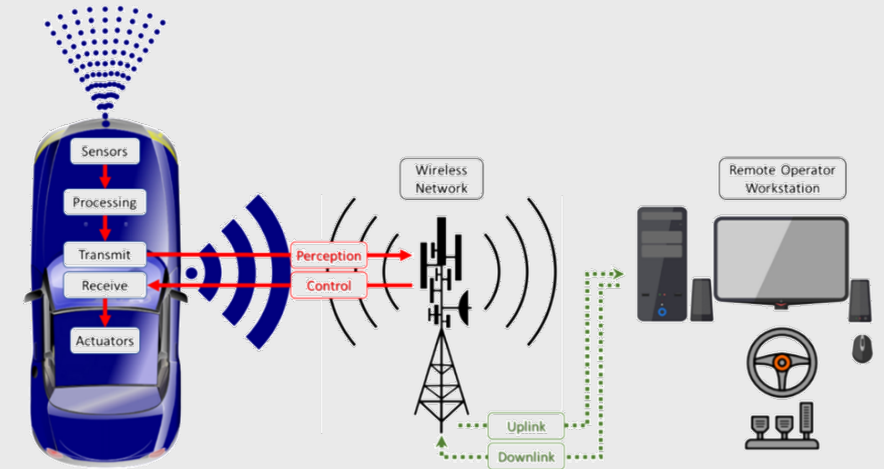
BACKGROUND & MOTIVATION

VEHICLE TELEOPERATION

CONCEPT

▶ Influence on the control of a vehicle by an instance that is located outside the vehicle

POTENTIAL APPLICATIONS

▶ In automated driving: e.g. managing and handling of unexpected/ complex situations (e.g. construction site)

▶ In non-automated driving: e.g. delivery and hand-over of shared cars

(McNicol, 2022)

DEFINITIONS

Remote Driving	The **remote driver takes control** of the vehicle at the navigation, guidance and stabilization levels, whereby vehicle systems can support the remote driver in the driving task. The **remote driver is responsible** for safe driving.
Remote Assistance	The **remote assistant provides** control-relevant **recommendations/information** or initiates certain driving maneuvers, whereby the **vehicle control is carried out autonomously** by a corresponding driving system. The autonomous driving **system is responsible** for safe driving.

OBJECTIVES OF RESEARCH PROJECT
SUITABILITY AND COMPETENCE OF REMOTE DRIVERS

REQUIREMENTS FOR REMOTE DRIVERS

▶ Remote driver is confronted with tasks that are different to driver located inside vehicle, e.g.

- ▶ Perception and understanding of driving environment mainly video-based
- ▶ Dealing with latency
- ▶ Remote communication with further persons and/or passengers
- ▶ Changed communication with other road users

→ Need for definition of **minimum requirements concerning suitability, competence and reliability of remote drivers**

- ▶ Focus on remote driving   (i.e. remote assistance is not covered within research project)
- ▶ Focus on applications and scenarios that are likely to be feasible in near future

→ Derivation of concrete regulations for selection, training, further training and regular inspection and monitoring of remote drivers

APPROACH AND METHOD
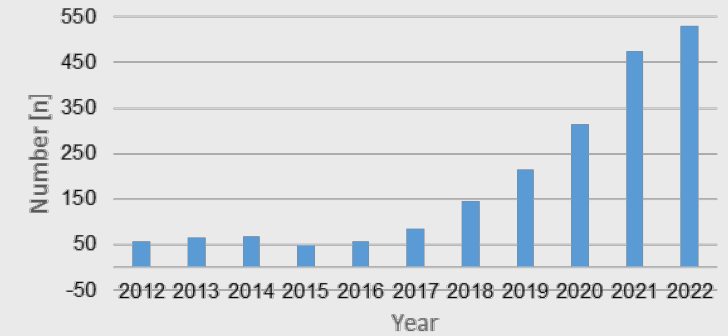## LITERATURE REVIEW & EXPERT SURVEY

LITERATURE REVIEW

▶ Topics

  ▶ Analysis of human factor challenges during remote driving

  ▶ Overview of current remote driving workplaces

  ▶ Suitability and capability in remote vehicle driving

  ▶ Suitability and capability in further remote application areas (e.g. railway, aviation, shipping, unmanned ground vehicles)

EXPERT SURVEY

▶ Requirements for suitability, competence and reliability of remote drivers

▶ Sample & Organisation

  ▶ N=13 Persons from research institutions, teleoperating companies, suppliers

  ▶ 2-hour online interview with interview protocol approved by interviewee

Scientific Papers (according to Google Scholar)

Search for the terms (vehicle & "remote driving") or (vehicle & "teleoperated driving")

HUMAN FACTOR CHALLENGES OF REMOTE DRIVING

▶ Latency/Jitter
  ▶ Delay time that necessarily occurs during remote driving, because information (video signals, vehicle states, control signals) is transferred between teleoperator workstation and vehicle.
  ▶ Impact on performance and efficiency (and thus also safety) of vehicle control by driver
  ▶ Could lead to cyber sickness

▶ Workload
  ▶ Alternation between phases of significant demand and phases of low workload
  ▶ Latency and jitter important factors influencing workload

▶ Lack of situation awareness
  ▶ Mental representation of the current driving situation by remote driver
  ▶ Consists of three levels: Perception, Understanding, and Anticipation (Endsley, 1988).
  ▶ Prerequisite for adequate control inputs and driving performance

▶ Tele-Presence (i.e. feeling of steering real vehicle in real environment)
  ▶ Includes cognitive and emotional components
  ▶ Feeling of presence is generated, among other things, by immersion (i.e. involvement in presented environment)

RESULTS

LITERATURE REVIEW

REMOTE DRIVER WORKPLACE

▶ Human-machine interface for remote driver, in order to control vehicle

▶ Structure similar to static driving simulators

  ▶ Mockup:

    ▪ Generic

    ▪ Seat, pedals and steering wheel

    ▪ No motion system

  ▶ Visual system:

    ▪ At least three screens

    ▪ Additional views (e.g. bird's eye view) or viewing aids (e.g. display of current ego trajectory)

    ▪ Rear views

    ▪ Other relevant information (e.g. current latency, quality of connection)

https://ottopia.tech

https://vay.io

https://mira-mobility.com

RESULTS

LITERATURE REVIEW

STATE OF RESEARCH ON SUITABILITY AND COMPETENCE REQUIREMENTS IN REMOTE DRIVING

▶ No scientific publications dealing with issues related to the suitability and competence of remote drivers

→ No derivation of science-based regulations for selection, training, and periodic assessments of remote drivers

STATE OF THE ART RESEARCH IN RELATED APPLICATION AREAS

▶ Analysis of publications in different teleoperation areas, e.g. shipping, railway, aviation, unmanned ground vehicle

→ Transfer knowledge to remote driving difficult, because of different characteristics of application areas (e.g. vehicle size, passengers, dynamics, complexity)

▶ Findings

    ▶ Experience and regular training in real vehicle important for teleoperators' situation awareness, perspective taking, empathy, and sense of presence

    ▶ Additional skills include understanding of data transmission (incl. possible problems) as well as communication

    ▶ Previous gaming experience could be helpful

    ▶ Simulative approaches suitable for training
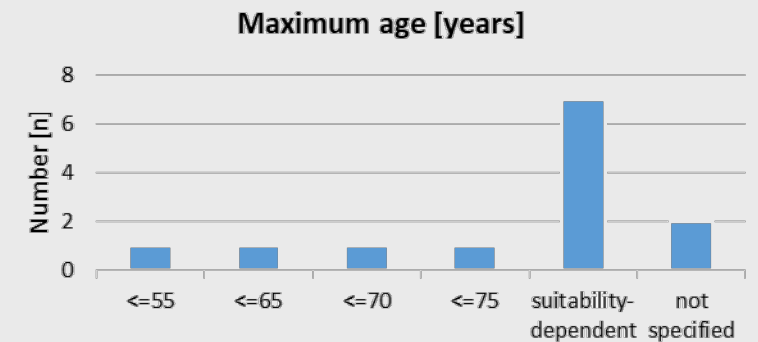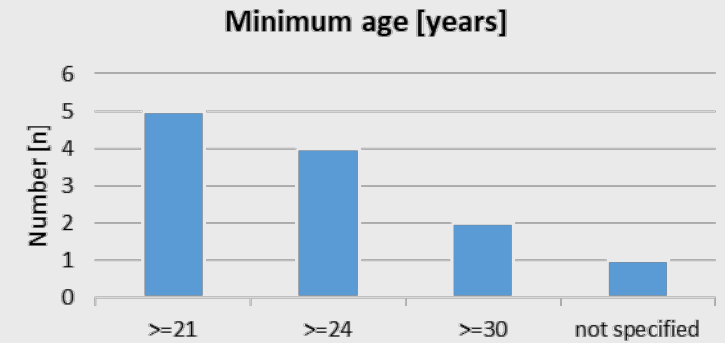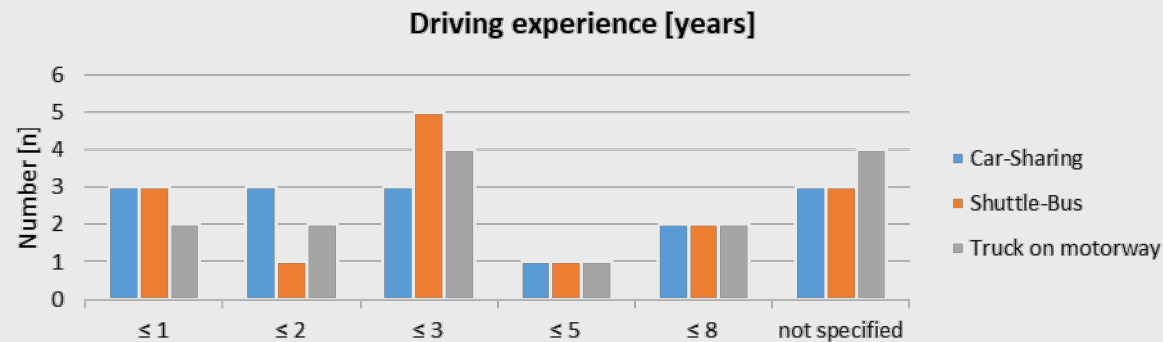
RESULTS

EXPERT SURVEY

DRIVER SUITABILITY AND SELECTION

▶ Prerequisites for remote driving trainees

- ▶ Driving licence for (at least) teleoperated vehicle
- ▶ Significant driving experience
- ▶ Minimum age of about 21-30 years
- ▶ No maximum age, but regular assessment of fitness to drive
- ▶ Character of driver is very important for safe driving
  - ▪ Compliance with traffic regulations
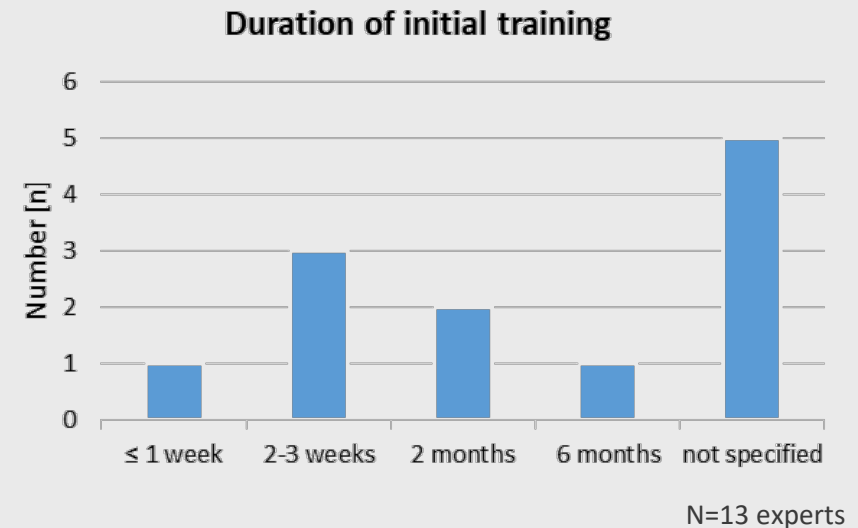 - ▪ → Criterion regarding traffic register

Minimum age [years]

Driving experience [years]

Legend:
- Car-Sharing
- Shuttle-Bus
- Truck on motorway

Maximum age [years]

N=13 experts

RESULTS

EXPERT SURVEY

EDUCATION AND TRAINING

▶ Training content, e.g.

  ▶ Basic information concerning teleoperation

  ▶ Technical information about teleoperation system and vehicle

  ▶ Impact of latency/jitter and further human-factors challenges

  ▶ Awareness for road safety and safety culture

  ▶ Functionality and handling of teleoperator workstation

  ▶ Driving practice (in closed-off areas and real traffic)

  ▶ Takeover and return of vehicle control

  ▶ Influence of operating conditions (e.g. weather)

  ▶ Procedures in case of incidents/accidents

  ▶ Communication with personnel and, if applicable, passengers

  ▶ Knowledge of local traffic environment

▶ Estimation still difficult, but initial training to become remote driver should have a duration of at least a few weeks

  ▶ Subsequent phase of practice under supervision (under supervision of experienced driver)

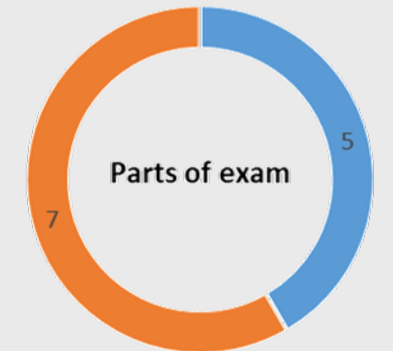▶ Further training as required (e.g. for new system functions or vehicle types)

Duration of initial training

Number [n] — vertical axis (0 to 6)

Categories: ≤ 1 week (1), 2-3 weeks (3), 2 months (2), 6 months (1), not specified (5)

N=13 experts

RESULTS

EXAMINATION AND REGULAR FITNEES-TO-DRIVE ASSESSMENT

▶ Exam should complete initial training for remote drivers

    ▶ Assessment of theoretical knowledge as well as practical driving

▶ As far as possible, final exam should be done by external body

▶ Simulative approaches could complement training and examination of remote drivers

    ▶ Creation of controlled operational/traffic situations

    ▶ Operating a virtual vehicle in simulated traffic environment

▶ Regular assessment of fitness-to-drive

    ▶ As already mandatory for professional drivers

    ▶ Including regular assessment of character (e.g. by checking traffic register)

SUPERVISION AND MONITORING OF DRIVER STATE

▶ Experts do not agree if technical systems (e.g. gaze detection) should be used to assess remote drivers' level of attention/distraction

    ▶ Distraction as major cause for accidents vs.

    ▶ Training, raising awareness and organizational measures (e.g. break times)

Parts of exam

5
7

- theory & practice
- theory & practice & driving sim

Institution conducting exam

1
2
2
6

- internal - external - both possible - other

N=13 experts

RECOMMENDATIONS (PRELIMINARY)
SUITABILITY, COMPETENCE AND RELIABILITY OF REMOTE DRIVERS

PRIOR KNOWLEDGE/EXPERIENCE & FITNESS-TO-DRIVE

▸ Driver license and driving experience
  - ▸ **Valid driver license** corresponding to the class of the teleoperated vehicle
  - ▸ At least 3 years of active **driving experience** with same vehicle class as driven remotely

▸ Minimum and maximum age
  - ▸ **Minimum age of 21 years** (same as regulation for driver license for passenger transportation)
  - ▸ No maximum age, but regular assessment of physical, cognitive and character fitness-to-drive

▸ School diploma
  - ▸ Completed **secondary school** education
  - ▸ **Sufficient cognitive ability** to understand learning content of education for remote drivers

▸ Fitness-to-drive
  - ▸ Due to **high level of responsibility**, the remote driver should be subject to (at least) similar driving fitness requirements as for passenger transport driver license
  - ▸ Sufficient **capability to extract relevant information from screens** → specific tests
  - ▸ Certificate of good conduct and few entries in traffic register (i.e. nearly no documented traffic offences)
  - ▸ Specific physical handicaps could be handled less restrictive compared to in-vehicle drivers
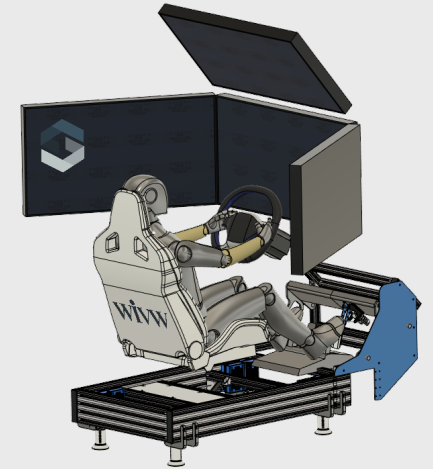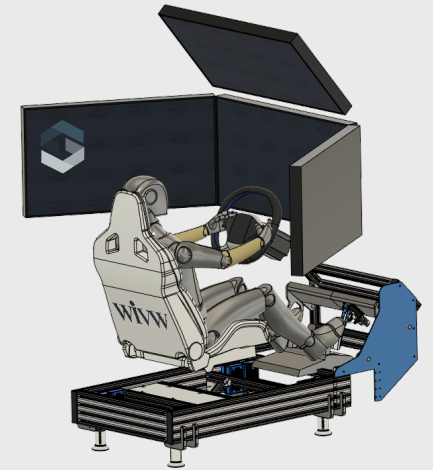
RECOMMENDATIONS (PRELIMINARY)
SUITABILITY, COMPETENCE AND RELIABILITY OF REMOTE DRIVERS

INITIAL TRAINING

▶ <u>Learning content</u> according to the specifics and tasks for remote driver, e.g.

- ▶ **Teleoperation concept**: legal basis, technology, process, vehicle control incl. takeover and return, stakeholders and roles, organization, policies and regulations, use cases, ODD and conditions for operation

- ▶ **Teleoperator workstation**: components, technology, operation, login, integration into control center

- ▶ **Latency/Jitter**: causes, implications, compensation

- ▶ **Communication and video transmission**: technical background, potential problems

- ▶ **Virtuality**: sensor information and video display, cyber sickness, immersion and tele-presence

- ▶ **Human-factor challenges**: workload, situational awareness, implications for driving safety

- ▶ **Communication** with other operational personnel, passengers (if any) and other road users

- ▶ **Safety awareness** (safety and security) and assumption of perspectives regarding comfort and safety

- ▶ **Operational design domain**: Teleoperation and driving in different traffic environments (city, country, highway) and environmental conditions (brightness, weather conditions, traffic density)

- ▶ **Safety checks**: before departure, during the journey, after parking the vehicle
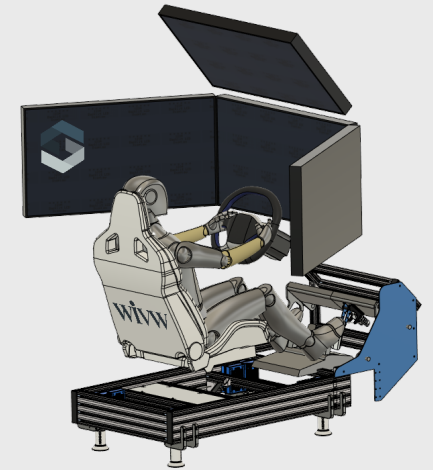
RECOMMENDATIONS (PRELIMINARY)
SUITABILITY, COMPETENCE AND RELIABILITY OF REMOTE DRIVERS

INITIAL TRAINING (CONT.)

▶ <u>Scope and approach</u> of initial training

- ▶ **Theoretical** as well as **practical** learning methods
- ▶ **Simulator** training for practicing correct behaviour in certain scenarios that can hardly be trained in reality

▶ <u>Final examination</u>

- ▶ Conducted by a person who was not involved in training
- ▶ Evaluation of **theoretical knowledge**
  - ▪ Too many errors or one safety-relevant error lead to failure of exam
- ▶ **Practical driving** test
  - ▪ Covers essential operational and traffic situations
  - ▪ Failed if one safety-related error or repeated errors
 - ▪ Usage of driving simulator is encouraged

RECOMMENDATIONS (PRELIMINARY)
SUITABILITY, COMPETENCE AND RELIABILITY OF REMOTE DRIVERS

CONTINUOUS TRAINING AND ASSESSMENT

▶ Regular <u>fitness-to-drive assessment</u>
  ▶ Remote driving **license for a limited period** (e.g. 5 years)
  ▶ **Renewal** only if physical, cognitive, and character requirements are fulfilled
  ▶ Concerning **older drivers**, assessment should be done at **shorter intervals**
  ▶ Regular check for valid driver license for respective vehicle class

▶ Regular/continuous <u>training</u>
  ▶ Ensures competence of personnel - especially in case of technical or operational changes
  ▶ **Documentation** of training measures and success of participation

▶ Assessment <u>safety of driving</u>
  ▶ Possible measures include real **driving accompanied by instructor/supervisor**, assessment using **driving simulator,** or check of performance using **logged driving files**
  ▶ **Incident management** including evaluation of incidents
    ▪ Situational causes
    ▪ Identification of remote drivers who stand out due to frequent incidents
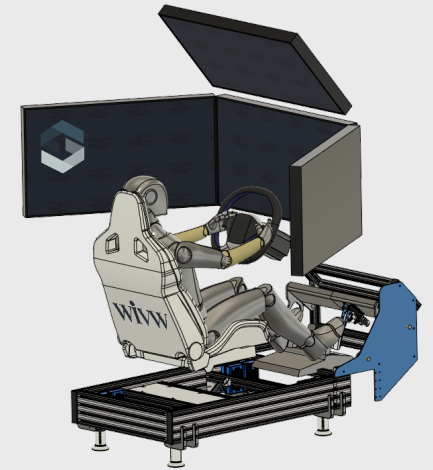
RECOMMENDATIONS (PRELIMINARY)
SUITABILITY, COMPETENCE AND RELIABILITY OF REMOTE DRIVERS

MONITORING OF DRIVER STATE

▶ Distraction warning
  ▶ Detection of distraction using **technical system**
  ▶ Warning if remote driver is distracted (and MRM if necessary)
  ▶ See also: EU Regulation 2019/2144 Automotive Type Approval regarding attention monitoring systems

▶ Limited driving time and regular breaks
  ▶ Remote drivers need to remain focused and attentive regardless of the time of day or workload

▶ Complete ban on alcohol and other intoxicating substances
  ▶ Compliance should be checked regularly
  ▶ **Spot checks** on alcohol and drug consumption
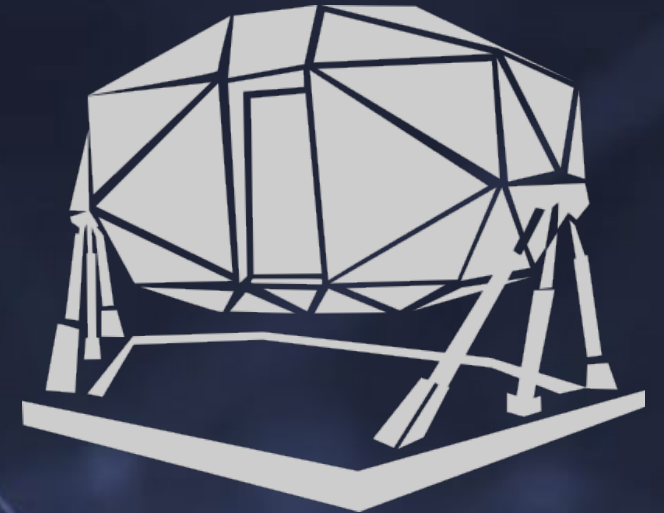 ▶ Alcolocks as an option
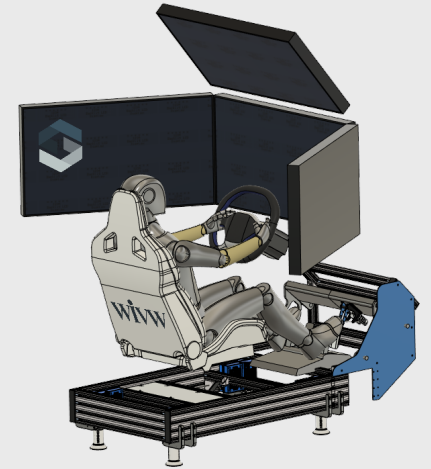
Thank you for your attention

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