

Remote Operation Centre For Automated Vehicles

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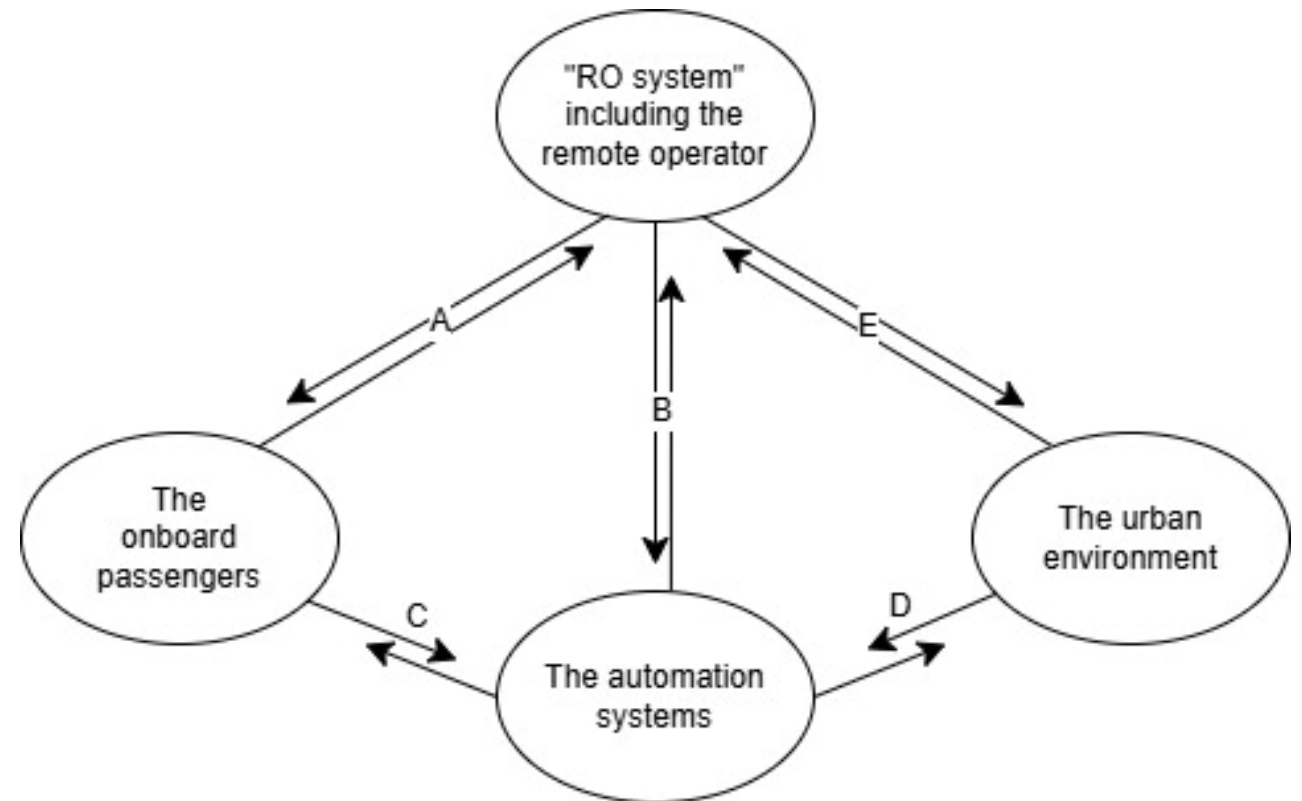
The Necessity of Remote Operation in Automated Vehicles

- **Technical challenges and failures:** such as navigating interactions with non-AVs. In high-risk, safety-critical systems like transport, automation introduces new types of risks, such as system failures (software or hardware failures) and latency issues.
- **Society/Safety:** Still, we are dealing with the concept of “Trust” in people's attitudes regarding AVs.
- **Regulatory:** There are still significant regulatory gaps regarding the testing and operation of AVs on public roads that must be addressed.
- **Financial aspect:** Remote operation is claimed as a cost-saving solution.



Challenges and Requirements of Remote Operation

- 1) Design of the RO workstation,
- 2) Human factors and Human-Machine Interaction (HMI),
- 3) Design of AVs and HAVs.



Remote operation modes in driving

Remote Monitoring: Involves observing an AV, user status, and surrounding conditions remotely to collect data for identifying potential issues and supporting decision-making processes.

Remote Assistance: Focuses on providing remote support or information to vehicle users or external agents, such as emergency responders or recovery teams.

Remote Management: Entails issuing commands to an AV remotely to initiate system actions when the vehicle is unable to operate independently. This function can be applied to entire fleets.

Remote Driving: Refers to taking direct control of the dynamic driving task (DDT) of an AV remotely, typically for a short duration.

Aramrattana, M., Schrank, A., Andersson, J., Zhao, L., Hermann, D., Mharolkar, S., Vanzura, M., Habibovic, A., & Oehl, M. (2024). A Roadmap Towards Remote Assistance: Outcomes from Multidisciplinary Workshop at the 2023 Intelligent Vehicles Symposium. In C. Stephanidis, M. Antona, S. Ntoa, & G. Salvendy (Eds.), *HCI International 2024 Post-ers* (Vol. 2118, pp. 175–185). Springer Nature Switzerland.

Parr, H., Harvey, C., Burnett, G., & Sharples, S. (2024). Investigating levels of remote operation in high-level on-road autonomous vehicles using operator sequence diagrams. *Cognition, Technology & Work*, 26(2), 207–223.

Selection and Application of Methodology

Due to the limited number of studies, the Delphi method was applied to reach a consensus among experts and to gather their insights through two rounds of surveys.

Round 1 included 54 questions, and Round 2 included 21 questions.

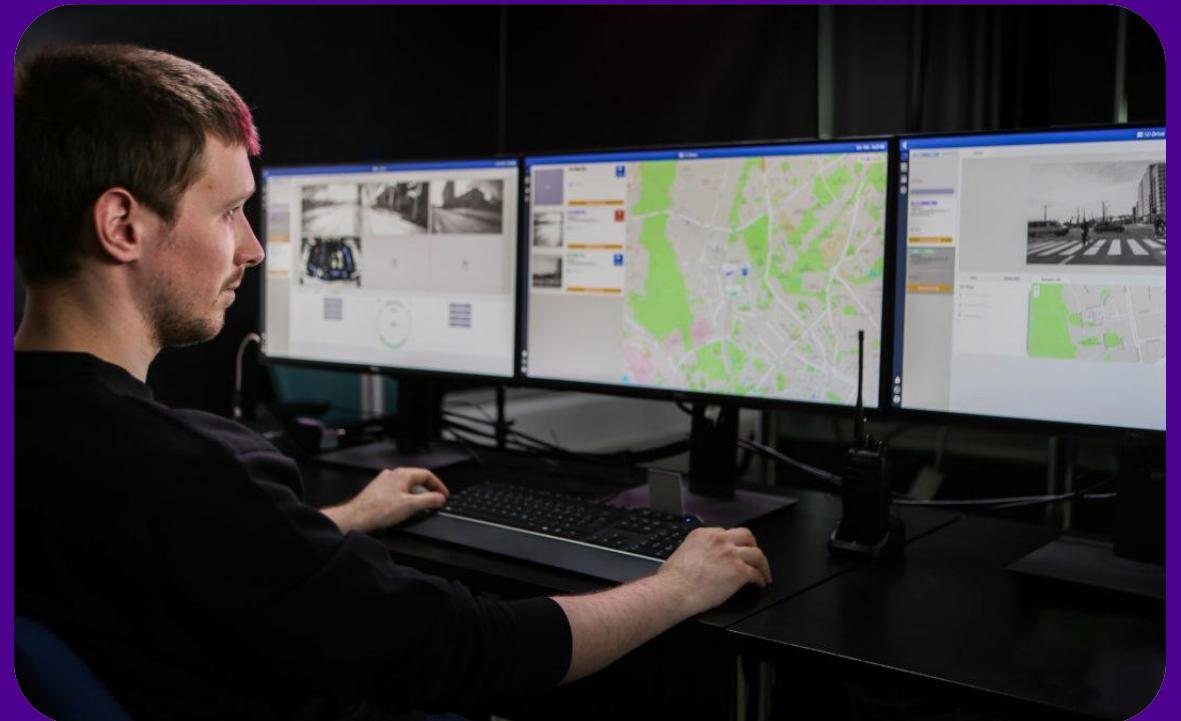
The surveys were sent to 60 experts selected based on their background and proficiency.

In Round 1, 31 experts responded to the survey, and in Round 2, 21 experts participated.

Professional backgrounds or current role	Number of people	Years experience average	of on project concerning the RO of AVs	Not involved
Leadership and Management	8	14.25	22	9
Academic and Research	15	8.06		
Consultants, Technical and Engineering people	8	9.5		
Total	31	10.03 (Average in total)		

Findings from the Delphi Study

- The Technology Readiness Level (TRL) of the remote operation is 5.4, indicating that the technology is between validation and demonstration in a relevant environment.
- Key factors for RO project success:
 - Connectivity and network
 - Human-Machine Interaction and Situational awareness
 - Remote operators' capabilities
 - Remote Operation Centre (work environment)



Connectivity & Network

- Low latency and high bandwidth are critical for real-time AV control: delays risk safety and efficiency
- high bandwidth and reliable network increases vehicle numbers
- Maintenance teams should be available online 24/7 to monitor and resolve any issues with systems, networks, or vehicle fleets.
- The impact of latency depends on the type of remote operation and the specific tasks assigned to the remote operator.
- A key factor here is having a fail-safe strategy
- Learning how to cope with latency rather than solely trying to eliminate it



Key Features of Effective HMI for Remote AV Operators

Situation Awareness & Minimal Control: Align with ADS maturity and ODD; test remote driving needs.

Real-Time Visualization: Display video, maps, and sensor data for situational awareness.

Intuitive, Responsive Controls: Enable fast decisions, low-latency HD video, clear feedback, and emergency alerts.

Automation Compatibility: Seamlessly switch between manual and automated modes.

Multitasking & Ergonomics: Support multiple vehicle management and reduce operator fatigue.

Immersive Interface: Create a realistic, context-rich virtual workspace.

360° Visibility & Decision Support: Provide multisensory feedback for full situational awareness.

Remote Operators' capabilities

Essential Skills & Certifications for Remote Operators

- Valid Driving License
- HMI Systems & Feedback Proficiency
- Understanding of Autonomous Systems
- Stress Management & Situational Empathy
- Technical expertise and interpersonal skills (operator and passengers)
- High ability in processing large amounts of information and focussed attention
- Decision-making under pressure
- Troubleshooting
- Specific training for RO (awareness of the limitations of the sensors, knowledge of how to react to unexpected/emergency situations)
- Traffic and road behaviour knowledge

Remote Operators

Potential candidates for remote operator roles

- **Professional Drivers**
- **Gamers**
- **IT Professionals & Systems Engineers**
- **Control Room Operators/Dispatchers**
- **Psychologists & Engineers**
- **Experienced Drivers (Non-active)**



ROC (work environment)

Key Features & Design Elements for RO Workstations:

- Reliable Hardware & Software
- Robust IT Infrastructure
- RO-Specific Design
- Ergonomic & Adjustable Setup
- Rapid Situation Awareness
- Operation-Specific Design
- Distraction-Free Environment
- Large Monitors & Live Feedback
- Adaptive user interface
- Smart Information Management
- Cognitive Balance



Conclusion

Designing an Efficient Remote Operation Centre: should adopt a human-centred approach

Prioritize ergonomic design and workstation usability

Aim to:

- Reduce **cognitive load**

- Enhance **situational awareness** through efficient HMI design and supporting subsystems

- Ensure **intuitive and responsive interfaces**

Test system in real-world conditions to verify:

- Effectiveness** in continuous operations

- Performance** under real-time demands

Thank you

Link to the thesis: <https://urn.fi/URN:NBN:fi:tuni-202504013165>

