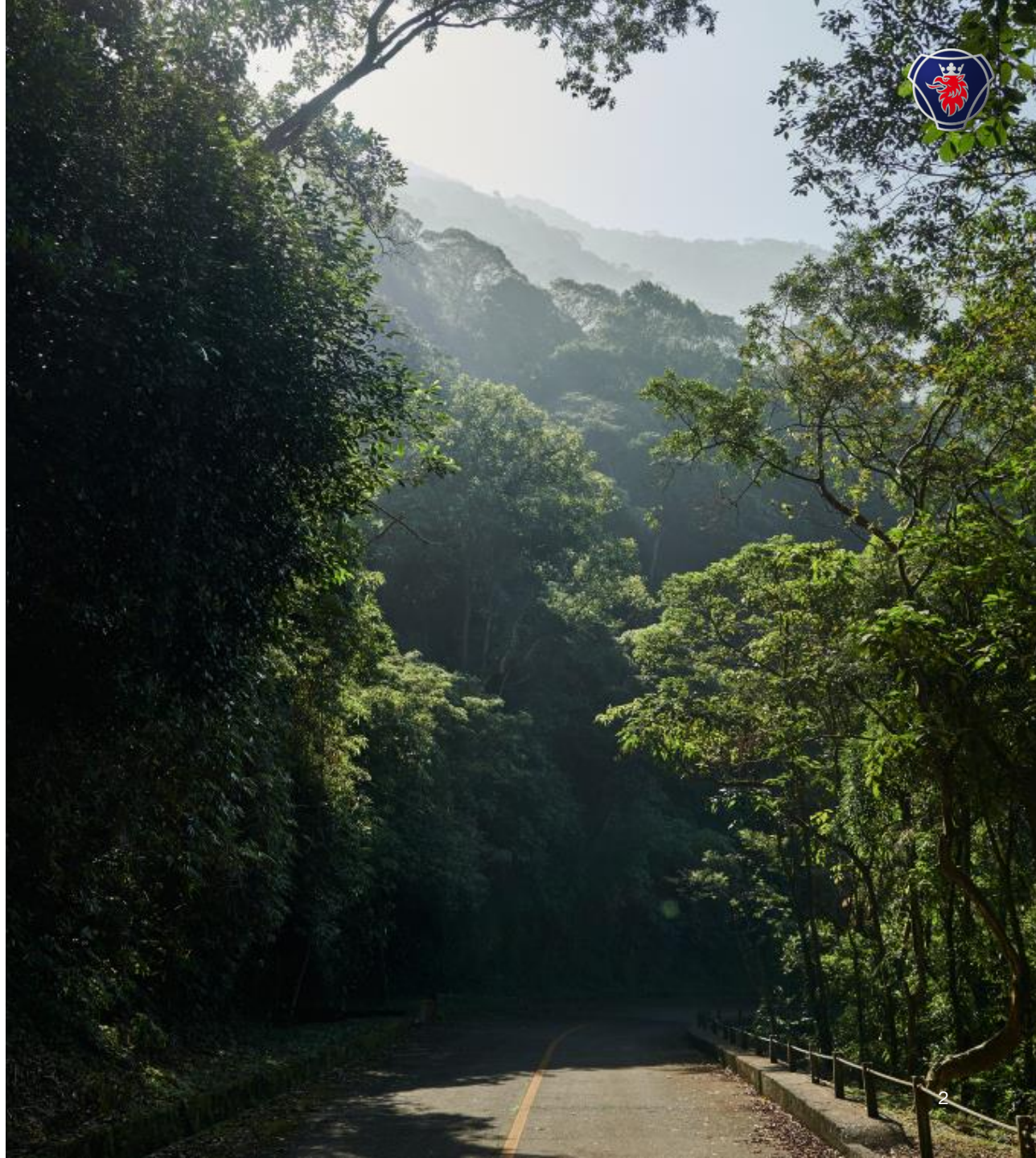
Human Factors in Remote Operation of Automated Vehicles: Frequently Asked Questions

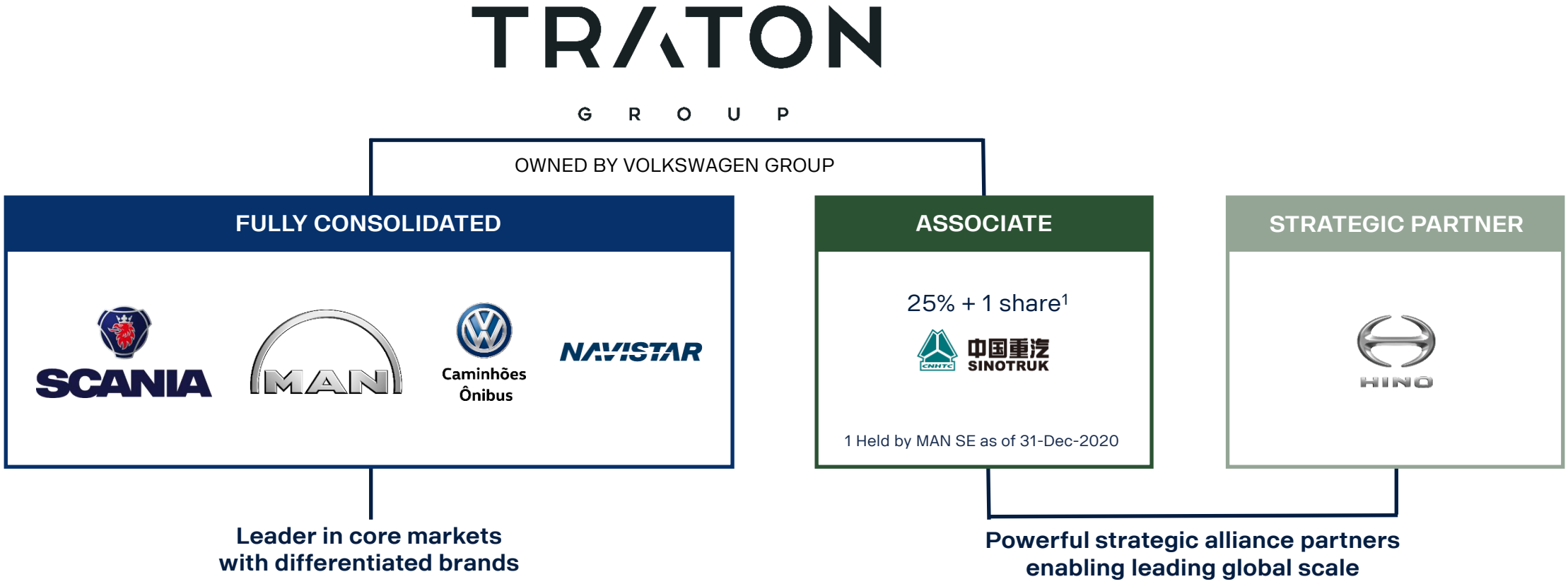
Azra Habibovic
Technology Leader Human Factors, Scania CV AB
azra.habibovic@scania.com

SCANIA IS A WORLD LEADING PROVIDER OF TRANSPORT SOLUTIONS

Together with our partners and customers we are driving the shift towards a sustainable transport system.



TRATON GROUP
– LEADING GLOBAL BRANDS AND STRATEGIC ALLIANCE PARTNERS



SCANIA IN BRIEF

FOUNDED
1891

100+
COUNTRIES

1,500
SERVICE POINTS

54,000
EMPLOYEES

R&D SPEND
7,458
SEK M.

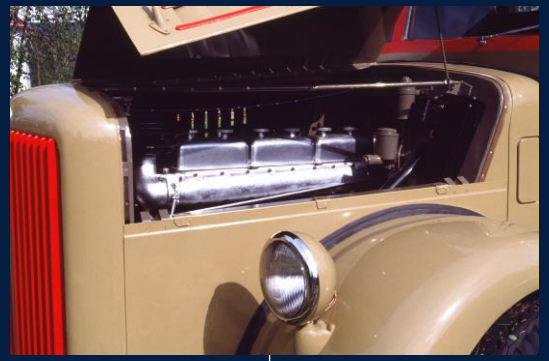
NET SALES
146,146
SEK M.

LAST RED FIGURES
1934

2020

130 YEARS OF INDUSTRIAL HISTORY

IN SHORT



1891
Company founded
Bicycles and railroad carriages

1902
First truck

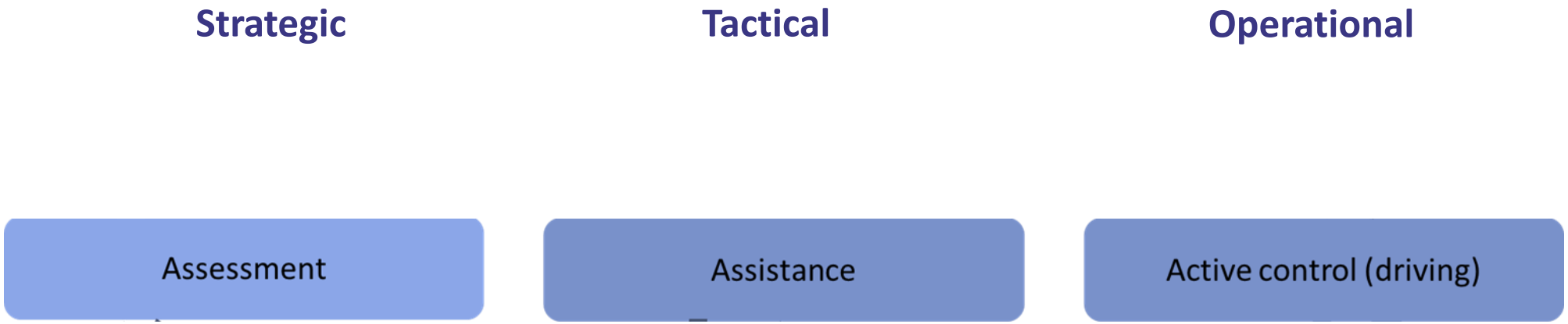
1940s
Diesel engines increasing fuel efficiency by 20-25 percent

1961
First turbocharged truck engine – Scania Super

1980
First fully modularised truck range – Scania modular system

SCANIA TODAY: LEADING THE SHIFT

Remote operation: three control modes



Examples of potential human factors challenges

Insufficient situational awareness

- Reduced sense of the vehicle and its surroundings
- Detachment from the action (i.e. lack of embodiment)
- Decreased feeling of urgency
- Lack of empathy and sensitivity towards surroundings

Examples of potential human factors challenges

Information overload

- Incapability to understand the situation
- Change blindness (failure to detect large changes)
- Stress and unwellness

Examples of potential human factors challenges

Physiological and cognitive demands

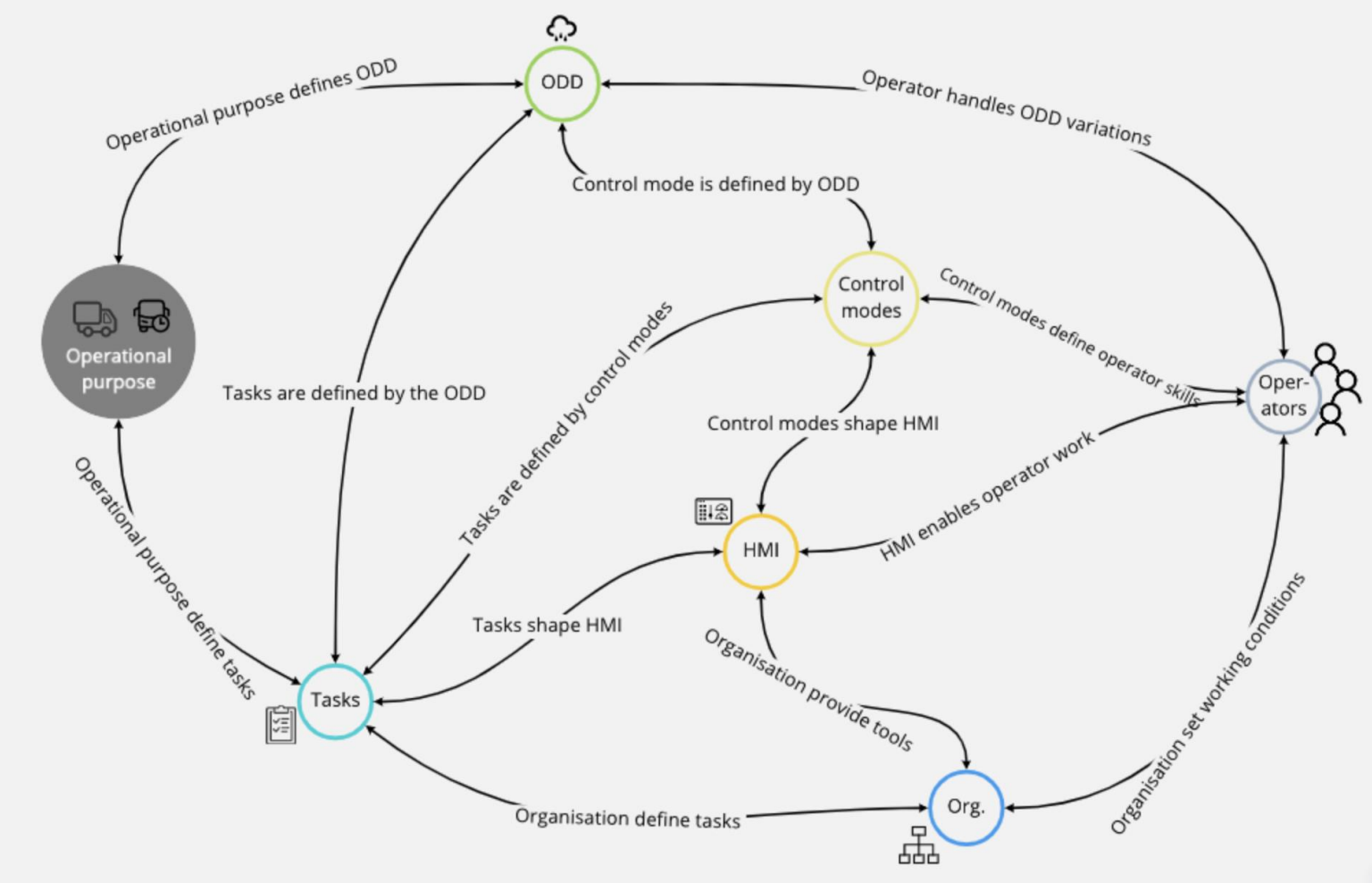
- Boredom
- Vigilance
- Inattention and distraction
- Motion sickness

Many human factors challenges – Still not solved

Habibovic, A., Andersson, J., Castor, M., Meiby, L. and Rizgary, D. Final report on Human factors related to remote control of automated heavy vehicles. SAFER, 2020. Link

- What are the tasks of remote operators for different ODDs?
- What is the maximum number of vehicles that can be operated by one human operator simultaneously?
- How do we define Operational Design Domain (ODD) for remote operation?
- What are the methodologies and tools required for describing properties of and prerequisites for different ODDs?
- How could classical human-centric automation issues like trust, responsibility, automation surprises, boredom and vigilance be mitigated?
- How should a remote HMI be designed to accommodate different remote operation roles and switching between these roles?
- How can HMI be designed to enable people physically present in a traffic situation to support a remote operator?
- What are differences between operational, tactical and strategical control levels from a human factors perspective when it comes to road automation?
- What education/training is needed for remote operators, and how do we train operators to handle edge cases?
- How will certification function with regard to regulatory aspects and frequent updates of automated driving systems?
- What are differences and similarities between different types of vehicles?
- ...

These challenges are often interrelated



HAVOC

Heavy Automated Vehicle Operator Center: Requirements and HMI design

A recently completed research project

Link: https://www.vinnova.se/en/p/heavy-automated-vehicle-operation-center-havoc---requirements-and-hmi-design/

Conducted by:

RI. SE

Co-financed by:

FFI Strategic Vehicle Research and Innovation

VINNOVA Swedish Energy Agency TRAFIKVERKET

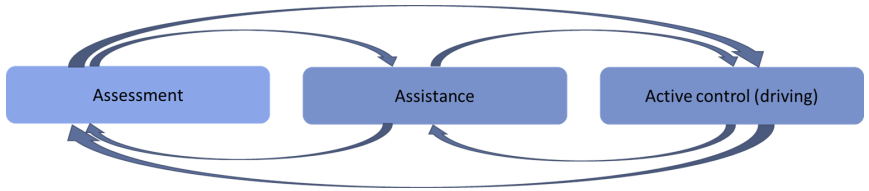
SCANIA VOLVO

In association with:

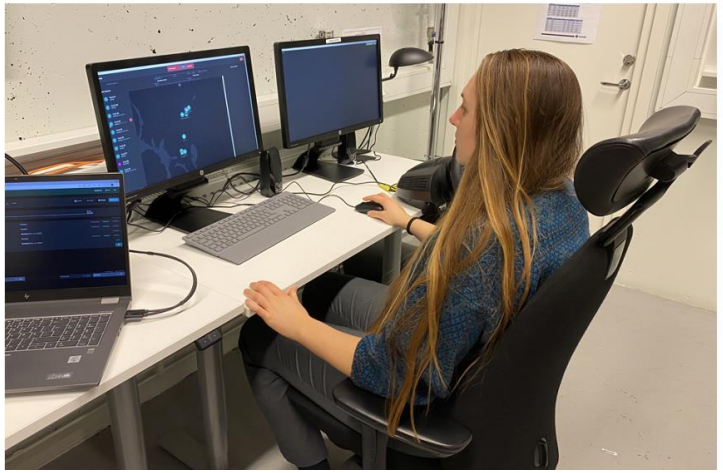
SAFER

Exploratory user study

- **Primary remote operator task**: Monitor 10 trucks in a hub-to-hub scenario and respond to events.
- **Secondary remote operator task**: Keep even time distance between the trucks.

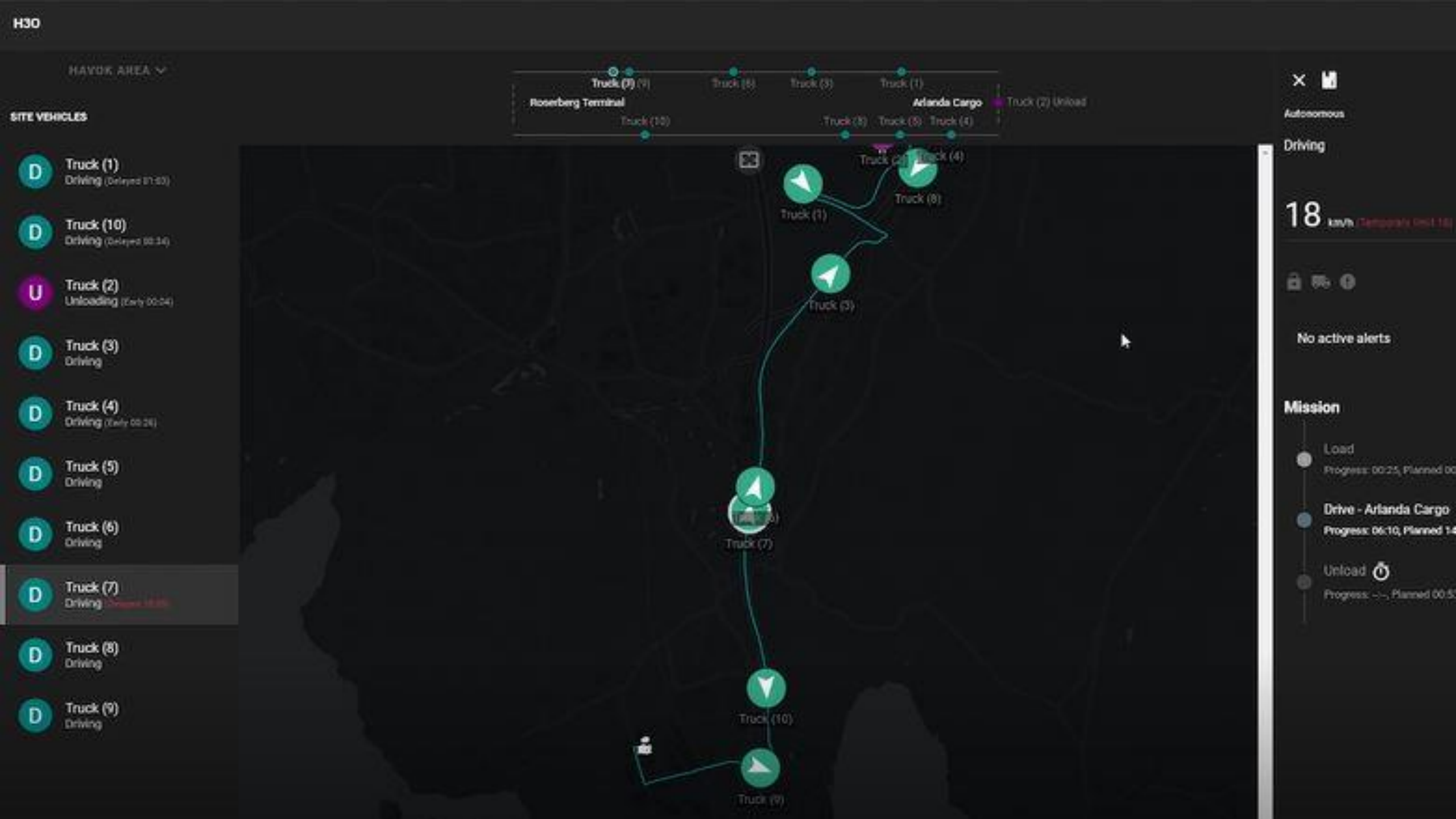


Mouse/keyboard
(assessment, assistance)



Steering wheel/pedals
(driving)

- **"Roadworks"** (Assessment) – Vehicles slowed down on the road
- **"Water puddle"** (Driving) – Vehicle stopped
- **"Bathtub"** (Assistance) – Obstacle on the road
- **"Loading dock"** (Driving) – Vehicle stopped in a hub
- **"Sensor degradation"** (Assistance) – Sensor malfunction, safe stop


H3O
HAVOK AREA
SITE VEHICLES
Truck (1)
Driving
Truck (10)
Driving
Truck (2)
Unloading
Truck (3)
Driving
Truck (4)
Driving
Truck (5)
Driving
Truck (6)
Driving
Truck (7)
Driving
Truck (8)
Driving
Truck (9)
Driving
Truck (9)
Truck (6)
Truck (3)
Truck (1)
Truck (10)
Truck (8)
Truck (5)
Truck (4)
Roserberg Terminal
Arlanda Cargo
Truck (2) Unload
Truck (1)
Truck (8)
Truck (3)
Truck (7)
Truck (10)
Truck (9)
Autonomous
Driving
18 km/h
No active alerts
Mission
Load
Drive - Arlanda Cargo
Unload

H30

HAVOK AREA

SITE VEHICLES

- Truck (1) — Driving (Early 00:23)
- Truck (10) — Driving
- Truck (2) — Driving
- Truck (3) — Loading
- Truck (4) — Driving (Delayed 00:34)
- Truck (5) — Driving (Delayed 00:37)
- Truck (6) — Driving (Delayed 01:10)
- Truck (7) — Driving (Delayed 01:06)
- Truck (8) — Driving (Delayed 00:46) 1
- Truck (9) — Driving (Delayed 00:49)

30ms

Autonomous

Driving

0 km/h

D N R

Summary

Mission

Assist

Truck (4)

Truck (10)

Truck (8)

Truck (5)

Path Blocked
Planned path blocked.

ACKNOWLEDGED

2021-12-13T10:56:59.3559464+01:00

Planned path blocked.

Give vehicle permission to drive on roadside. Verify the path can be driven without risk of collision.

APPROVE AND RELEASE DRIVE LOCK

VEHICLE CAMERAS

CCTV

DashCamera

FrontCamera

Frequently asked question #1

How many vehicles can one human operator handle?

How many operators are needed?

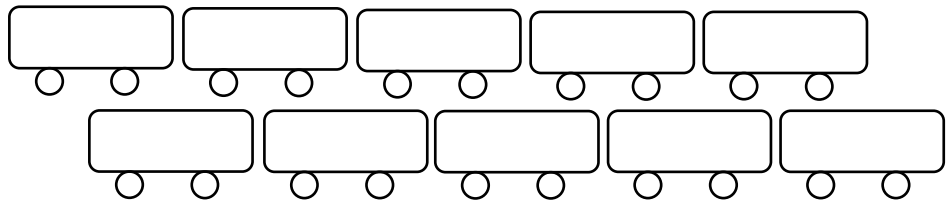
1:X

What is required from a human factors perspective to scale up the number of vehicles that an operator can remotely operate?

From the HAVOC study:

What is required from a human factors perspective to scale up the number of vehicles that an operator can remotely operate (1:X ratio)?

- **1:10 ratio was feasible** in the HAVOC setup (remote system manages vehicles – operator responds to actions suggested by the system).



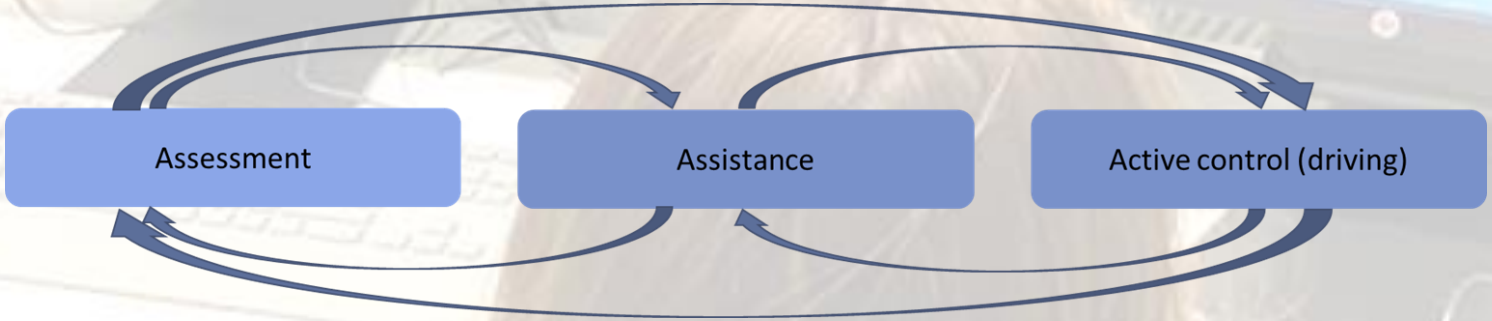
- One operator was able assess several vehicles at the time, but not in parallel to assistance and driving.
- One operator was able to assist and drive only one vehicle at the time.

To accommodate remote operation of multiple vehicles simultaneously, several operators and an efficient task distribution system will be needed.

Frequently asked question #2

Which tasks are most important to handle?

Will an operator be able to swap between different tasks?

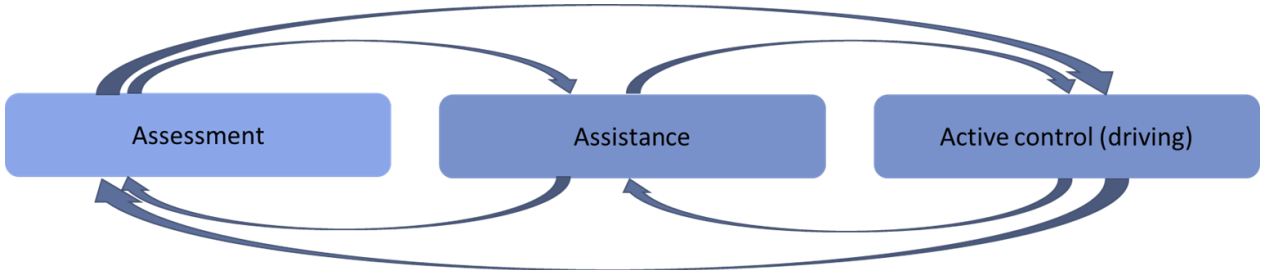


How should a remote operation center be designed to allow the operator to swap between different control modes?

From the HAVOC study:

How should a remote operation center be designed to allow the operator to swap between different control modes?

- Operators **easily and quickly** swapped between different control modes in the HAVOC setup.
  - They trusted the system.
  - The task-based HMI design (e.g., verify that the path can be driven) simplified their job.



System transparency and trust must be built and maintained, at the same time as the system overreliance is reduced.

The design goal should not be to keep the operator "in-the-loop", but to enable the operator to easily "get-in-the loop" when needed.

Frequently asked question #3

What capabilities should a remote operator have?

Should an operator have a truck drivers license?

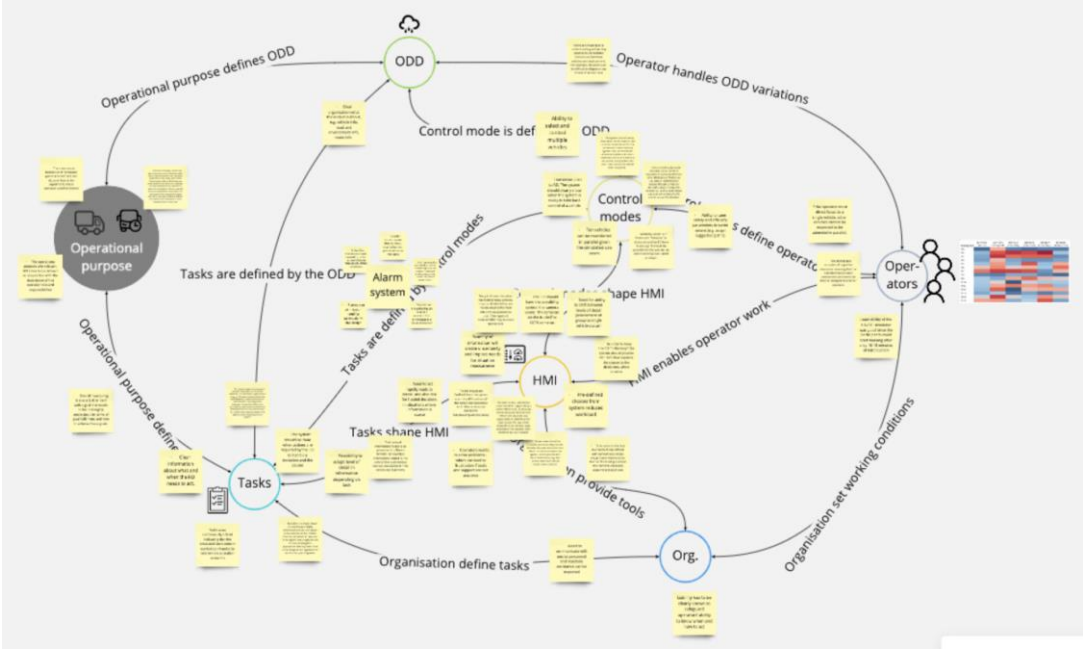
What requirements are posed on the operator and automated driving system for different control modes?

From the HAVOC study:

What requirements are posed on the operator and automated driving system for different control modes?

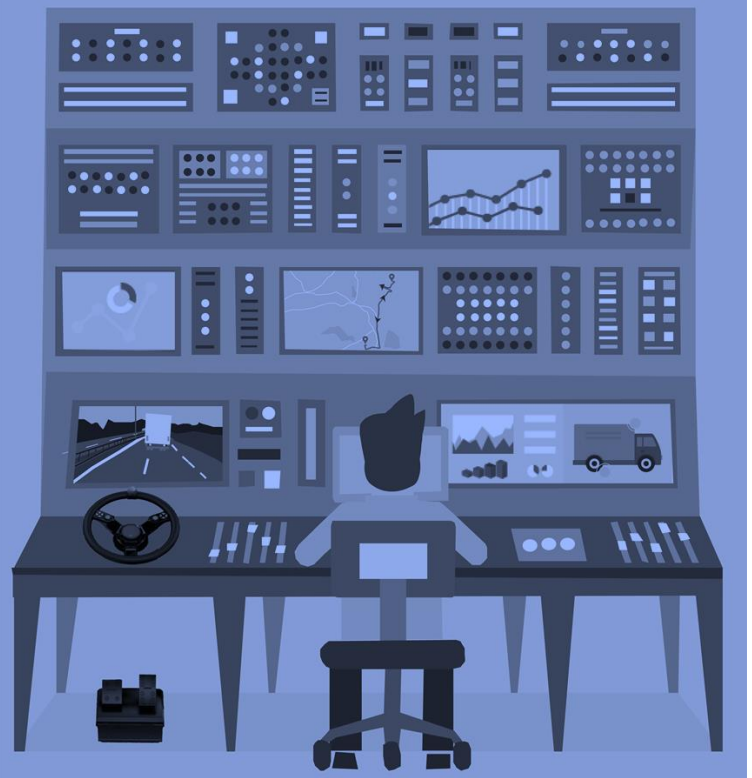
Requirement webpage:
http://www.tinyurl.com/havocproject

- **Generic requirements** for human-automation interaction and remote operation, as well as **multiple inter-dependencies** between them, apply in the HAVOC setup



Requirements on both operators and automated driving system are defined by a range of interfering socio-technical factors.

Summary and reflections



- Taking a **socio-technical system perspective** is crucial.
- The design goal should be to enable the operator to easily **“get-in-the loop”**.
- **Task-based HMI** should be explored further to understand its pros and cons.

Thank you!

For more info about the HAVOC-project, contact the core project team:

Jonas Andersson, jonas.andersson@ri.se
Johanna Vännström, johanna.vannstrom@scania.com

Related publications:

Andersson, J., Rizgary, D., Söderman, M., Vännström, J. **HAVOC Heavy Vehicle Operation Centre**. Final project report. 2022. Link

Andersson, J., Rizgary, D., Söderman, M., & Vännström, J. **Exploring remote operation of heavy vehicles – findings from a simulator study.** Paper submitted to Human Factors and Ergonomics Europe Chapter Conference, Turin, 2022.

Vreeswijk, J., Habibovic, A., Madland, O., & Hooft, F., **Remote support for automated vehicle operations.** In Road Vehicle Automation 9 Book (Ed. Gereon Meyer, VDI/VDE-IT, and Sven Beiker, Stanford University). 2022.

Habibovic, A., Andersson, J., Castor, M., Meiby, L. and Rizgary, D. **Final report on Human factors related to remote control of automated heavy vehicles.** SAFER, 2020. Link

HF-IRADS. **Human Factors Challenges of Remote Support and Control A Position Paper from HF-IRADS**. Informal document GRVA-07-65
7th GRVA, 21-25 September 2020. Link