Remote Operation:
A Human Factors Perspective

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Human Factors Research Group Work on Remote Operation

ServCity (Innovate UK, CCAV), Burnett, Harvey, Large, Hallewell (Jan 2020 – March 2023)

- Project deliverable on teleoperation workstation user requirements, involving interviews with key stakeholders and refined task analysis activity

MSc HF Final Project 'Goal-Directed Task Analysis for CAV teleoperation', Callum Thomas (2021)

- MSc final project, developed Goal-Directed Task Analysis and information requirements specification, based on analysis of Remote Operation across domains (video analysis – Covid)

PhD on Remote Operation of Autonomous Vehicles, Hannah Parr (2021 -)

- Aims: define levels, scenarios; determine role requirements; simulate/evaluate scenarios

- Parr, Harvey & Burnett (Under review) Investigating levels of remote operation in high-level on-road autonomous vehicles using operator sequence diagrams. *Cognition, Technology and Work.*

UoN-funded Remote Operation Simulator Development (Jan 23 -)

- To simulate RO/control centres across domains, linked with driving simulator

The AV Context

- Focus on Levels 4 and 5

- Vehicle occupant/s cannot drive

- Typical use case is AV taxi service
    - Significant understanding of this from ServCity Project

www.ServCity.co.uk
Nissan, Connected Places Catapult, Hitachi, TRL, University of Nottingham, SBD Automotive

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Defining RO Roles

Increasing Influence over dynamic driving task (DDT)

Remote Driving (RD)

'Remote control over the dynamic driving task (DDT) of an AV for a limited time period, where RA, RMa and RD are unable to resolve issues of vehicle function.'

Remote Management (RMa)

'Remote provision of instructions to AV to initiate system actions where the AV systems are unable to proceed independently. May also cover fleet management.'

Remote Assistance (RA)

'Remote provision of assistance and/or information to the AV user or external agents in close proximity to the AV (e.g. emergency services or vehicle recovery).'

Remote Monitoring (RMo)

'Remote observation of AV, user state and environmental factors, supporting the prediction and identification of issues to inform decision making.'

RO Scenarios

- Path disruption
- **Weather disruption**
- Insufficient range/fuel
- AV will not begin journey
- Mechanical failure
- Sensor perception error
- **Vehicle damage (collision)**
- Occupant medical emergency

Based on analysis of:
State of California Department of Motor Vehicles (2021, 2022) *Autonomous vehicle Disengagement Reports* (electronic data set), [https://www.dmv.ca.gov/portal/vehicle-industry-services/autonomous-vehicles/disengagement-reports/]
And other literature

- AV/User Occupant Witness
- Change in Road Layout
- Follow Path Indicated by External Person
- Path Disruption
- Weather Affecting Operation
- Choosing Stopping or Parking Location (User Specified)
- Choosing Stopping or Parking Location (External Agent Specified)
- Insufficient Fuel/Charge to Complete Journey
- AV Will Not Begin Journey
- Inspection of Vehicle Interior
- Mechanical Failure
- Sensor Perception Error
- Vehicle Damage (No Collision)
- Vehicle Damage (Collision)
- Location Not Valid
- Occupant Medical Emergency
- User Leaves Something in Vehicle
- User Requires Specific Location
- User Requests Assistance
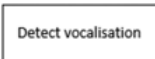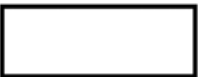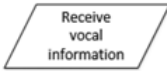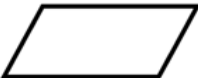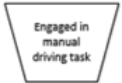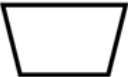- User Unable to Locate Vehicle
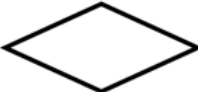
Operator Sequence Diagrams (OSDs)

Offer a way of modelling and graphically representing interactions between 'agents'

- In a RO scenario, agents are **computing systems**, **AV occupant/s**, **Remote Operator/s**, and **external agents**

- Agents are represented in 'swim lanes', interactions are depicted over time

OSDs have been applied and validated previously:

- Banks, V. A., Stanton, N. A., & Harvey, C. (2014). Sub-systems on the road to vehicle automation: Hands and feet free but not 'mind' free driving. *Safety Science*, 62: 505–514.

- Stanton, N. A., et al. (2022). Validating Operator Event Sequence Diagrams: The case of an automated vehicle to human driver handovers. *Human Factors and Ergonomics in the Manufacturing & Service Industries*, 32: 89–101.

| Example	Description	OESD elements
Detect vocalisation	A generic task	
Receive vocal information	Information is received	
Intelligible Response? No / Yes	A decision with two or more possibilities	
"Hazard vocalisation"	Audio output	
Autopilot icons unlit	Display output	Autopilot icons unlit
Engaged in manual driving task	A manual task	

OSD
1. Weather disruption

Key findings:

- Remote management with potential for remote driving
  - But RD is 'last resort'
- Need for RO-AV occupant communication
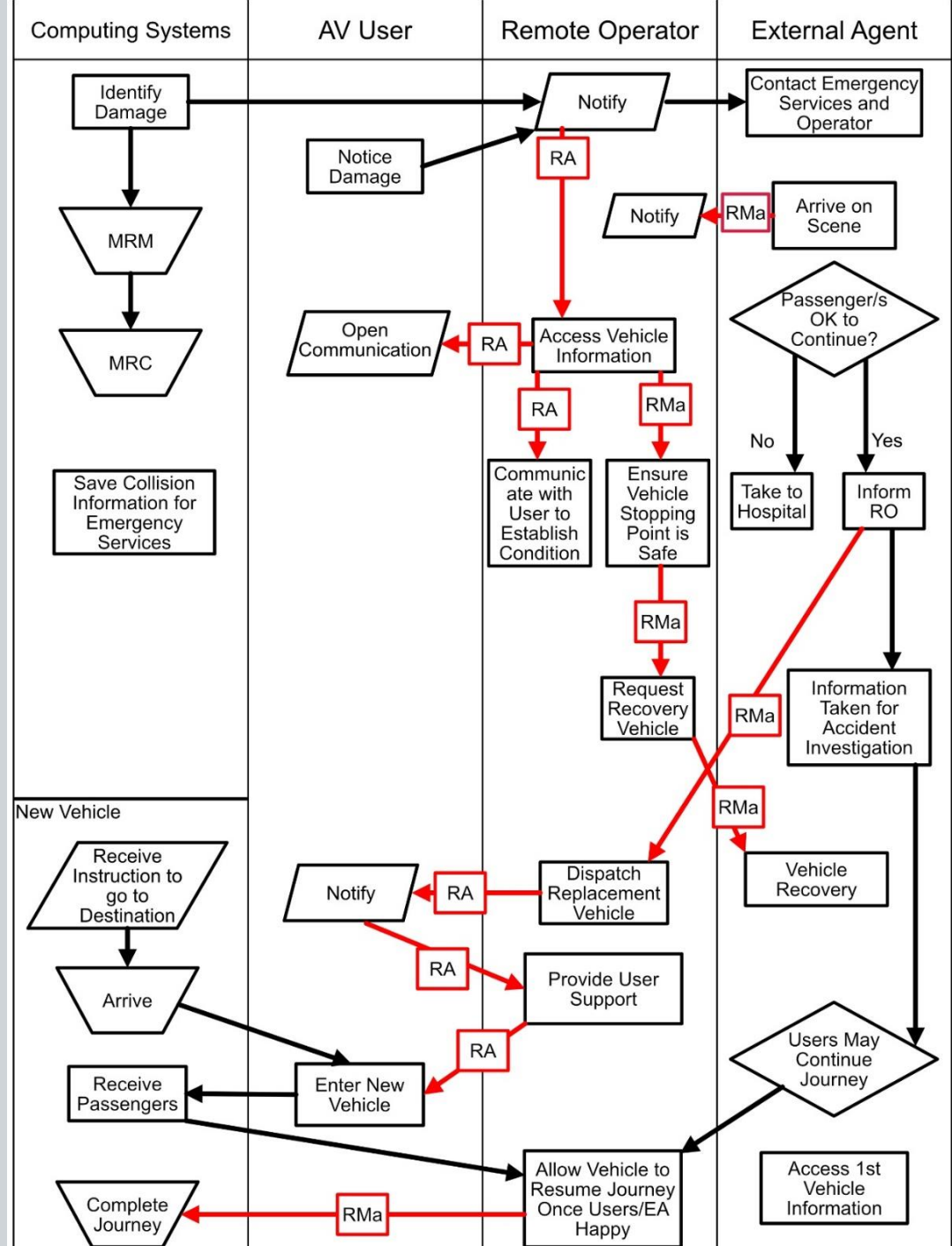- No external agent involvement
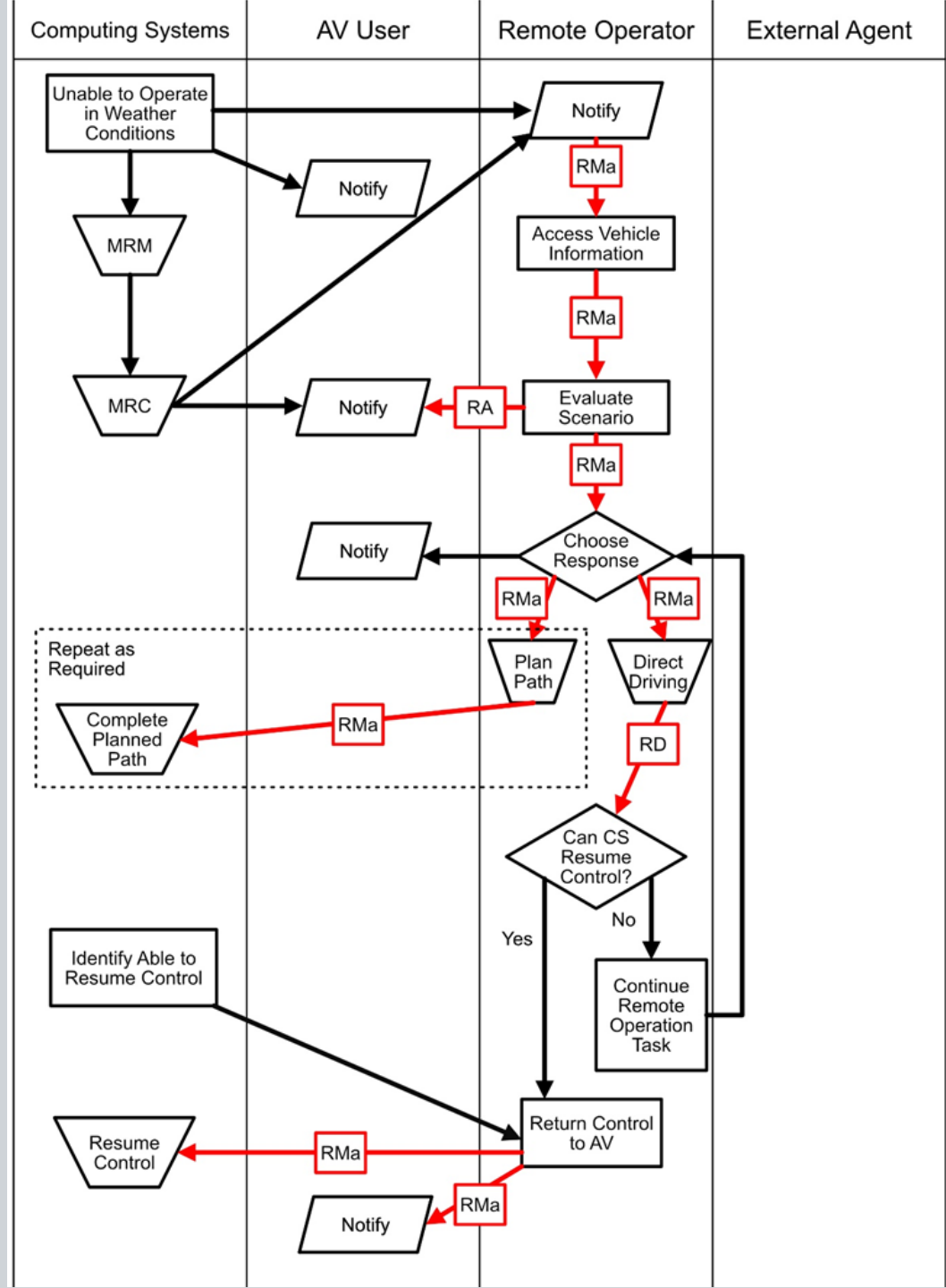
OSD
2. Vehicle collision

Key findings:
- Significant external agent involvement – need for comms
- Need for RO-AV occupant communication
- No direct RD
- Simultaneous Remote Assistance and Remote Management

OSD Main Findings

1. **Remote Assistance** and **Remote Management** occur **frequently** (more than expected and more than remote driving) and **together**

2. Remote Driving is required infrequently, as a 'last resort'

3. Scenarios are complex, with multiple 'agents', therefore **Shared Situation Awareness is significant** – needs further research, focusing on vehicle occupants and other external agents

4. Like driving, Remote Operation will operate at different levels of automation, which will influence the human role

Michael, 38

Michael works from home part-time running a business. He is the primary carer for his two children - a daughter aged 13 and a son aged 6. His daughter, who has a visual impairment, goes to the local secondary school and his son to the primary school.

He uses taxis everyday for the school-run as his wife works late/early shifts and needs the family car. He would take a bus, but the primary school isn't on the route and his daughter struggles to use public transport when it's busy.

Michael would like go out more with the children at the weekend but struggles if he doesn't have the family car. He's considering joining a 'car share' scheme as he likes to drive but can't afford a second car.

"I wish taxi drivers has disability awareness training - my daughter's disability is not always obvious - I think technology could help"

"We all know the drivers well now – it's nice that we can just have a chat and they always ask the kids what they are up to"

Michael has an Apple iPhone for business and an Android phone for personal use.

The family has an Apple Mac at home and several tablet devices which all the family use.

They also have two Amazon Alexa devices, one in the kitchen and one in the home office. These help Michael's daughter to access music and other content.

Travel & Transport

Top 3 modes of transport
- Taxi
- Shared car
- Walking

Top 3 reasons for taxi usage
- Caring
- Business
- Leisure

Willingness to share a taxi

Technology and Income
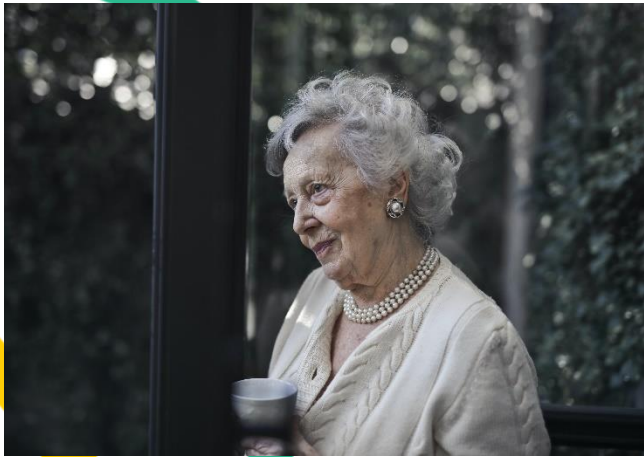
Technology acceptance

Openness to experience

Budget

ServCity

Mary, 81

Mary lives in sheltered housing in a small town. She is very active in her local community. However, she has mild hearing loss, and she finds it difficult to walk, she often needs to use a walking stick.

Her husband died 5 years ago and as she has never driven, she relies on the local bus to get about. She's happy to take the bus, but the service is limited and it's hard for her to stand and wait if its late. She will ask friends for lifts but doesn't like to impose unless it's important.

If she goes out in the evening, she prefers to get a taxi knowing it will take her door to door, so won't have to walk far in low light.

"I know I can be a bit slow, but when taxi drivers don't show up because they recognise the address (sheltered housing), it's very frustrating"

" I like to be independent, I don't like to rely on my friends for lifts, but some 'out of town' places are so hard to get to otherwise"

Mary has an old Android smartphone that her son gave her so they can always contact each other when she's was out and about, but she finds it hard to hear on it, particularly when outside.

She prefers to use her landline for making any arrangements, as she can hear better and finds the raised buttons much easier to press than those on the flat smartphone screen.

Travel & Transport

Top 3 modes of transport

- Bus
- Taxi
- Lifts with others

Top 3 reasons for taxi usage

- Leisure
- Shopping
- Medical

Willingness to share a taxi

Technology and Income

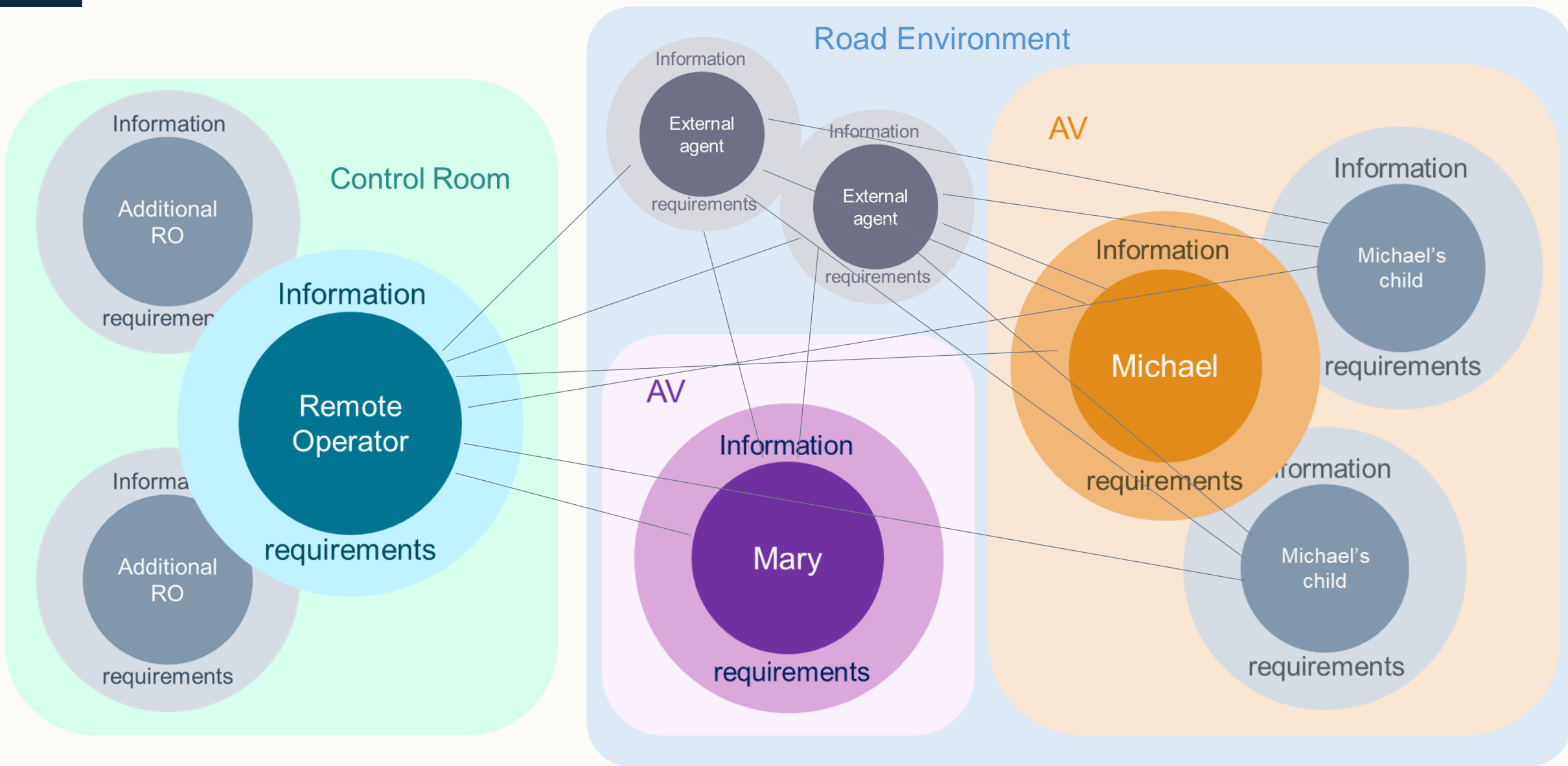Technology acceptance

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Shared Situation Awareness

Further Human Factors Issues for RO

- Misuse, Abuse and Disuse
    - Important to examine the negative issues around RO
- Training needs
    - Do particular skills and experience make a better RO?
- Trust in Remote Operation
    - From the various perspectives of system actors and general public
- Use of VR/AR/XR in remote operation

Thank you

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