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Evaluation of the Remote Driver's Interaction with the Connected and Automated Logistics

V-CAL

School of
Engineering

5G Connected & Automated Logistics (CAL)

- 5G CAL PoC Jul 20-Jun 22
- £4.9m proof of concept
- £2.4m from DCMS 5G Create
- 5G infrastructure
- Autonomous system
- Teleoperation
- Cyber security

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CATAPULT Connected Places
Coventry University
Newcastle University
perform green
STREETDRONE
Sunderland City Council

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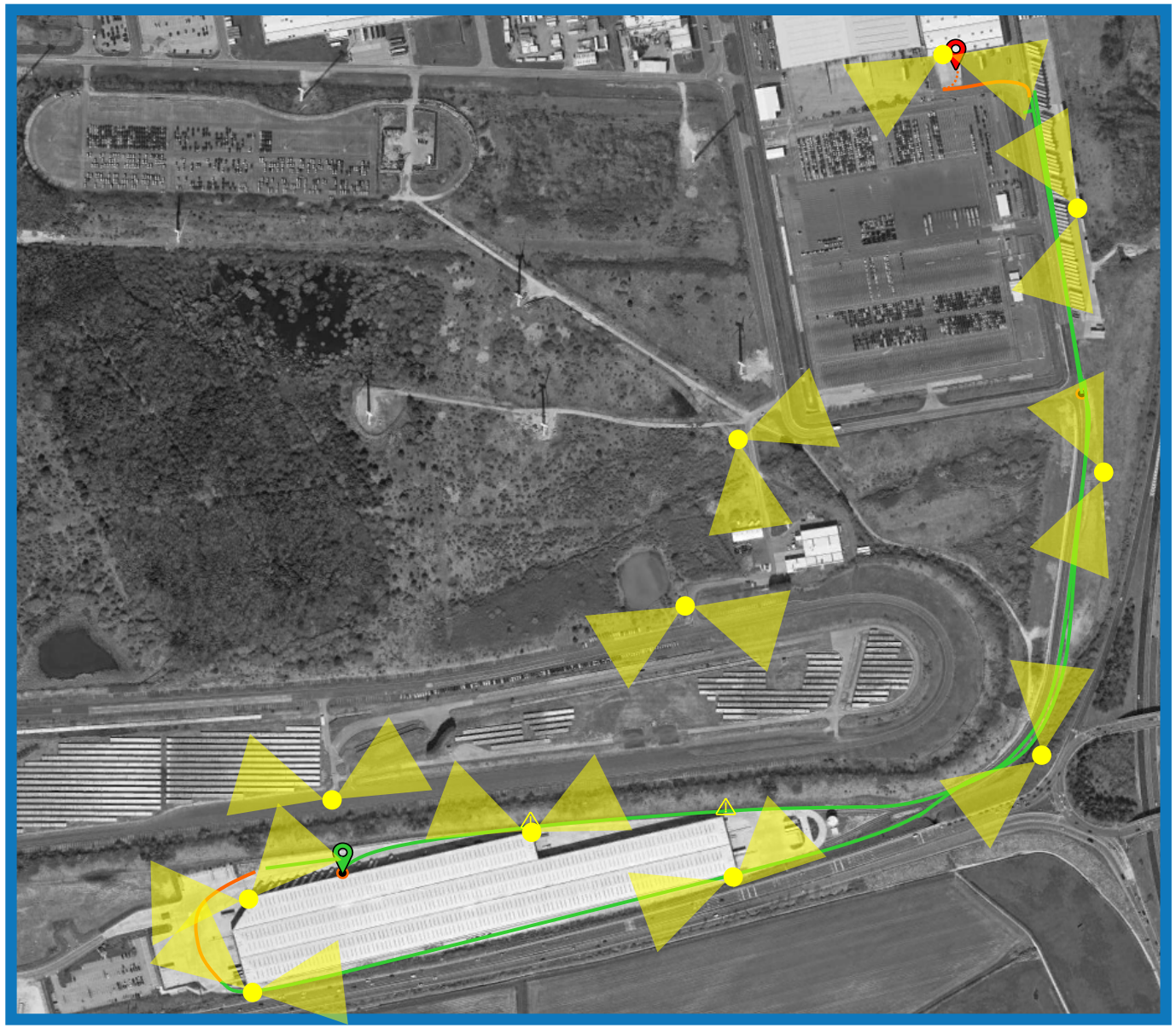
5G Infrastructure



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Access Spectrum N77

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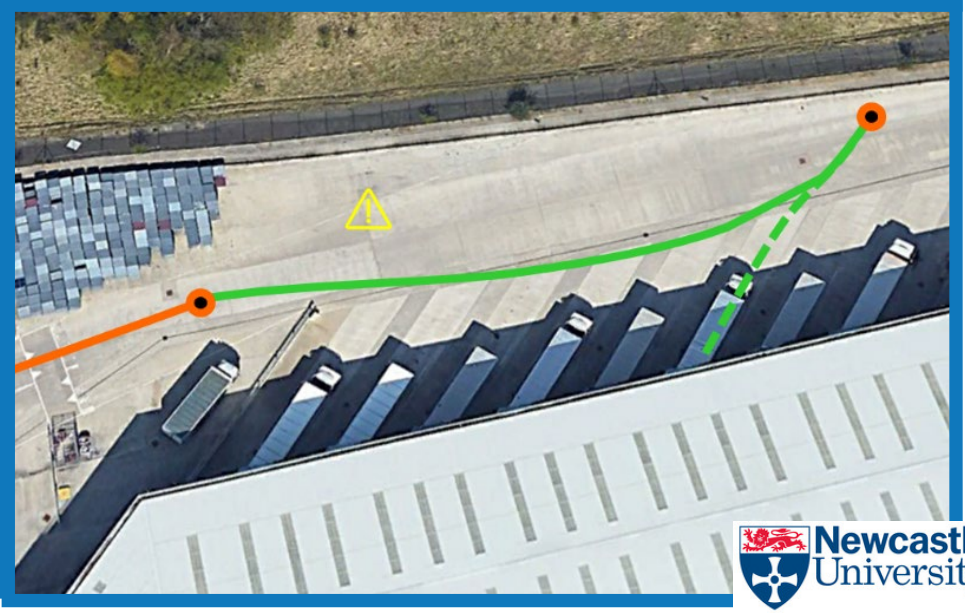
Trial Route



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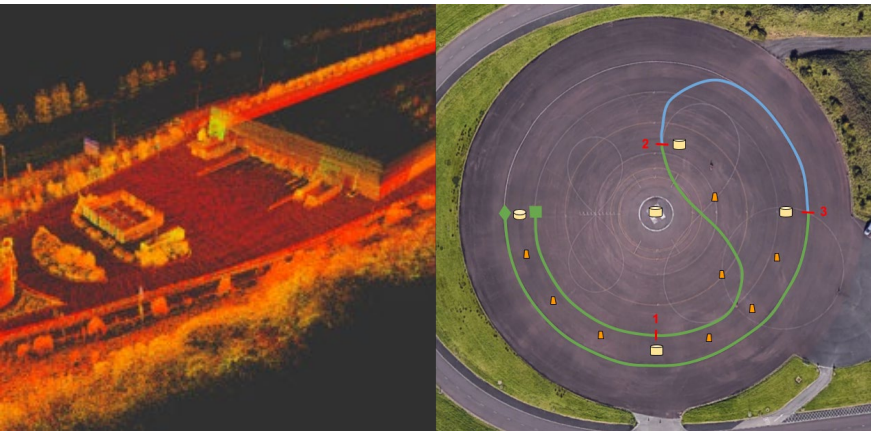
Autonomous & Teleoperation

Integration and verification testing on Electric Terberg

Teleoperation

Self driving development



Early autonomous software development carried out on eNV200 test mule

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Evaluation Structure-A Twofold Evaluation Structure

Evaluation of the teleoperation of the 5G enabled Connected and Automated Logistics (CAL)

Part 1 Quantitative Evaluation

- To quantify remote driver's attention, workload and performance when teleoperating the CAL.

Part 2 Qualitative Evaluation

- To collect qualitative (non-numerical) data to explore remote driver's perception and needs of support when teleoperating the CAL.

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Part 1 Quantitative Evaluation-Experimental Design

Aim:

- To explore the remote driver's attention and behaviour when interaction with the connected and automated logistics, with a particular focus on investigating the effect of the mental disengagement on the remote driver's takeover performance and behaviour in 5G CAL.

Methods

- Outline of the trial
  - Automated driving → Encountering system limitation → Pull to a stop → Inform the teleoperation system to take over the control.
- Experimental Design
  - Baseline condition-Monitoring driving (constantly monitoring the AV driving)
  - Experimental condition-Disengaged (distracted by a reading task on a tablet)

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Part 1 Quantitative Evaluation-Methods

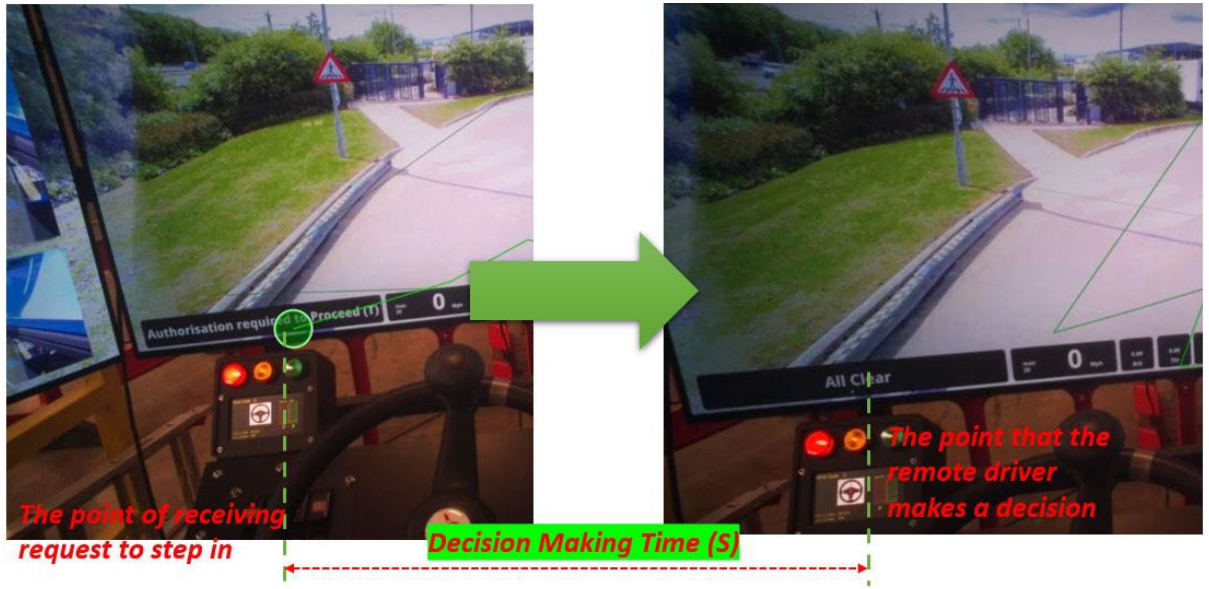
Methods

- Data collection
  - Motor readiness time (s)-
  - Decision-making time (s)
  - Virtualisation of the attention and workload.

Part 1 Quantitative Evaluation-Results

Time aspects

- Comparing to constantly monitoring driving, the mental disengagement led to slowed motor readiness time, with a difference of 5.309s.
- Comparing to constantly monitoring driving, the mental disengagement leads to slowed decision-making time , with a difference of 4.232s.



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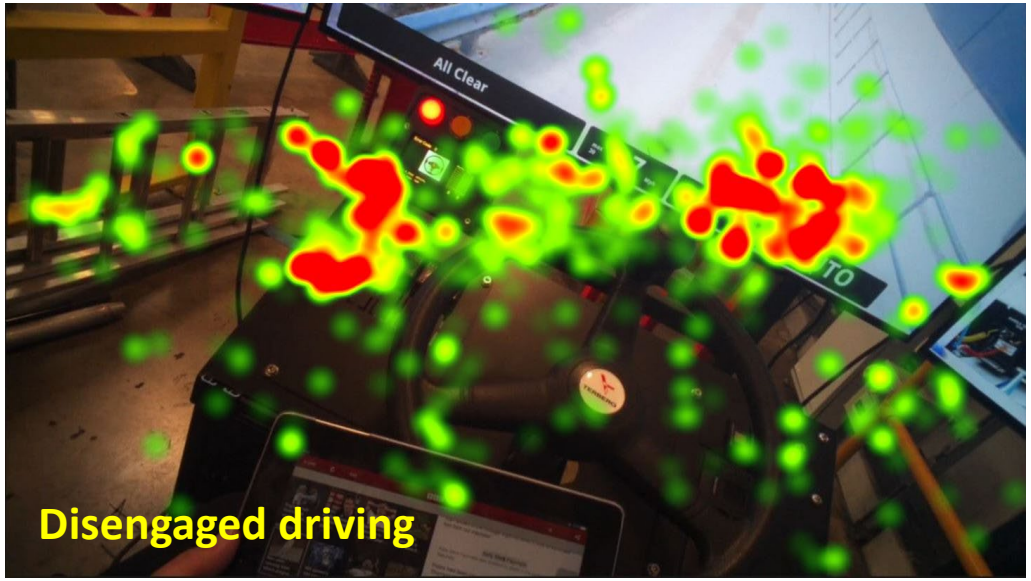
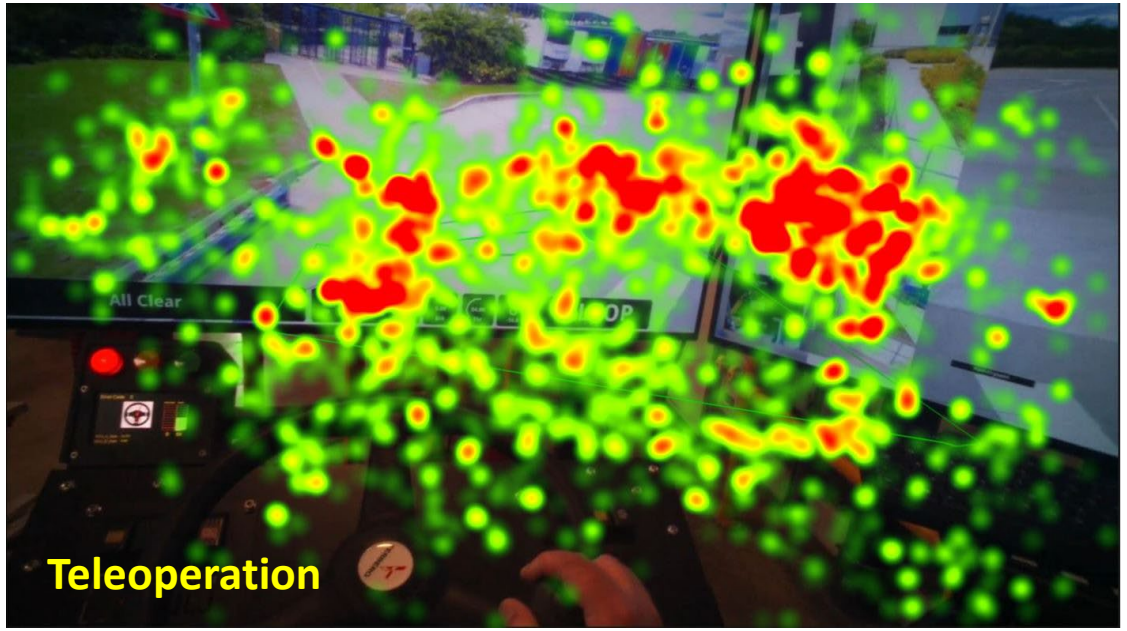
Part 1 Quantitative Evaluation-Results

Visualisation of Remote driver's attention and workload

- Comparing to constantly monitoring driving, the mental disengagement affects remote driver's attention focus from the road.
- Comparing to constantly monitoring driving, the mental disengagement leads to increased cognitive workload of the remote driver (more heat).
- When the remote driver is controlling the vehicle remotely, it resulted in higher cognitive workload compared to monitoring and disengagement conditions.





Part 2 Qualitative Evaluation-Methods

Aim

- to qualitatively investigate the remote operator's needs of support when teleoperating the connected and automated vehicles.

Methods

- Qualitative data collection method- semi-structured interviews.
- Sample: six people who experienced as the remote driver.

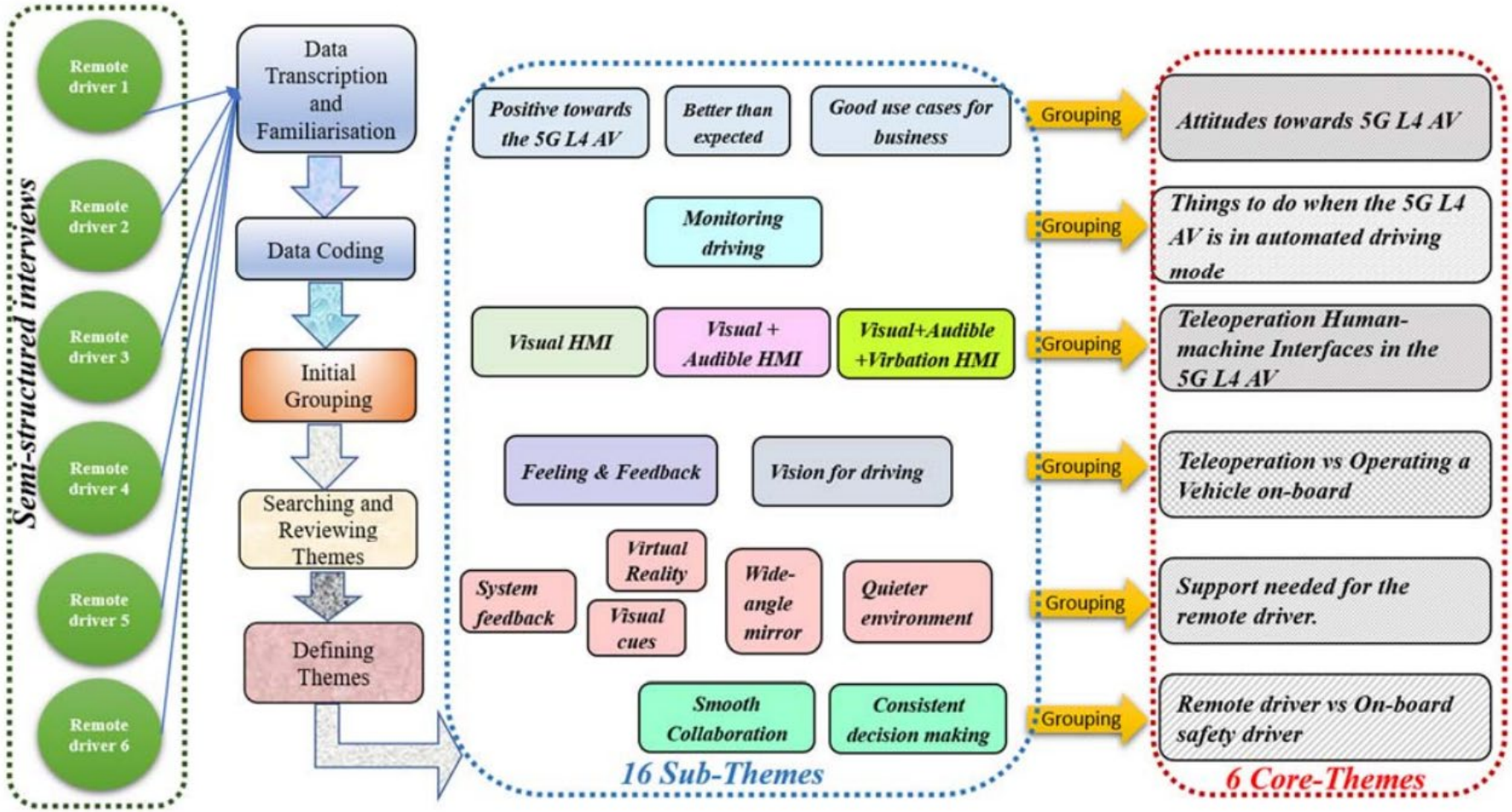
Part 2 Qualitative Evaluation-Results

Summary of Key findings

- Remote drivers would be monitoring the road when the CAL is performing automated driving. They expect to be informed if something happens.
- HMI: they prefer verbal communication if a safety driver is present; otherwise, they find visual, audible, and vibrational feedback beneficial.
- Challenges they perceived include lack of depth perception and missing vehicle feedback during maneuvers.
- More support regarding their visual field driving when teleoperating the CAL.
- More support in terms of enhancing the perception of physical feedback when teleoperating the CAL.
- Possible support includes introducing Virtual Reality, wide angle mirrors, as well as full motion feedback systems into the teleoperation workstation of the CAL.

Part 2 Qualitative Evaluation-Results

- Li, S., Zhang, Y., Edwards, S. and Blythe, P.T., 2023. Exploration into the Needs and Requirements of the Remote Driver When Teleoperating the 5G-Enabled Level 4 Automated Vehicle in the Real World—A Case Study of 5G Connected and Automated Logistics. *Sensors*, *23*(2), p.820. https://doi.org/10.3390/s23020820



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Next Step V-CAL Project 2023-25

£8.1m CCAV Commercialising CAM

Scale UP

- 5G network
- 3 new fully electric yard tractors
- Autonomous & teleoperation system

Success Factors:

- Operational flexibility to match current state
- Integrating within operational conditions
- Remote driver supervision (1:3)
- Commercially viable systems

Scale Out

- Original 5GCAL vehicle
- Car transporter trailer
- Fully autonomous system

Success Factors

- Operational flexibility to match current state
- Integrating within operational conditions
- Ability to handle more complex road infrastructure

Supported by

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Innovate UK

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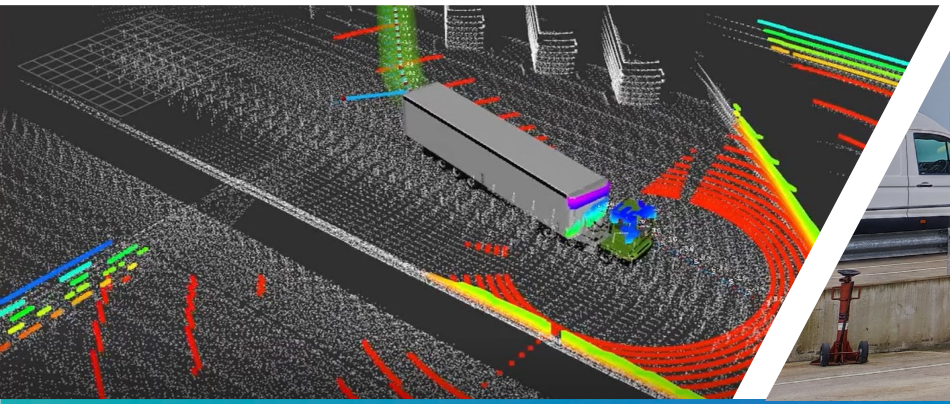

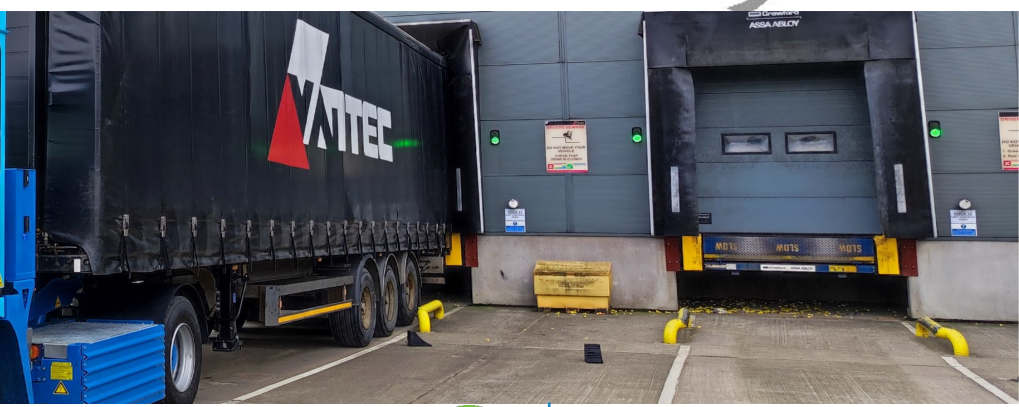

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