Sim4CAMSens

Sim4CAMSens Project – Modelling, Simulation and Testing of Automotive Perception Sensors

AESIN Conference 2024

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rFpro - Company Mission

To provide the world's leading **simulation software and digital content** to **reduce** the reliance on real world testing and training data generation

Sim4CAMSens Project

Part of CCAV's Commercialising CAM Supply Chain Competition (CCAMSC).

The Commercialising CAM programme is funded by the Centre for Connected and Automated Vehicles, a joint unit between the Department for Business and Trade (DBT) and the Department for Transport (DfT) and delivered in partnership with Innovate UK and Zenzic.

Project Introduction

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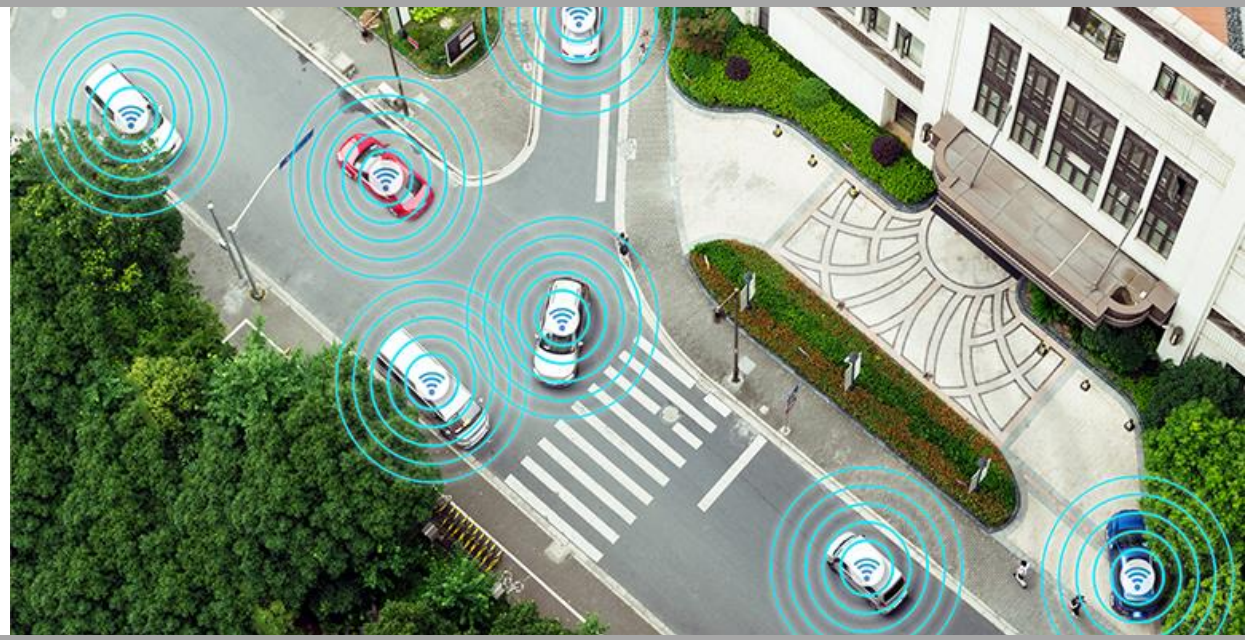
Mobility for all: *more efficient, lower operating costs, safer*

- Huge investments being made to develop and deploy AVs

- **<u>MUST</u> ensure that AVs are safe to deploy to the satisfaction of the regulators**
- **Simulation is <u>ESSENTIAL</u> in AV development and safety assurance**



Challenges:

- Large array of sensor types & new options
- Many factors affect sensor performance
- Vast amounts & diversity of training data
- Proving simulations are credible

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Project challenges

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To develop and mature a modelling and simulation supply chain, in the UK, for perception sensor development and testing

1. Quantify and simulate the perception sensors under all conditions

- Enable a sensor supplier to demonstrate the capabilities of their device
- Develop a sensor evaluation framework spanning modelling, simulation and physical testing
- Create test methods to cover the whole test spectrum for perception sensors

2. Generate highest value multi-modal AI/ML training data using simulation

- Real-world data collection is difficult, expensive and time consuming
- Integrate high fidelity digital models of real-world environments with sophisticated sensor models and automatic annotation

3. Propose a framework for simulation credibility and AV safety to regulator

- Including real-world validation

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The consortium

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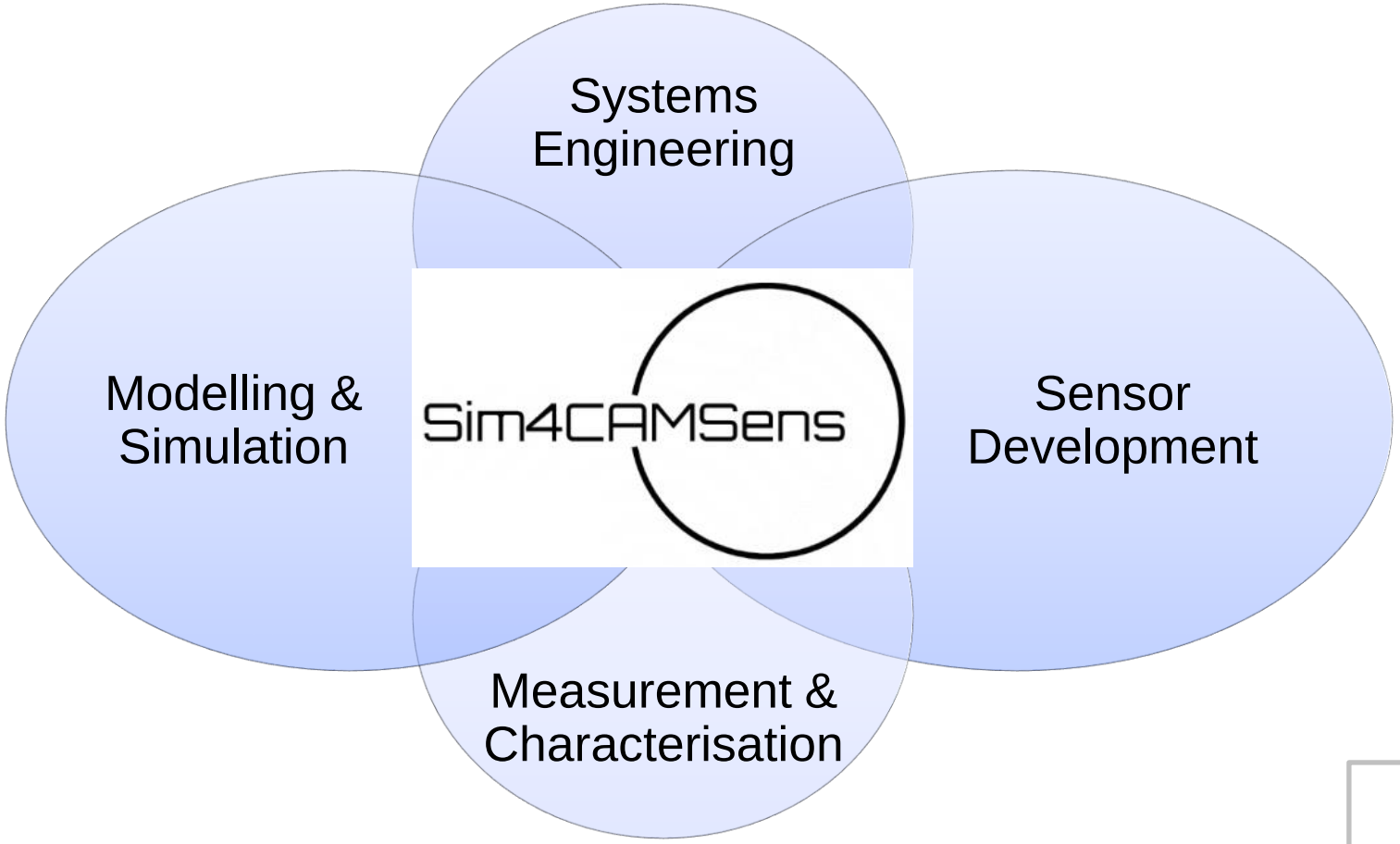

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Project Advisory Board

Project Overview

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WP1

Perception sensor requirements

Identify generic sensor suites for selected applications and develop sensor performance requirements, DVMs, and targets

WP2

Test data collection and analysis

Develop test methods to measure material properties and noise factors that affect sensor performance

WP3

Modelling and Simulation

Improve the simulation environment and sensor models to allow for physics based simulation of more noise factors

WP4

Accelerating sensor development

Apply the learnings from WP2 and 3 to accelerate the development of Oxford RF's perception sensor

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WP1: Perception sensor requirements

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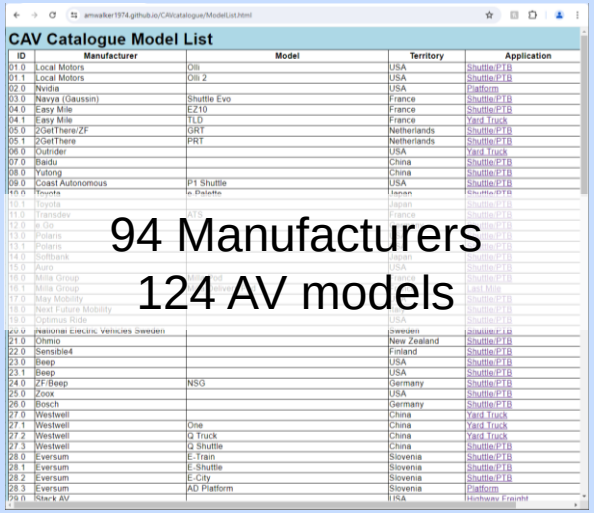
CAV Catalogue©



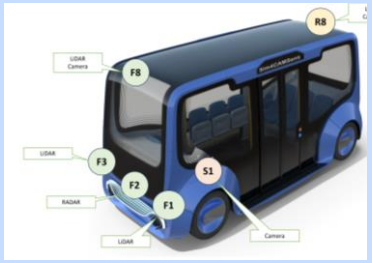
CAV Catalogue Model List

ID	Manufacturer	Model	Territory	Application
01.0	Local Motors	Olli	USA	Shuttle/PTB
01.1	Local Motors	Olli 2	USA	Shuttle/PTB
02.0	Nvidia		USA	Platform
03.0	Navya (Gaussin)	Shuttle Evo	France	Shuttle/PTB
04.0	Easy Mile	EZ10	France	Shuttle/PTB
04.1	Easy Mile	TLD	France	Yard Truck
05.0	2GetThere/ZF	GRT	Netherlands	Shuttle/PTB
05.1	2GetThere	PRT	Netherlands	Shuttle/PTB
06.0	Outrider		USA	Yard Truck
07.0	Baidu		China	Shuttle/PTB
08.0	Yutong		China	Shuttle/PTB
09.0	Coast Autonomous	P1 Shuttle	USA	Shuttle/PTB
10.0	Toyota		Japan	Shuttle/PTB
11.0	Transdev		France	Shuttle/PTB
12.0	e.Go		Germany	Shuttle/PTB
13.0	Polaris		USA	Shuttle/PTB
13.1	Polaris		USA	Shuttle/PTB
14.0	Softbank		Japan	Shuttle/PTB
15.0	Auro		USA	Shuttle/PTB
16.0	Milla Group		France	Shuttle/PTB
16.1	Milla Group		France	Last Mile
17.0	May Mobility		USA	Shuttle/PTB
18.0	Next Future Mobility		USA	Shuttle/PTB
19.0	Optimus Ride		USA	Shuttle/PTB
20.0	National Electric Vehicles Sweden		Sweden	Shuttle/PTB
21.0	Ohmio		New Zealand	Shuttle/PTB
22.0	Sensible4		Finland	Shuttle/PTB
23.0	Beep		USA	Shuttle/PTB
23.1	Beep		USA	Shuttle/PTB
24.0	ZF/Beep	NSG	Germany	Shuttle/PTB
25.0	Zoox		USA	Shuttle/PTB
26.0	Bosch		Germany	Shuttle/PTB
27.0	Westwell		China	Yard Truck
27.1	Westwell	One	China	Yard Truck
27.2	Westwell	Q Truck	China	Yard Truck
27.3	Westwell	Q Shuttle	China	Shuttle/PTB
28.0	Eversum	E-Train	Slovenia	Shuttle/PTB
28.1	Eversum	E-Shuttle	Slovenia	Shuttle/PTB
28.2	Eversum	E-City	Slovenia	Shuttle/PTB
28.3	Eversum	AD Platform	Slovenia	Platform
29.0	Stack AV		USA	Highway Freight

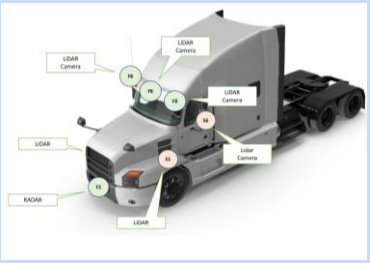
94 Manufacturers
124 AV models

Generic sensor suites

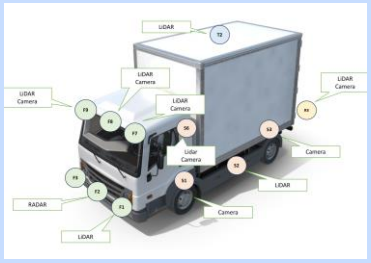
Passenger shuttle



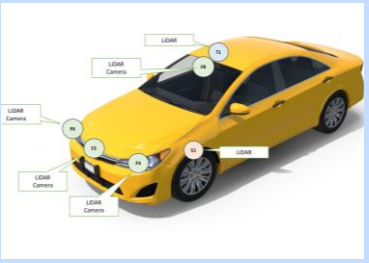
Highway freight



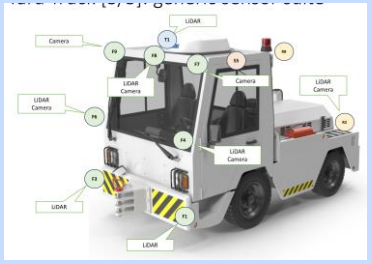
Last mile



Passenger car / Robotaxi



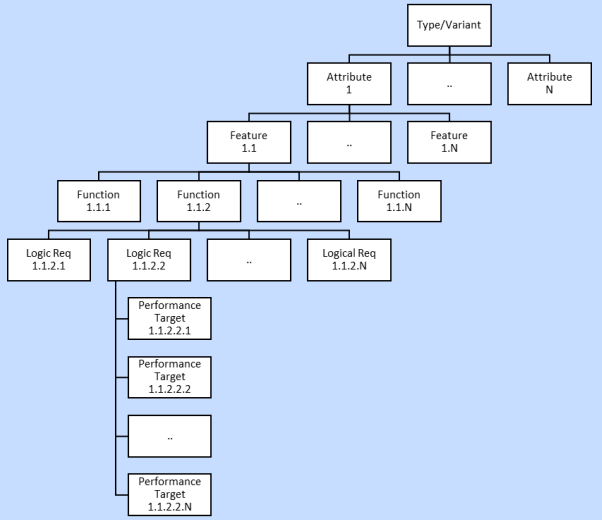
Yard truck



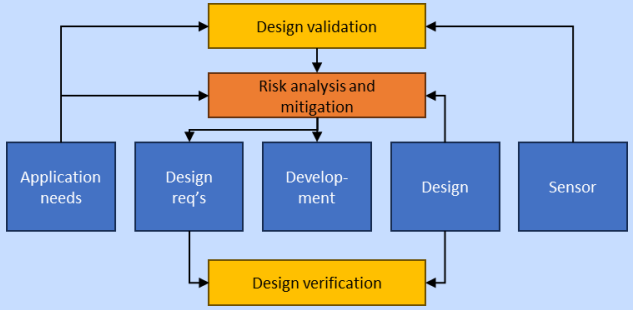
ODDs

Highway freight

Req's and perform. targets



DVMs



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WP2: Test data collection and analysis

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SOTA review

Noise Factors

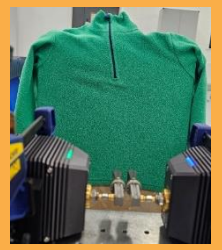
- Sources of perception sensor degradation e.g. snow, mud on the window, wear and tear.
- How does a noise factor impact perception sensor performance?
- How can performance degradation be measured experimentally?

Material Properties

- Properties that effect how perception sensors "see" a material in its field of view.
- Which objects and materials to focus on?
- What properties to focus on?
- How should/can property be measured, especially in the field.

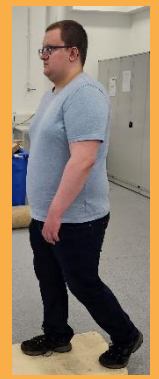
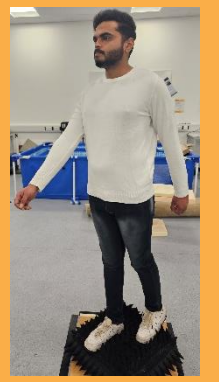
Material & Object Measurement

Measurement of material properties for lidar and radar

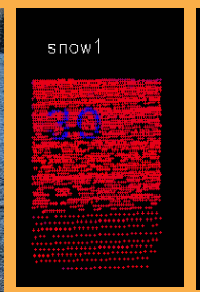

Measurement of VRU



Sensor Performance

Effect of weather on sensors

Performance across field of view with different targets

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WP3: Modelling and Simulation

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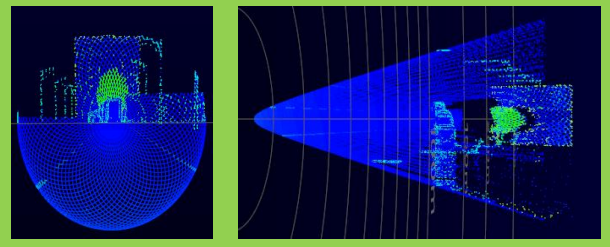
Validate Simulation to Physical Tests:

Create Locations

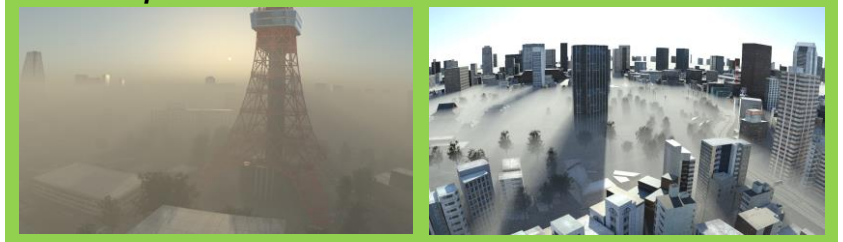
Create Sensor Models



Compare Results

Improve Simulation Capability:

Atmospheric Conditions



Sensor Specific Materials

Improve Sensor Models

Develop Required Documentation

Understand current regs requirements

?? BSI vs ISO vs EU vs UNECE ??

Create "Sim Handbook" Template

Commence internal projects for known improvements/validation gathering

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WP4: Accelerating sensor development

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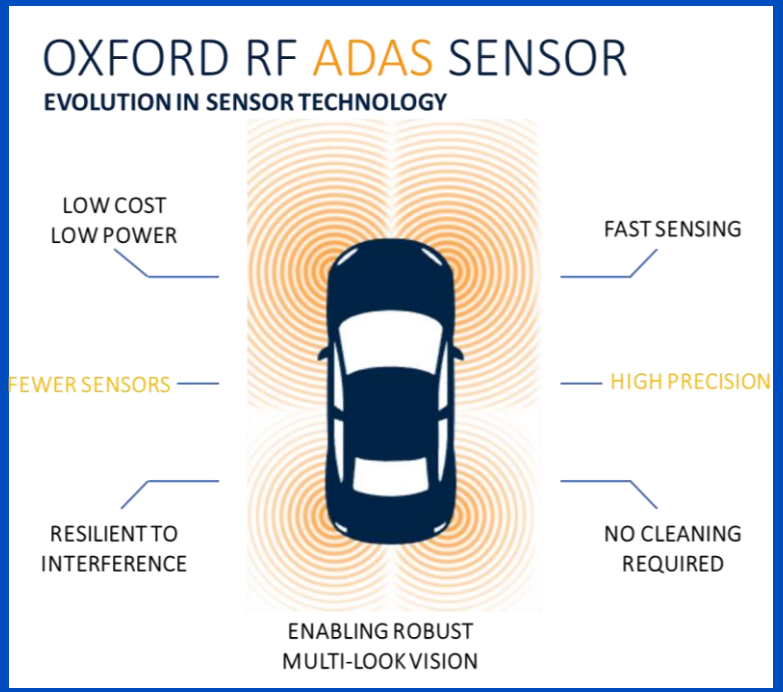
Oxford RF

Developing the world's first solid-state 360 sensors



Sensor model development

Improve Multipath and FMCW radar models

Validation of sensor model

Accelerate sensor development

Analysis work for Oxford RF

Create "Sim Handbook" for Oxford RF sensor model

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Sensor & Material Testing Campaign

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Winter Testing of Sensors – Weather Variability

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- 15 Sensors
  - Oxford RF radar + 2 radar development kits + 2 commercial radar
  - 5 lidar – 850nm, 905nm, 1550nm
  - 4 camera – 3 different CMOS chips
  - 1 thermal imaging camera
- Sensors recorded data every 5 minutes
  - 30s data for radar and lidar
  - 25 frames for cameras

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Material Measurements – LiDAR BRDF

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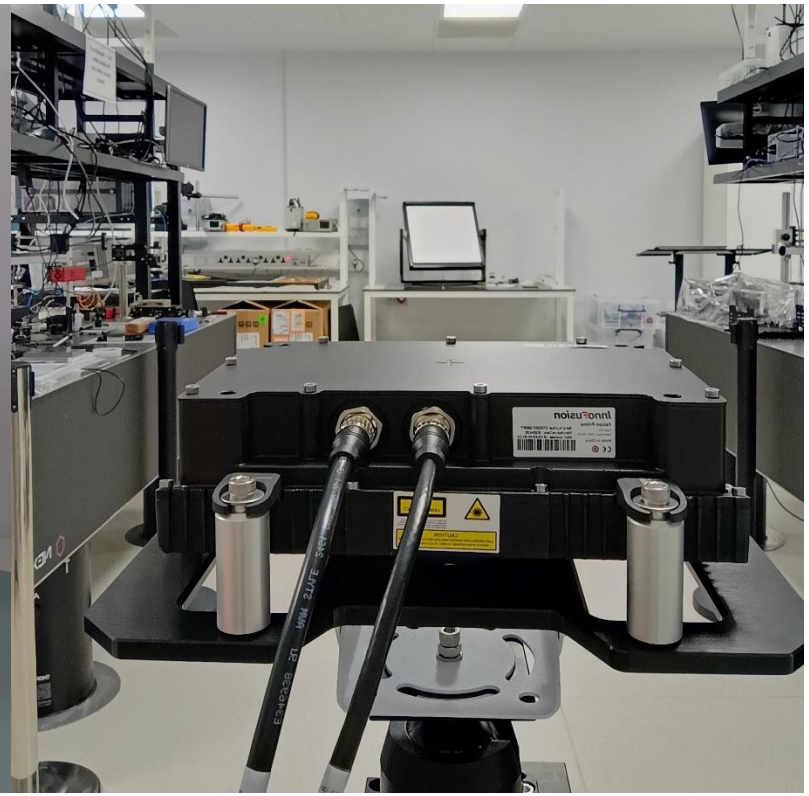

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Pedestrian & Clothing measurement

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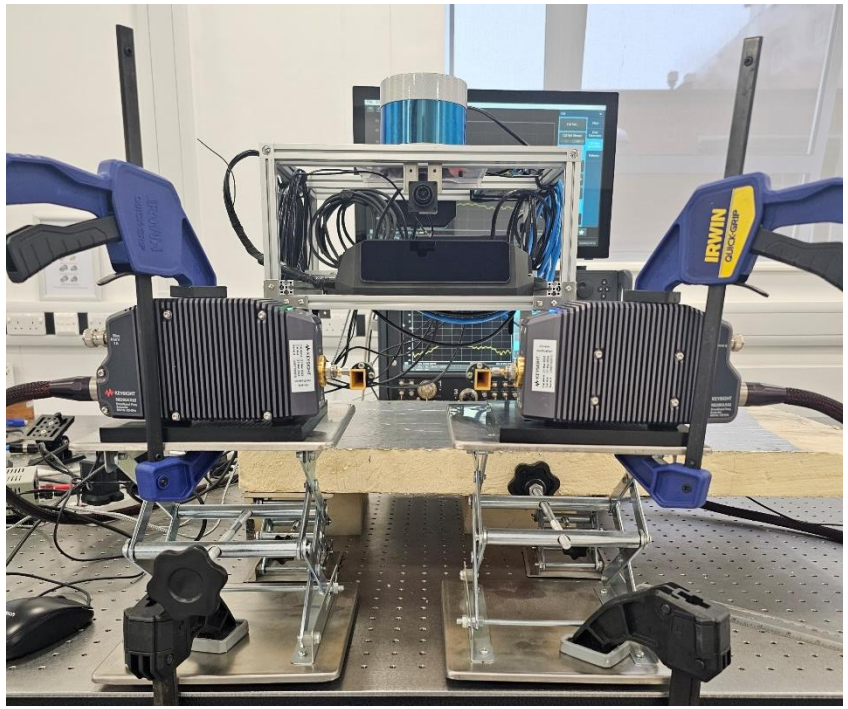
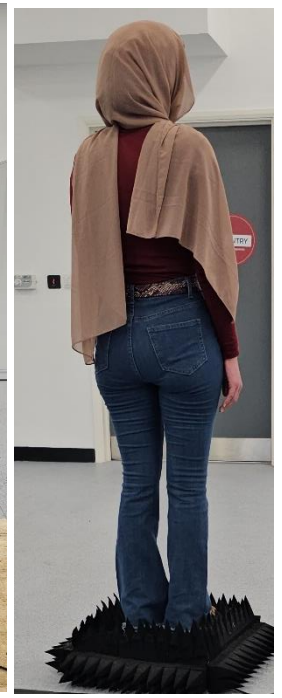
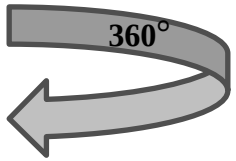




- Test Sensors:
  - VNA operating at 79GHz
  - 2x lidar operating at 905nm and 1550nm
  - Camera
- Test Targets:
  - Clothing over Sample Holder
  - Clothing over ADAS Dummy
  - Clothing over real humans



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Simulation Improvements

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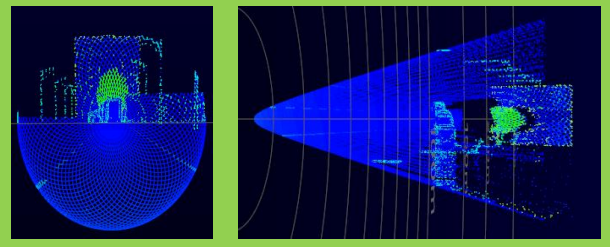

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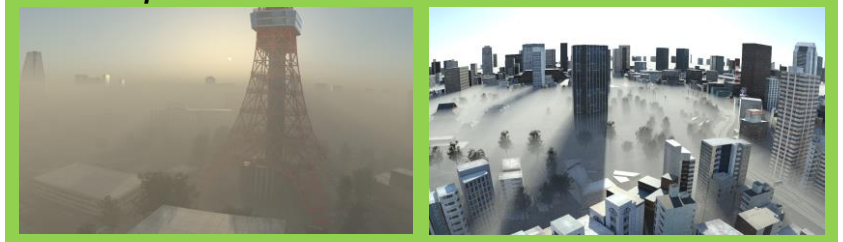

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Novel Radar Sensor & Sensor Model Developments

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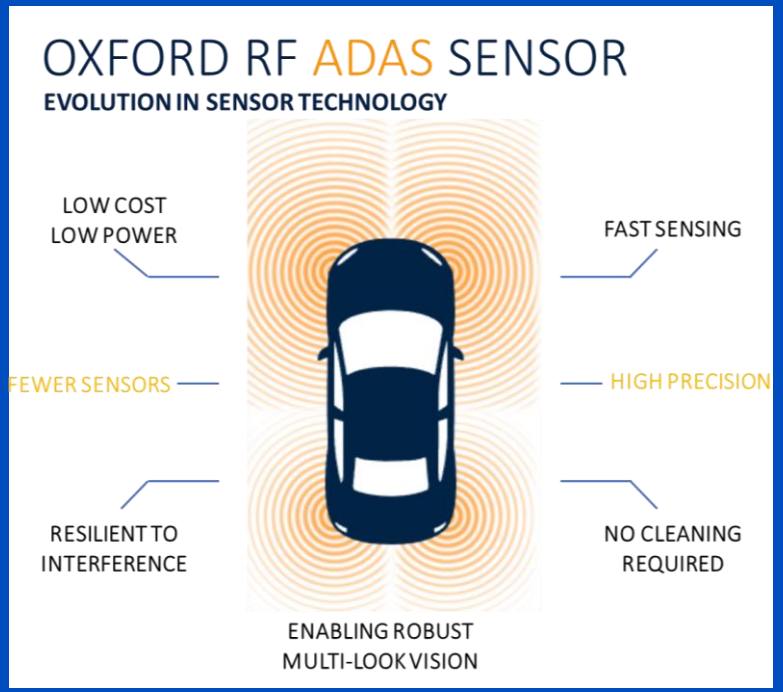

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Thank you

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