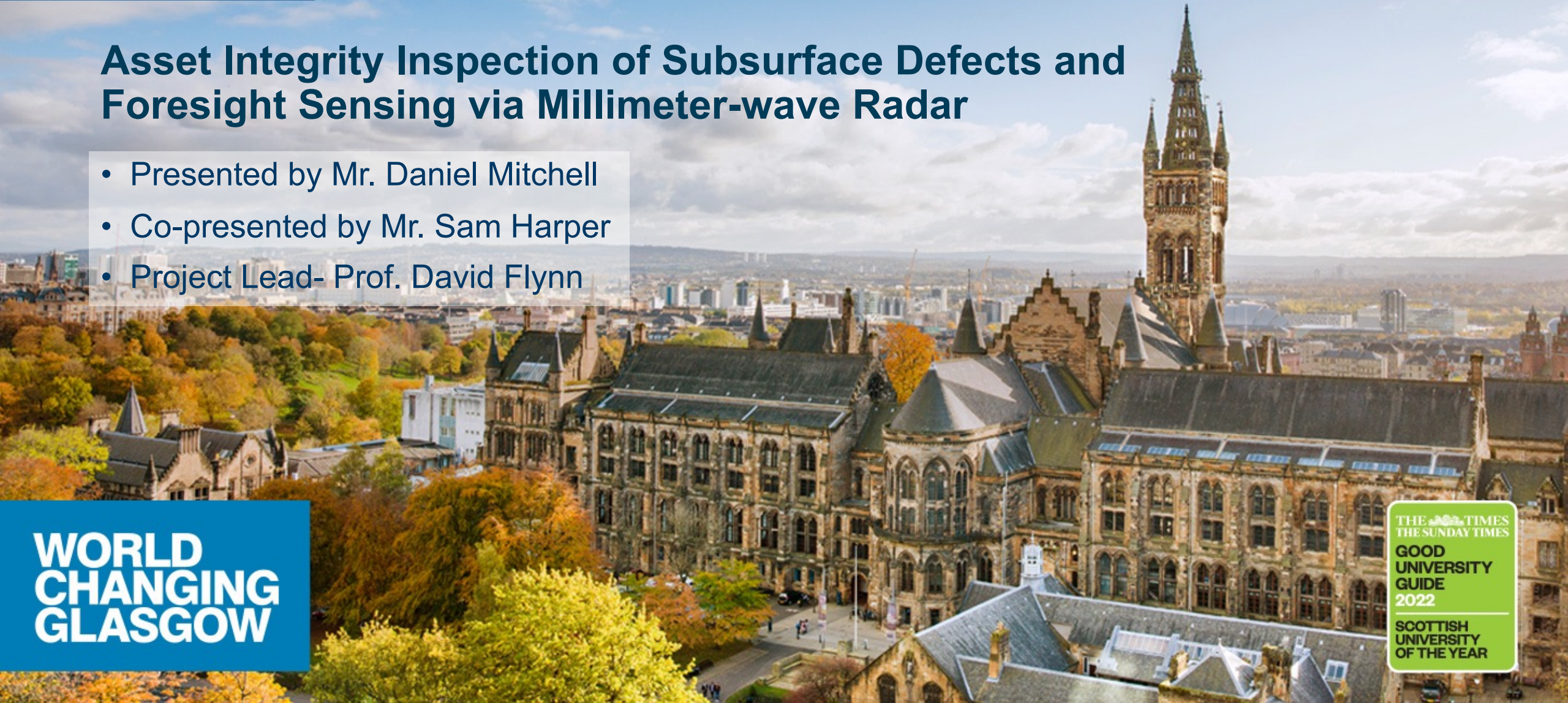
2022 Intelligent Maintenance Conference

EPFL

University of Glasgow

Asset Integrity Inspection of Subsurface Defects and Foresight Sensing via Millimeter-wave Radar

- Presented by Mr. Daniel Mitchell
- Co-presented by Mr. Sam Harper
- Project Lead- Prof. David Flynn



Asset Integrity Inspection

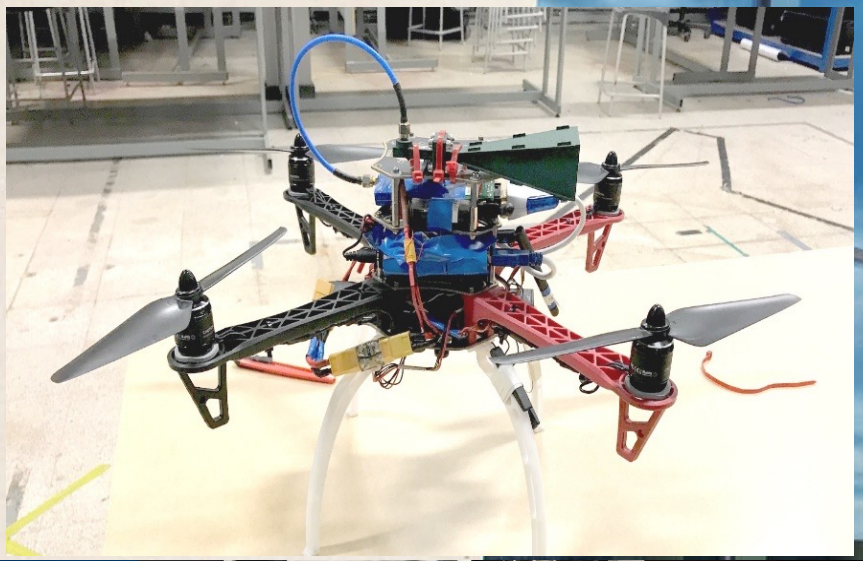
- Continuous cycles of monitoring and repair are vital to the economic development and functions of a community.
- This relates to critical infrastructure of all types in Energy, Transport, Civil and Water sectors.
- Inspection Maintenance and Repair are vital to ensure the safe operation of an asset or resource.
- Increasing demand and diversity in applications for non-destructive sensing mechanisms to provide detailed inspection.

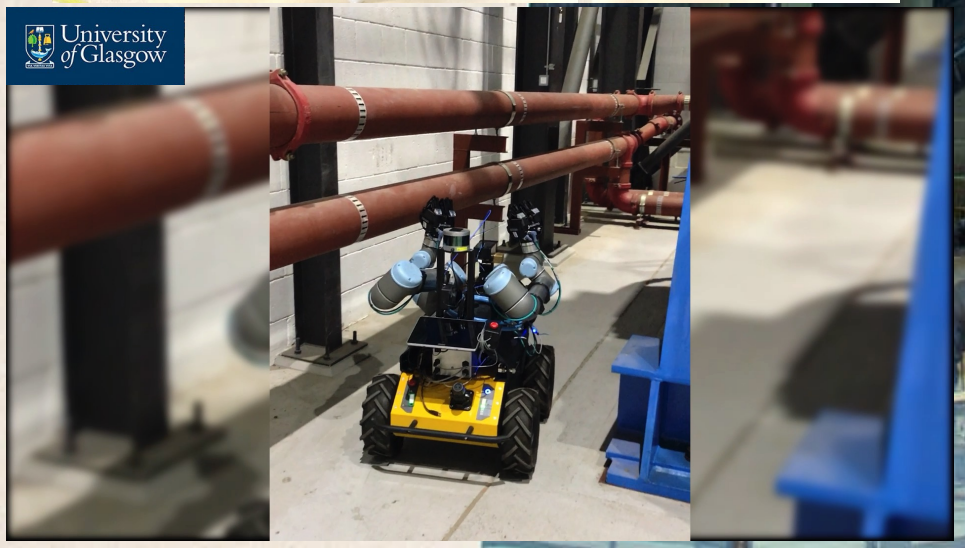
Challenge and Motivation

- **Increased number of Wind Turbine Blades**
  - Seagreen Wind Farm (Commissioned August 2022) (114 turbines)
    - Enough power for 1 million homes
    - Displace more than 2 million tonnes of CO_2 each year
- **Increased size of wind turbine blades**
  - Increased length of blades
  - Higher tower
  - Increased risk at working from height
- **Positioned further offshore**
  - More dynamic weather conditions

A review: Challenges and opportunities for artificial intelligence and robotics in the offshore wind sector- https://doi.org/10.1016/j.egyai.2022.100146

Millimeter-Wave Sensing



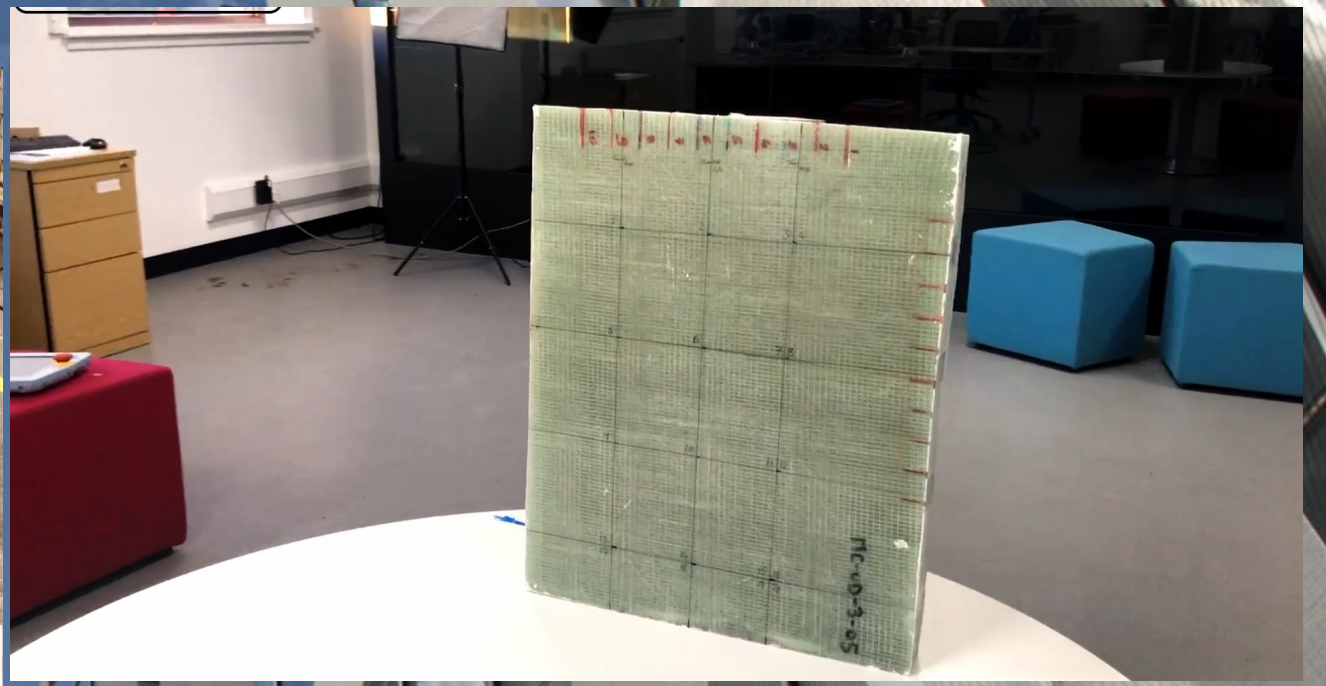


Key Advantages

- Low power
- Non-contact
- Non-Destructive
- Non-invasive
- High Sensitivity to water and porosity
- Real-time sensing
- Run-time front end analysis

Symbiotic System of Systems Design for Safe and Resilient Autonomous Robotics in Offshore Wind Farms
- https://ieeexplore.ieee.org/document/9558777

Case Study - Wind Turbine Blades



Machine Learning achieved 98.5% Classification Accuracy against healthy and uncured monolithic material

Machine Learning Analysis of Non-Destructive Evaluation Data from Radar Inspection of Wind Turbine- https://ieeexplore.ieee.org/document/9563264

Case Study – Decommissioned Wind Turbine Blade

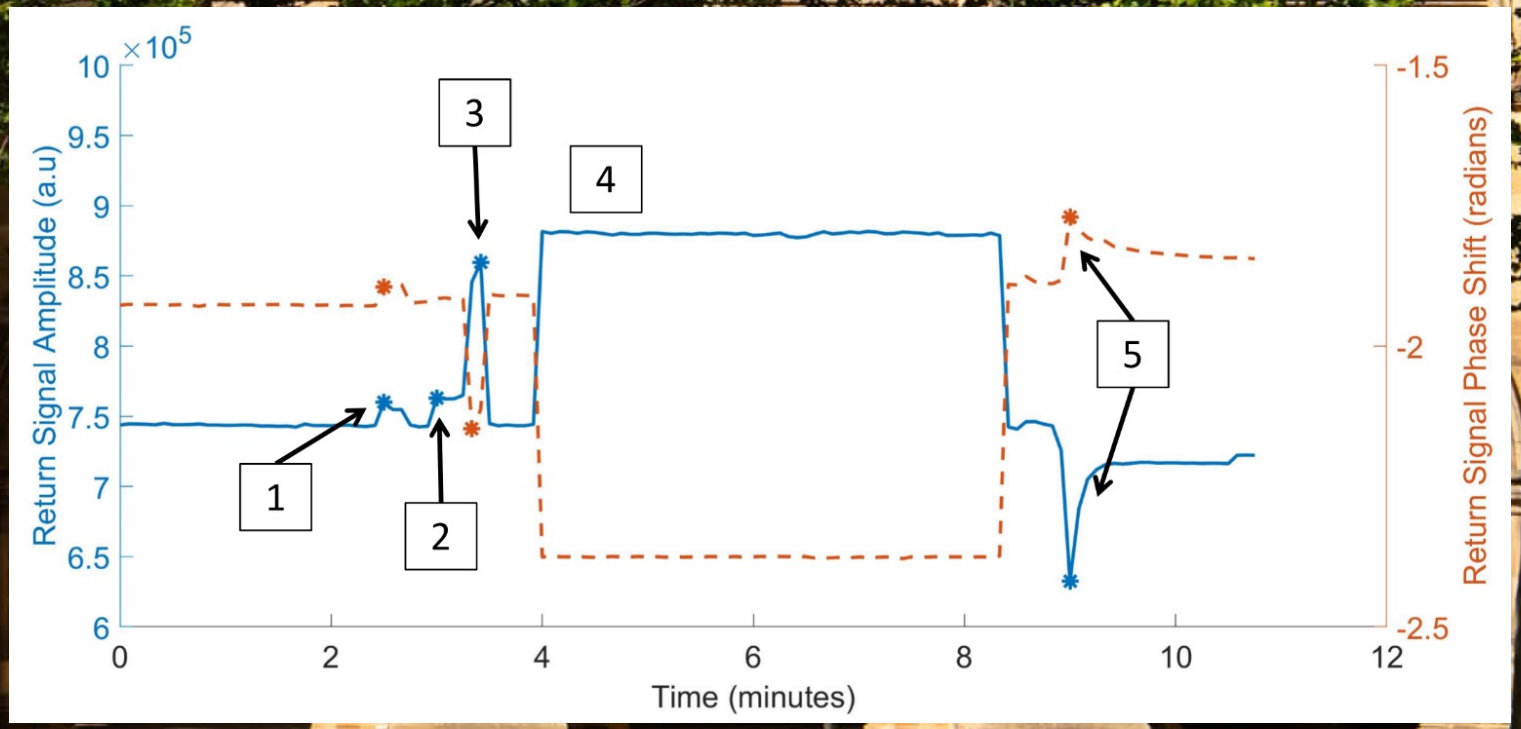
Fully decommissioned wind turbine blade

-Assess the sensitivity of the FMCW radar sensor to various properties present on the blade

-Assessment of how long it could take to complete an automated scan of a blade of this size

-Publication available soon

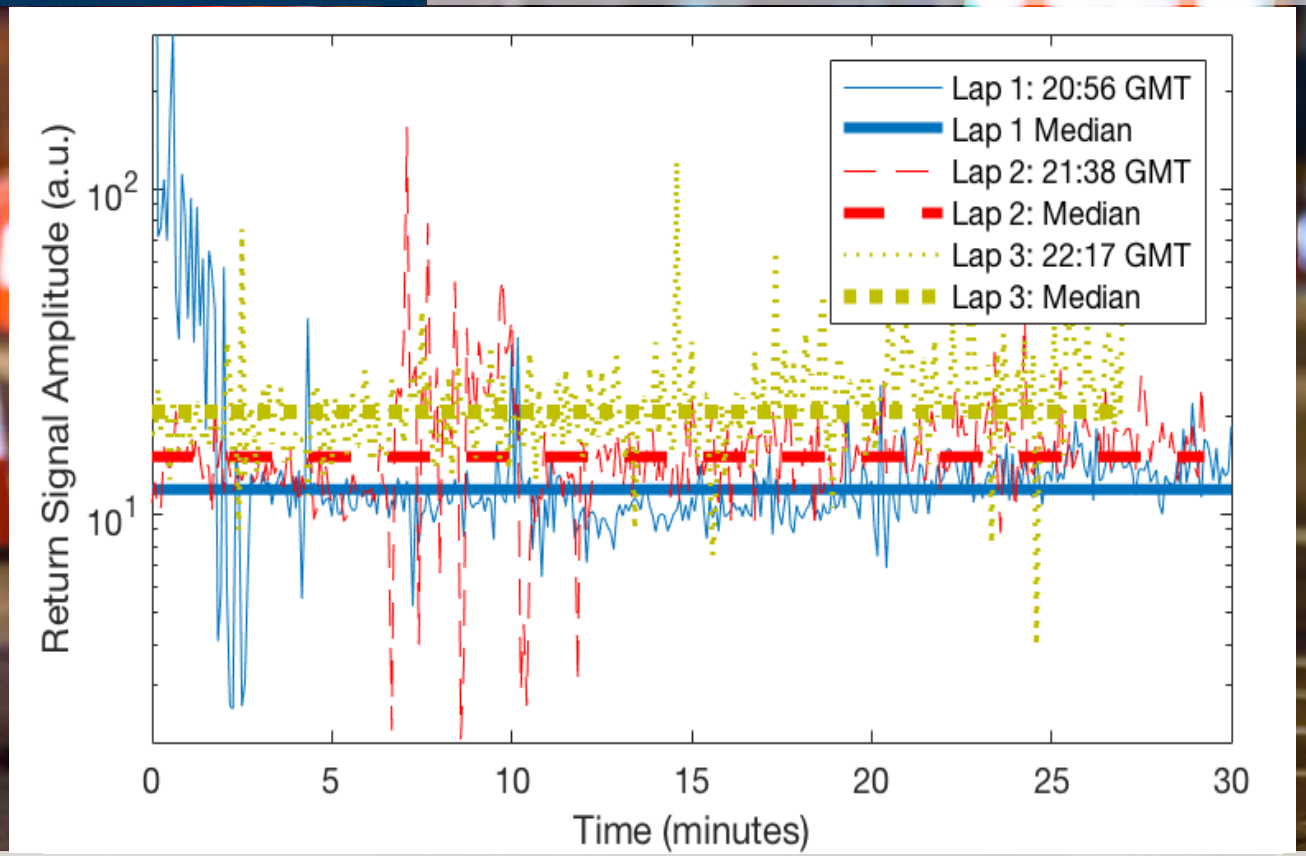
Case Study - Civil Infrastructure

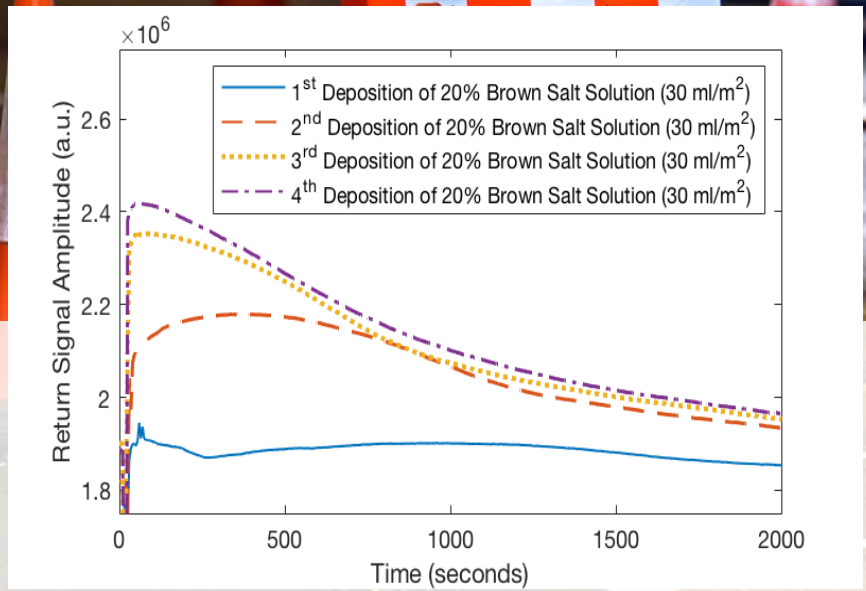


Return Signal Amplitude | Phase | Time of Flight | Real Permittivity | Water Presence | Metal Presence

An Evaluation of Millimeter-wave Radar Sensing for Civil Infrastructure- https://ieeexplore.ieee.org/document/9284883

Case Study – Salt and Road Surface Conditions





Key Metrics:

3 x ~30 minute night trials using circuitous route in Dundee

10g/m2 marine salt deposited during each trial

Run-Time Analysis of Road Surface Conditions Using Non-Contact Microwave Sensing

10.1109/GCAIoT51063.2020.9345917

Foresight Sensing - What is it?

Trust

Trust that an autonomous system will operate as intended

Training to ensure that an operator can maximise the effective deployment of autonomous systems

Resilience

The ability for an autonomous system to adapt to unforeseen circumstances and overcome barriers

Safety

The ability for an autonomous system to update safety compliance protocols

Safety compliance of robots and humans in shared workspaces

Increasing safety and resilience in robotic platforms and autonomous systems.

Layered approach to safety compliance.

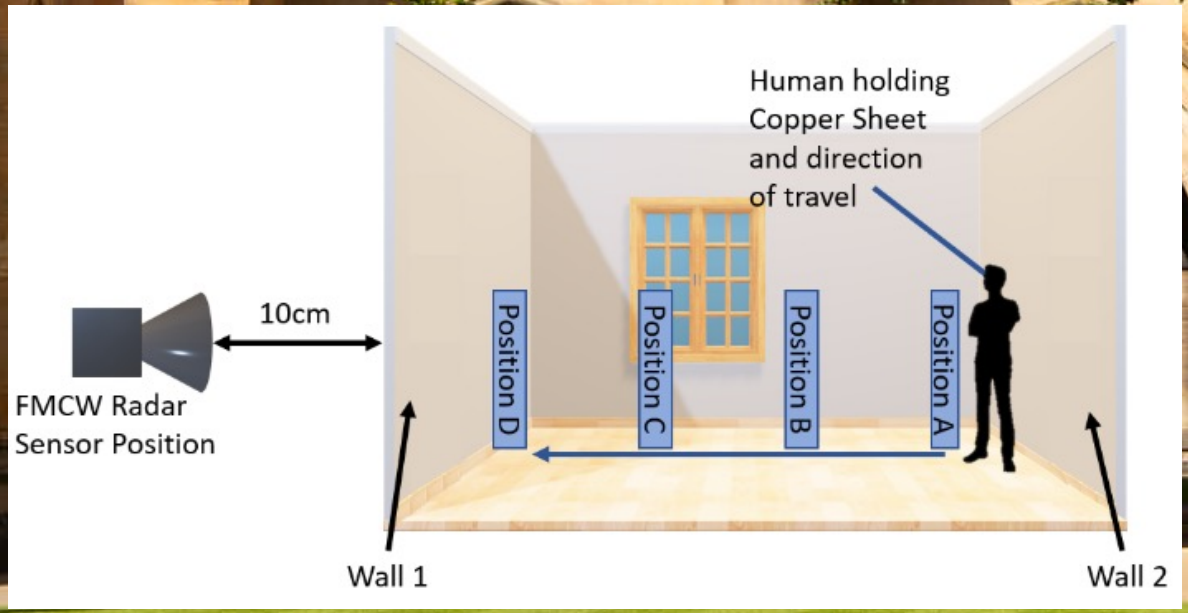
- No human in proximity- Full Speed
- Human in proximity- 50% speed
- Human in close proximity- Pause operations

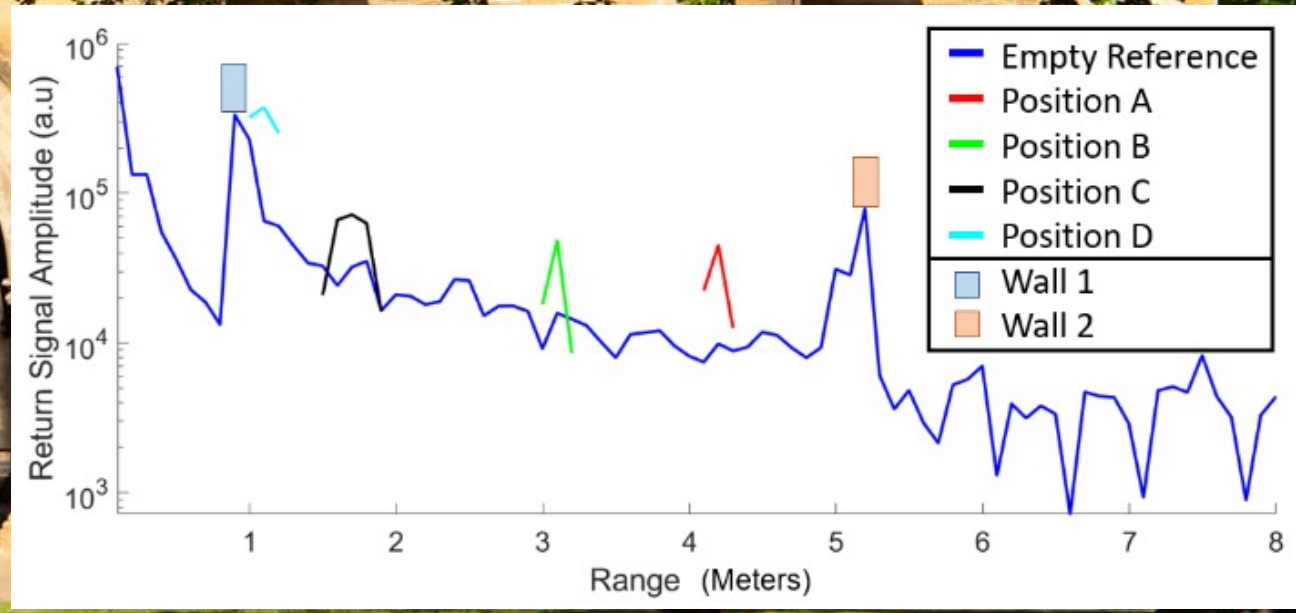
Privacy- Non-invasive approach.

-Ability to monitor from a distance. No optical line of sight required

-No direct contact required (range of 10's of meters)

Foresight Sensing – Through Wall



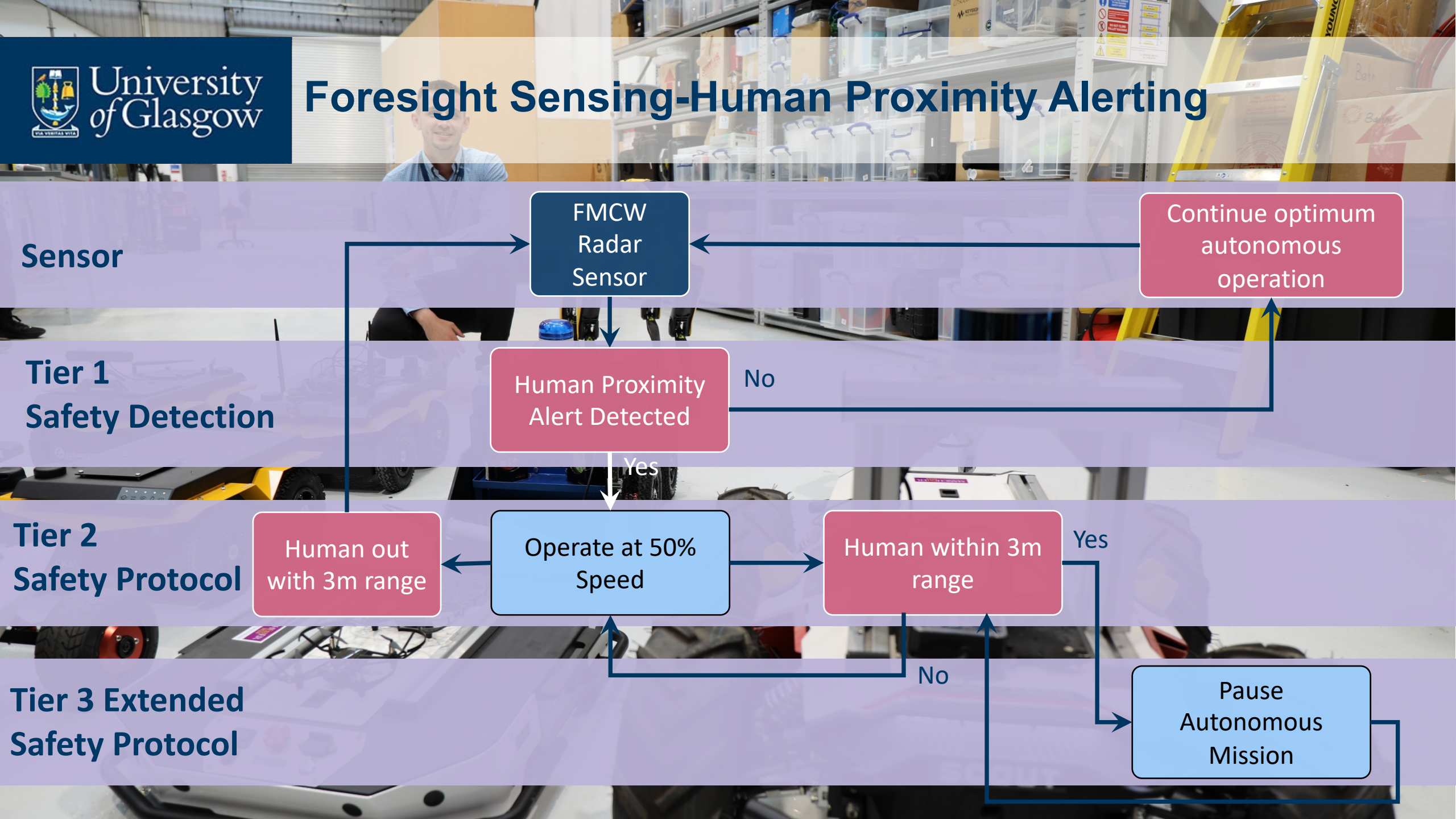


Foresight sensing

-To address concealed threats that are dynamic and are not within the immediate line of sight.

-If someone is walking into the room, we can detect ahead of time the point of entry

Foresight Sensing-Human Proximity Alerting



University of Glasgow

FOLLOW ME ON TIKTOK
@ROBOT_MYTHS

Mr. Daniel Mitchell- D.Mitchell.5@research.gla.ac.uk

LinkedIn https://www.linkedin.com/in/daniel-mitchell1/

YouTube Smart Systems Group
University of Glasgow

Mitchell *et. al.* 'Symbiotic System of Systems Design for Safe and Resilient Autonomous Robotics in Offshore Wind' Farms
doi: 10.1109/ACCESS.2021.3117727
IEEE Access
Multidisciplinary | Rapid Review | Open Access Journal

Machine Learning Analysis of Non-Destructive Evaluation Data from Radar Inspection of Wind Turbine Blades
doi: 10.1109/SDPC52933.2021.9563264 IEEE Xplore®

#UofGWorldChangers

@UofGlasgow