ORCA HUB

Offshore Robotics for Certification of Assets

Remote Safety and Integrity

Research in Robotics, Artificial Intelligence and Autonomous Systems for the Offshore Sector

About Us

The Offshore Robotics for the Certification of Assets (ORCA) Hub is a research programme developing Robotics, Artificial Intelligence and Autonomous Systems for the offshore sector.

We bring together five world-class universities and over 30 industry partners, who together, will revolutionise Asset Integrity Management for cheaper, safer and more efficient production.

We work with industry to develop technology in the field of Robotics, AI and Autonomous Systems, all the way through the Technology Readiness Level (TRL) scale. The Hub's mission is to translate research and discovery science into commercial products and services in order to support the UK offshore supply chain and make it the most productive in the world.

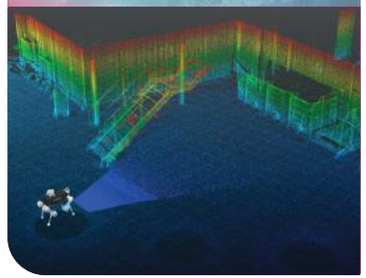
The ORCA Hub supports a long-term offshore industry vision for autonomous and semi-autonomous offshore energy fields; operated, inspected and maintained from shore.

Led by the Edinburgh Centre for Robotics (ECR), a joint-venture between Heriot-Watt University and the University of Edinburgh, the university partners are carrying out early-stage research and discovery science, with support from the industry partners.

An additional eight UK institutions joined the Hub in January 2020 as part of the ORCA Partnership Resource Fund. The nine research projects will expand the Hub's work into new areas with a clearly identified industrial need.

Research Themes

Mapping, Surveying and Inspection



Planning, Control and Manipulation

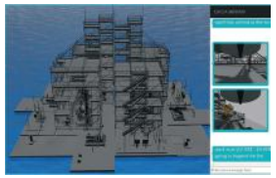
Intelligent Human-Robot Interaction

Robot and Asset Self-Certification

Technical Capabilities

Using Intelligent Interfaces to Reduce Cognitive Load

Human-Robot Learning by Demonstration

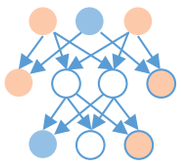


Mission Monitoring & In-Mission Goal Setting Using Natural Language

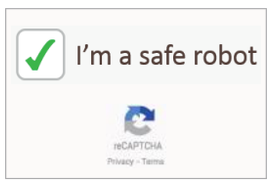
Robot Mission Planning and Situation Awareness

Asset & Robot Prognostic Health Management (PHM) with Digital Twin

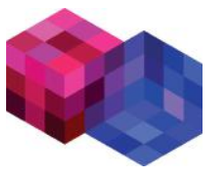
Hazardous Environment Autonomous Quadruped Robot Movement



Probabilistic Modelling of Robotic Systems



Verification & Validation of Autonomous Systems

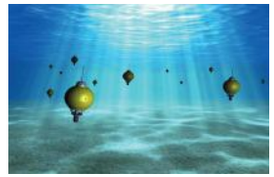


Robot Perception, Planning & Action

Methods for Human-Robot Interaction

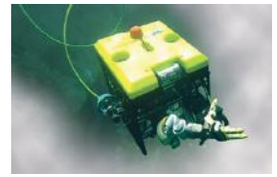
Using Simulation to Test & Validate Behaviour of Autonomous Systems

Autonomous Manipulation in Dynamic Environments

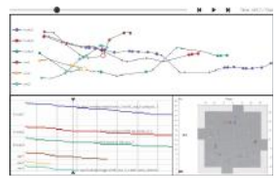


Smart Sensors and Robot Networks

Asset & Robot Anomaly Detection, Prediction Classification & Localisation



Subsea Autonomous Manipulation



Automated Mission Plan Visualisation

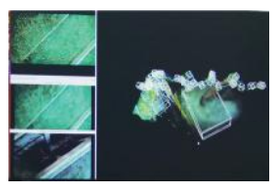
Verification & Certification of Deep Learning (for Autonomous Decision Making)

Autonomous Aerial Robot (UAV) Sensor Deployment

Navigation Methods for Autonomous Quadruped Robot Inspections

AUV Station Keeping in Dynamic Environments

Risk-Aware Shared Autonomy



3D Underwater Vision for Autonomous Inspection of Structures

Autonomous Aerial Robot (UAV) Infrastructure Perching

Visual & Language Robot Behaviour and AI Explanations

Academic Leads

Professor David Lane, PhD CBE FREng FRSE

The ORCA Hub Director, Professor David Lane PhD CBE FREng FRSE, is a passionate scientist, innovator & personal investor in the twin disciplines of Robotics & AI. A founding startup-to-scaleup award winning CEO (SeeByte Ltd/Inc Edinburgh, San Diego x23k investment multiple @exit) he is Chairman or NED in 5 businesses & 1 fund in the UK, Norway and Hong Kong. As Professor & Founding Director he co-created the Edinburgh Centre for Robotics and National Robotarium, a £120m research and translation hub with around 150 staff and PhD students. He has published over 300 peer reviewed papers engineering advanced cognition, sensing & bioinspiration into unmanned systems. His entrepreneurship has been recognised through the 2011 Praxis Unico Business Impact Achieved Award, the 2013 Scottish Digital Technology Award for International Growth (SeeByte), the 2018 Guardian University Business Collaboration Award (ORCA Hub) and the 2019 Scottish Knowledge Exchange Champion Award. He is co-chair of the UK Government Robotics Growth Partnership appointed by the Minister of State for Universities, Science, Research and Innovation and a member of the UK AI Council. He led the 2014 UK RAS2020 Robotics & Autonomous Systems Strategy generating > £500M of UK government & industry support for the sector which so far has led to x10 £250M VC investment in UK robotics businesses in 2017/18. His first job in the offshore industry in 1979 was as diver/maintainer with Vickers Oceanics (now Subsea7) operating Pisces manned submersibles, before moving to Ferranti Ltd (now Leonardo) as Development Engineer for the first generations of helmet mounted displays.

Professor Sethu Vijayakumar, PhD FRSE

Professor Sethu Vijayakumar FRSE is Deputy Director of ORCA Hub. He holds a Personal Chair in Robotics within the School of Informatics at the University of Edinburgh and is the Director of the Edinburgh Centre for Robotics and co-Programme Director of AI for The Alan Turing Institute. Since 2007, he holds the Senior Research Fellowship of the Royal Academy of Engineering, co-funded by Microsoft Research and is also an Adjunct Faculty of the University of Southern California (USC), Los Angeles and a Visiting Research Scientist at the ATR Computational Neuroscience Labs, Kyoto-Japan. He has a PhD (1998) in Computer Science and Engineering from the Tokyo Institute of Technology.

His research interest spans a broad interdisciplinary curriculum involving basic research in the fields of robotics, statistical machine learning, motor control, planning and optimization in autonomous systems and computational neuroscience. His latest project (2016) involves a collaboration with NASA Johnson Space Centre on the Valkyrie humanoid robot being prepared for unmanned robotic pre-deployment missions to Mars.

Professor Yvan Petillot, PhD

Mapping Surveying and Inspection

Professor Yvan Petillot leads our work in Mapping, Surveying and Inspection. He is a Professor of Robotics and Computer Vision at Heriot-Watt University, a leading member of the Oceans Systems Laboratory, Deputy Director of the Institute for Sensor Signals and Systems and Deputy Director of the joint research institute in Signal and Image Processing (ERP-SIP) with the University of Edinburgh.

Yvan specialises in robotics and sensing and is an expert in autonomous systems, image analysis and control applied to the subsea domain. With over 15 years experience in Robotics, Image Processing and Autonomous Systems in the maritime domain, he has made significant contributions to target detection and classification, multiple vehicle collaboration, and autonomous inspection and manipulation. He is the deputy director of the UK Defence Research Centre in Signal Processing and has extensive experience in subsea localisation and mapping.

Dr. Michael Mistry, PhD

Planning, Control and Manipulation

Dr. Michael Mistry leads our research in Planning, Control and Manipulation. He is a Reader in Robotics within the School of Informatics at the University of Edinburgh and Co-Director of the recently renewed £18m CDT in Robotics and Autonomous Systems (CDT-RAS) led by The Edinburgh Centre for Robotics (ECR). The funding from EPSRC and industry will train 90 PhD students - in five cohorts - over the next eight years. Research will focus on safety and safe interaction between robots, people and their environments.

Michael's past work covers a variety of locomotion over challenging terrain and autonomous robotics systems with a particular focus on the humanoids. His current research focuses on issues relevant to dexterous movement in both humans and humanoid robots, including redundancy resolution and inverse kinematics, operational space control and manipulation, stochastic optimal control and internal model learning and control, particularly in environmental contact. His current work within the Edinburgh Centre for Robotics involves the control of dynamic behaviours of humanoids.

Academic Leads

Professor Helen Hastie PhD

Intelligent Human-Robot Interaction with Explainable AI

Professor Helen Hastie leads the research in Human-Robot Interaction with Explainable AI. She is a Professor of Computer Science at the School of Mathematical and Computer Sciences at Heriot-Watt University and is a Leverhulme/RAEng Senior Research Fellow.

Helen is an international expert on interactive systems and human-robot interaction (HRI), working on methods for natural communication between users and systems through speech and gesture. She has over 20 years of experience in designing, building and evaluating multimodal and HRI systems, focusing on data-driven techniques and working both in academia and industry.

Professor Hastie is also the Director for the recently renewed EPSRC Centre for Doctoral Training in Robotics and Autonomous Systems (CDT-RAS) at The Edinburgh Centre for Robotics (ECR).

Professor David Flynn, PhD

Robot and Asset Self-Certification

Professor David Flynn leads the research looking at Robot and Asset Self-Certification. He is a Professor in the School of Engineering & Physical Sciences at Heriot-Watt University where he also founded the Smart Systems Group (SSG) whose activities involve multidisciplinary expertise in sensor technologies, manufacturing and embedded intelligence to create Smart Systems.

David is also Eminent Overseas Professor of Nagasaki University, a founder and Associate Director of the EPSRC National Centre for Energy System Integration and Deputy Director of the EPSRC Centre for Doctoral Training in Embedded Intelligence.

His expertise is in the research and development of novel sensors and intelligent sensor systems which he has applied to broad field of applications including energy, medical, offshore assets and environmental monitoring.

Academic Co-Investigators

In addition to our lead academics, we have a strong group of world-class Co-Investigators who lead teams of Post Doctoral Research Associates, delivering key research within each of our Research Themes. We have over 60 academics and researchers carrying out research within the Hub, all working towards making Asset Integrity Management cheaper, safer and more efficient.

Research Theme Profile: Mapping, Surveying and Inspection

The ORCA Hub is carrying out exciting research to develop vision, mapping, localization and sensing capabilities in marine, topside and air environments so that autonomous robotic systems can understand, navigate and interact with and around assets in hazardous offshore locations.

This research aims to aid the development of tools which will enable robots to accurately map and understand offshore environments and assess and inspect offshore structures. This includes navigating within their environment, locating specific structures or features of interest and inspecting these features if and when required.

Research areas include:

- Smart sensors and robot Internet of Things (IoT)
- Ultrasonic Electromagnetic Acoustic Transducer (EMAT) and Non-Destructive Evaluation (NDE) sensor development
- Multi-robot surveying
- Subsea vision and sonar based motion estimation and 3D reconstruction
- Navigation techniques for GPS-denied environments

Research Theme Profile: Planning, Control and Manipulation

ORCA Hub research is addressing the challenges in planning and executing efficient, localizable and repeatable motion of robotic platforms in marine, topside and air environments for autonomous sensor placement, manipulation and intervention in extreme and dynamic conditions.

Offshore robotic asset management and self-certification requires systematic information gathering through proactive and reactive sensor deployment.

The Planning, Control and Manipulation team will address the challenges involved in sensor placement, manipulation and intervention in extreme and dynamic conditions. Specific emphasis is placed on failure prediction, re-planning and recovery strategies.

Research areas include:

- Planning and control approaches of autonomous vehicles
- Mission failure prediction, reactive re-planning and recovery strategies
- Autonomous manipulation and placement of sensors
- Controllability and station-keeping of autonomous vehicles
- Risk-aware shared autonomy

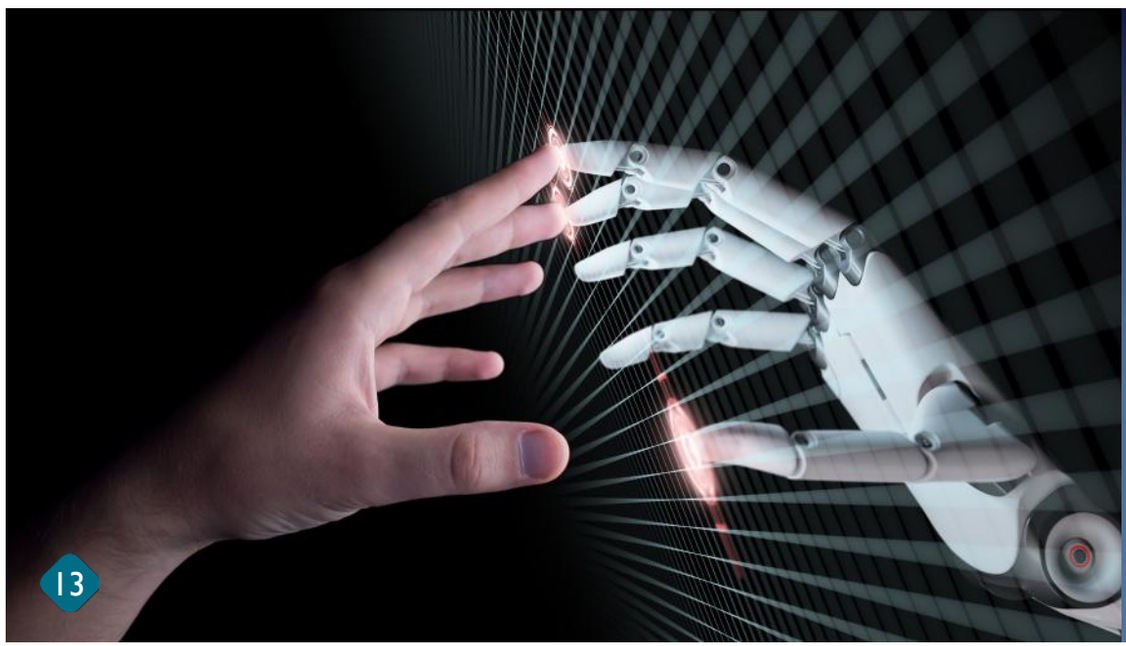
Research Theme Profile: Human-Robot Interaction with Explainable AI

There is currently a communication barrier between robots and the operator with regard to perceived world views and reasoning behind system actions and plan failures. This is particularly problematic in remote, highly challenging and hazardous environments involving multiple vehicles and/or platforms. This lack of transparency can lead to a reduction in trust and situation awareness, thereby hindering the true human-machine teaming and resulting in unnecessary aborts and/or laborious manual manipulation of the assets.

The Intelligent Human-Robot Interaction team are developing interaction techniques that support joint human-machine decision-making, maintaining the appropriate level of human situational awareness during human-robot teamed missions and explaining important aspects of Robotics & Artificial Intelligence (RAI) transparency.

Research areas include:

- Building trust between humans & robot teams
- Methods for human-robot interaction
- Using intelligent interfaces to reduce cognitive load
- Robot perception, planning and action
- Visual & language robot behaviour and AI explanations
- Human-robot task learning (activity model recognition)
- Automated plan visualisation



Research Theme Profile: Robot and Asset Self-Certification

A major obstacle for adopting Robotics & Artificial Intelligence (RAI) for certification is the need to assure systems in terms of their safe operations.

While safety and certification procedures have a track record for traditional industrial assets, current regulatory frameworks do not effectively address the technologies used in RAI systems. This is especially true for self-adaptive or self-learning systems, which optimise their behaviour using Artificial Intelligence and Machine Learning techniques.

Working with our industrial partners as well as regulators, the ORCA Hub is designing RAI systems that can diagnose faults, self-certify and guarantee their safe operation.

Research areas include:

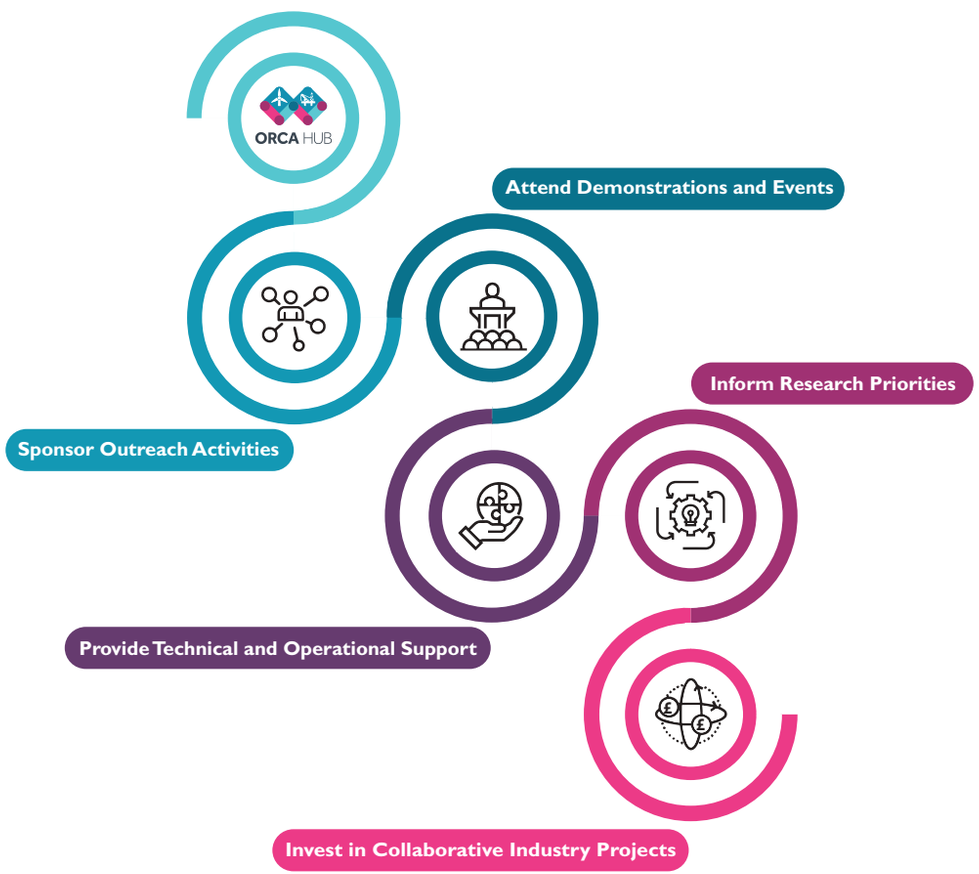
- Asset and robot anomaly detection, prediction, classification and localisation
- Verification and certification of deep learning (for autonomous decision making)
- Using simulation to validate and test the behaviour of autonomous systems in hazardous environments
- Asset and robot Prognostic Health Management (PHM)
- Reliability modelling of robots
- Probabilistic mission planning
- Probabilistic modelling of robotic systems

Engaging with ORCA Hub

The engagement between ORCA Hub academics, companies and organisations is vital to the success of our mission.

The ORCA Hub relies on industry working with our university partners to shape, mould and direct our research so that it provides the foundations on which new and ground-breaking technology in the offshore industry can be built.

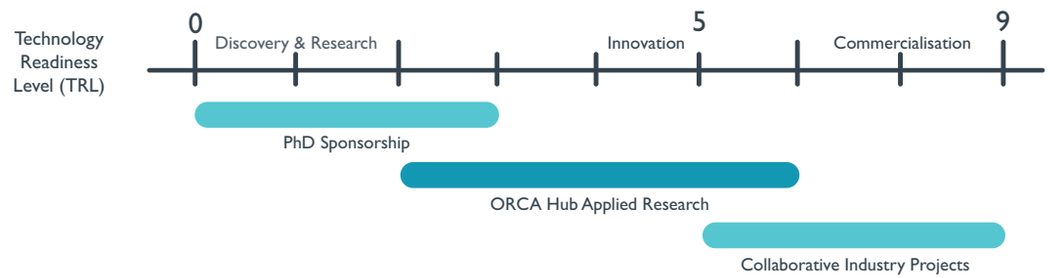
If the work being carried out within the Hub could improve your business by providing technological advancements that could make your business safer, cleaner, more efficient, more productive and/or more cost effective, we encourage you to engage with us and our work.



Industry driven use cases are the bridge that connects our research to the offshore market. They are the operational challenges that cause downtime, unsafe working and inefficiencies.

In order to solve the problems that matter most to industry, we need use cases that our research can solve.

We encourage any company working in the offshore environment to tell us about your challenges so we can work together to solve them.



The most effective form of engagement is to become actively involved in the translation of our research. By engaging directly with us in a project we will work collaboratively together to transition ORCA Hub applied research into your organisation.

In doing so, you will gain access to early stage technology that could benefit your business and differentiate you from your peers.

Have a use case or challenge you think we can work together to solve? Follow the process below.

1. Review

Review our research areas, capabilities and expertise that could support solving your use case/challenge.

2. Engage

Engage to discuss methods of solving the use case / challenge collaboratively.

3. Develop

Jointly develop a work scope around the use case / challenge, to include information such as:

- **Scope of work**
- **Development road map and timeline**
- **Goals and outcomes**
- **Resources and funding required**

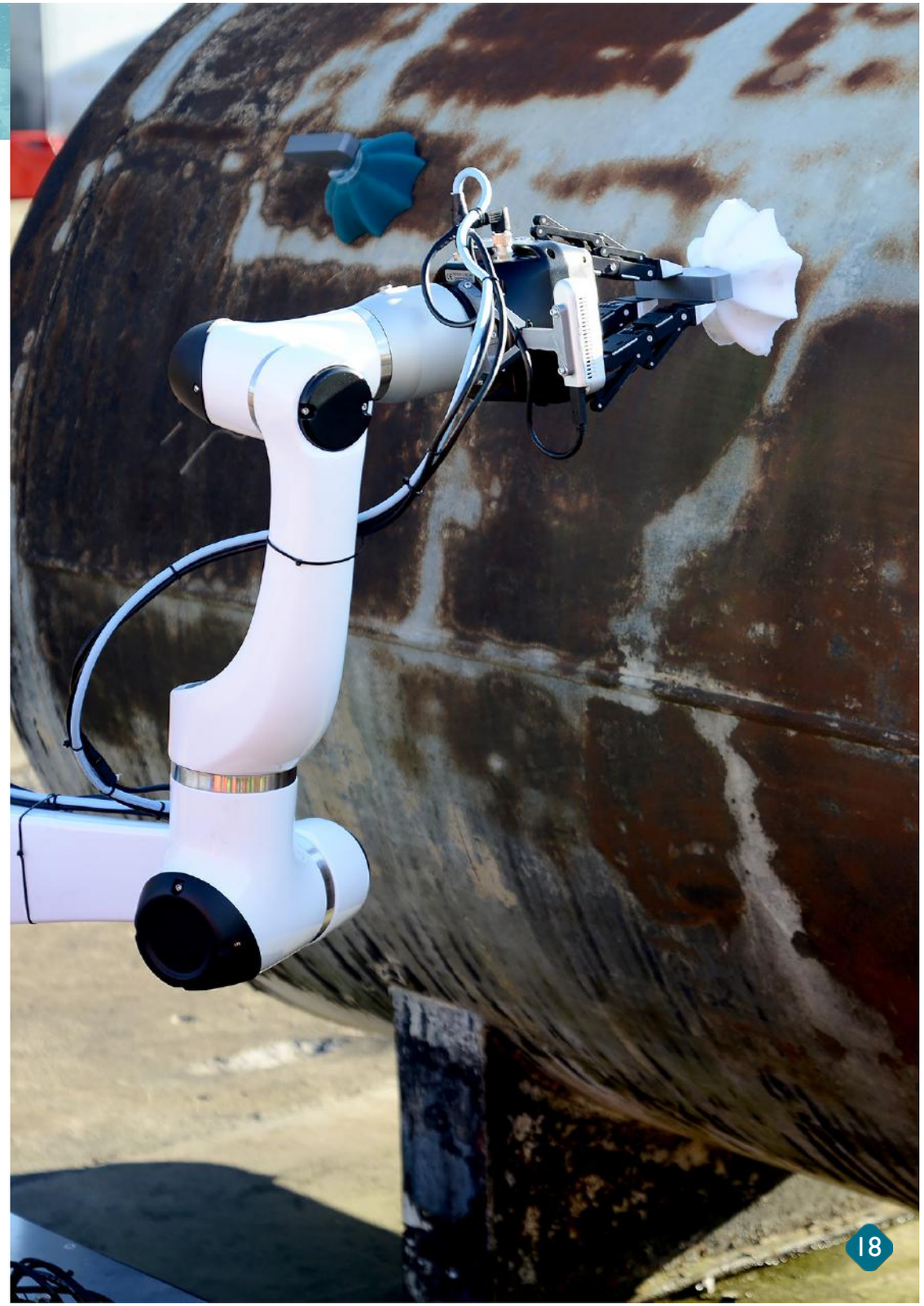
4. Execute

Agree terms and IP, and work collaboratively on an Industry Project.

ORCA Hub Partners

The ORCA Hub has a number of partners at each layer of the supply chain that provide input from all those that could benefit from our research. Some of our current partner are shown below. If you would like to become a partner, get in touch to find out how.

CENSIS
cybernetix A TechnipFMC Company
EDF ENERGY
GUIDED ULTRASONICS LTD.
HYDRASON solutions
i-Tech7
Kawasaki Powering your potential
KUKA
L3 ASV
Lloyd's Register
OGIC Oil & Gas Innovation Centre
The Oil & Gas Technology Centre
ROVCO OCEAN INSIGHT
ROVOP
IHC
SCHUNK
seebyte
SPRINT ROBOTICS
SUBSEA UK
TEXO DRONE
THARSUS
THE DATA LAB value from data
TOTAL
Tritech
wood.



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Prof. David M Lane, CBE FREng FRSE
Heriot-Watt University
ORCA Hub Director

Prof. Sethu Vijayakumar, FRSE
University of Edinburgh
ORCA Hub Deputy Director

Dr. Lindsay Wilson
ORCA Hub Manager
E: Lindsay.Wilson@hw.ac.uk
T: +44 (0)131 451 8253
M: +44 (0)7779 982 134

David Wavell
ORCA Hub Business Development
E: D.Wavell@hw.ac.uk
T: +44 (0)131 451 8200
M: +44 (0)7717 779 417

ORCAHub.org
ORCAHub@hw.ac.uk

@ORCA_Hub
ORCA Hub