Acacia Systems

Sovereign Deep Tech Capability Company

ACACIA SYSTEMS

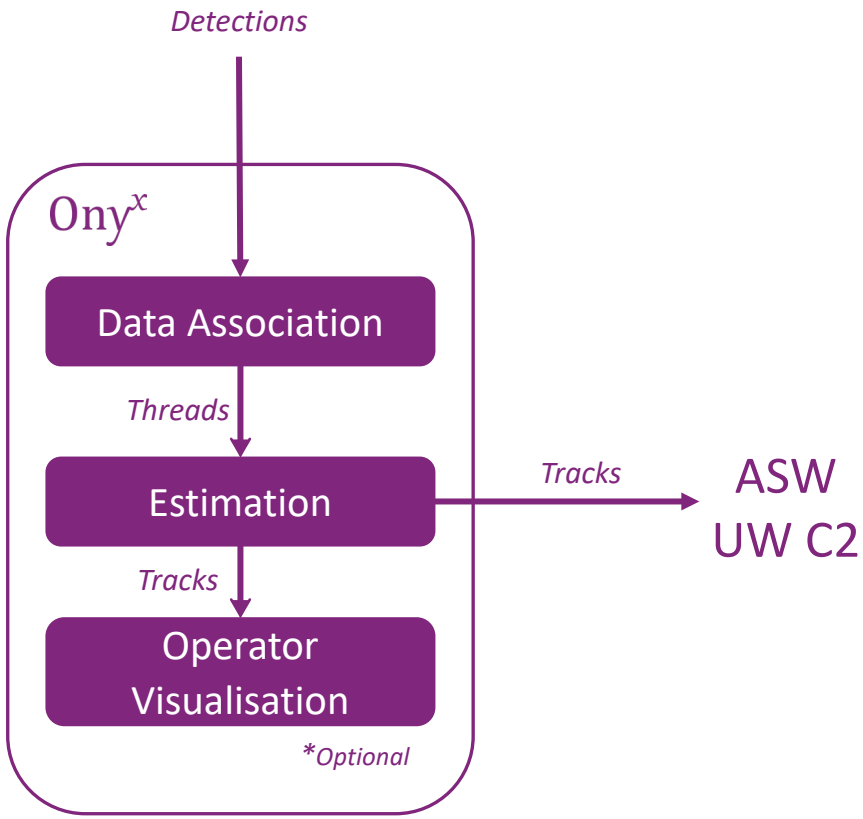
Ony^{x}

Cross Sensor and Cross Platform Automatic Target Detection, Tracking and Localisation

What is Ony^x ?

Key Features

- Increases detection ranges and reduces time to a firing solution.
- Sensor vendor agnostic
- Sensor type agnostic
- Designed for many sensors in any geometric scenario



Ony^x Single Platform Deployments

RAN Air Warfare Destroyer (Ultra Electronics' Integrated Sonar System)
RN Type 23 Sonar Upgrade (Ultra Electronics’ Sonar 2150)
RN Type 26 (first 3 ships) (Ultra Electronics’ Sonar 2150)
Allied submarine passive sonar system (Atlas)

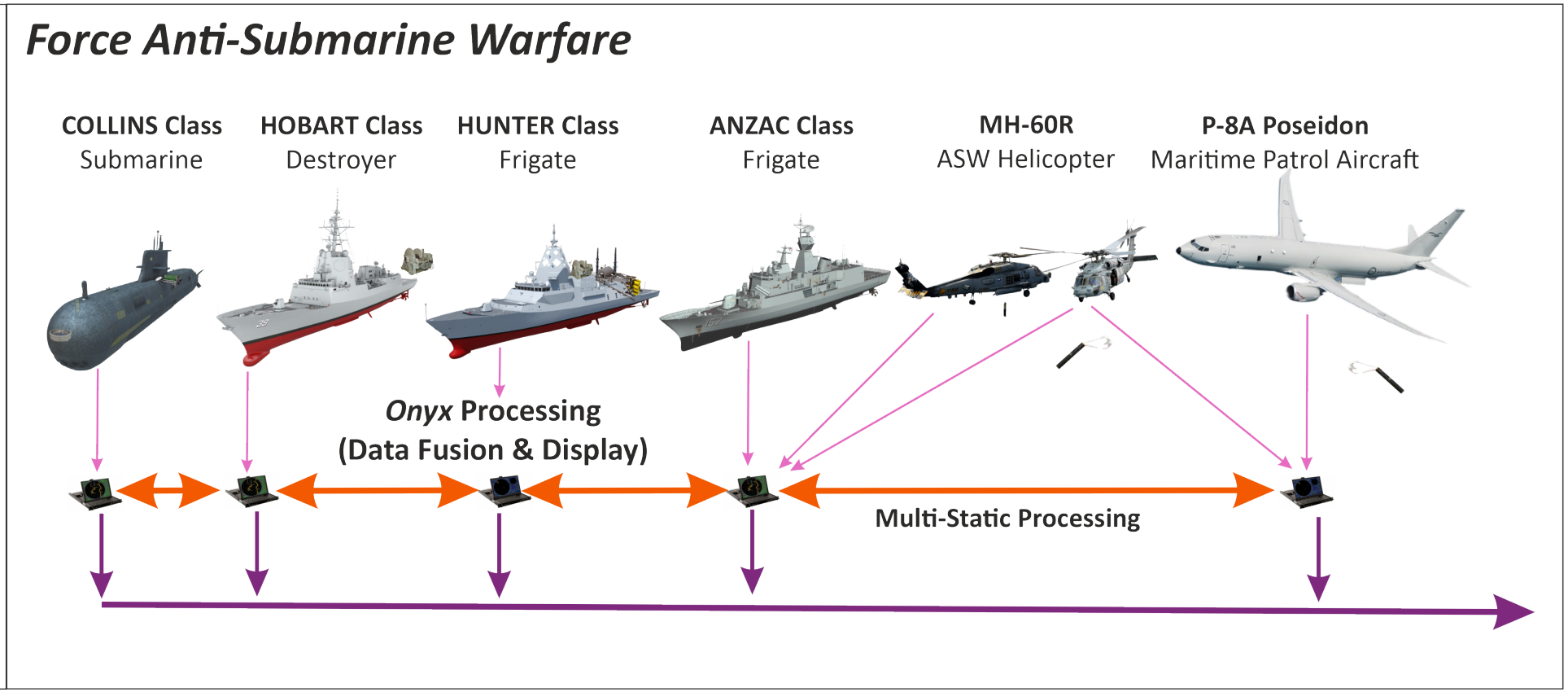
Cross Platform Fusion

Task Group Level Data Fusion (Operational Level)

Onyx Fuses sensor data at the Task Group level to deliver higher probability of detection, increased range of detection and increased tracking accuracy. This allows detection to be made at the Task Group where individual platforms may be unable to form a track.

Onyx increases the performance of sensors across the Task Group by combining their detections as if all sensors were local (multi-statics).

Onyx provides the architectural framework for the distribution of data between sensors and platforms via nodes.

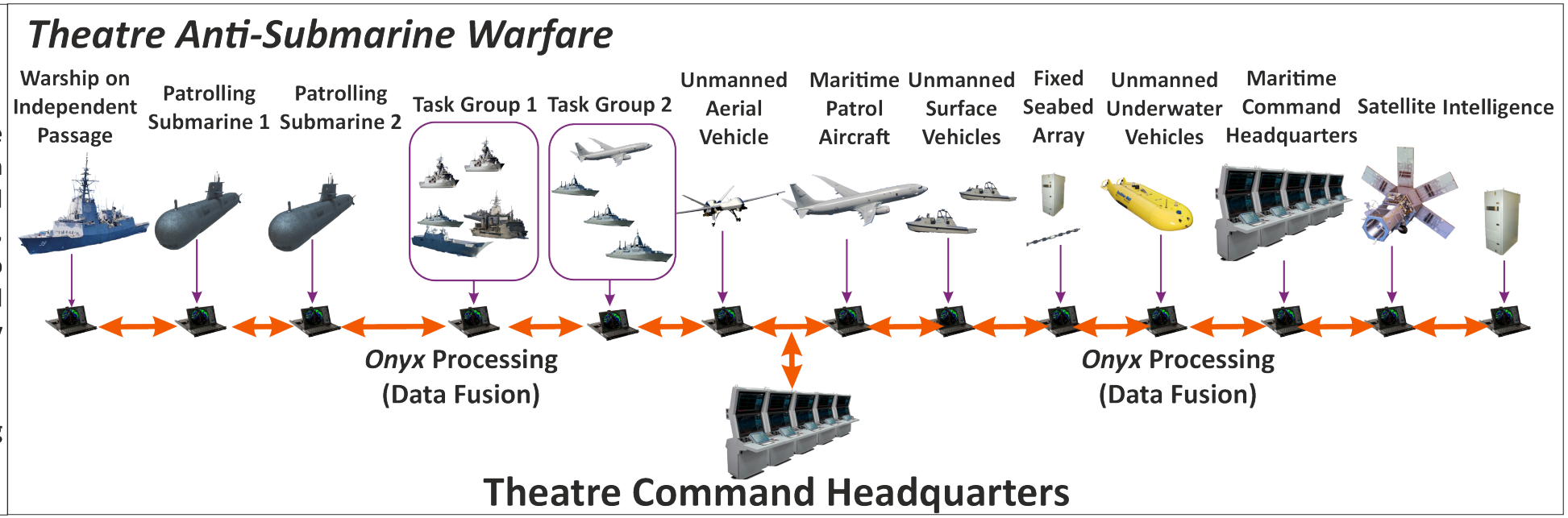


Cross Theatre Undersea Warfare

Theatre Level Data Fusion (Strategic Level)

Onyx **combines and displays data at the Theatre Command level to deliver a coherent and accurate picture of all strategic assets and the data they hold, allowing the Theatre Commander to make earlier and more informed decisions as to where best to deploy assets.**

Onyx **increases the decision-making ability of the Theatre Commander.**

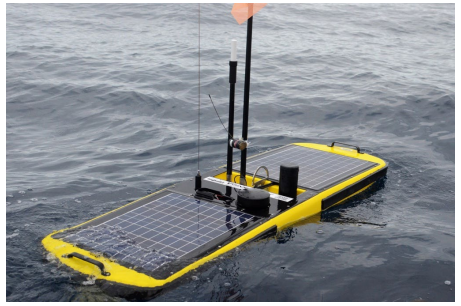


ACACIA SYSTEMS

Ony^x

Uncrewed Surface Vehicle Implementation

Uncrewed Surface Vehicles (USV)
Anti Submarine Warfare Trials August 2022

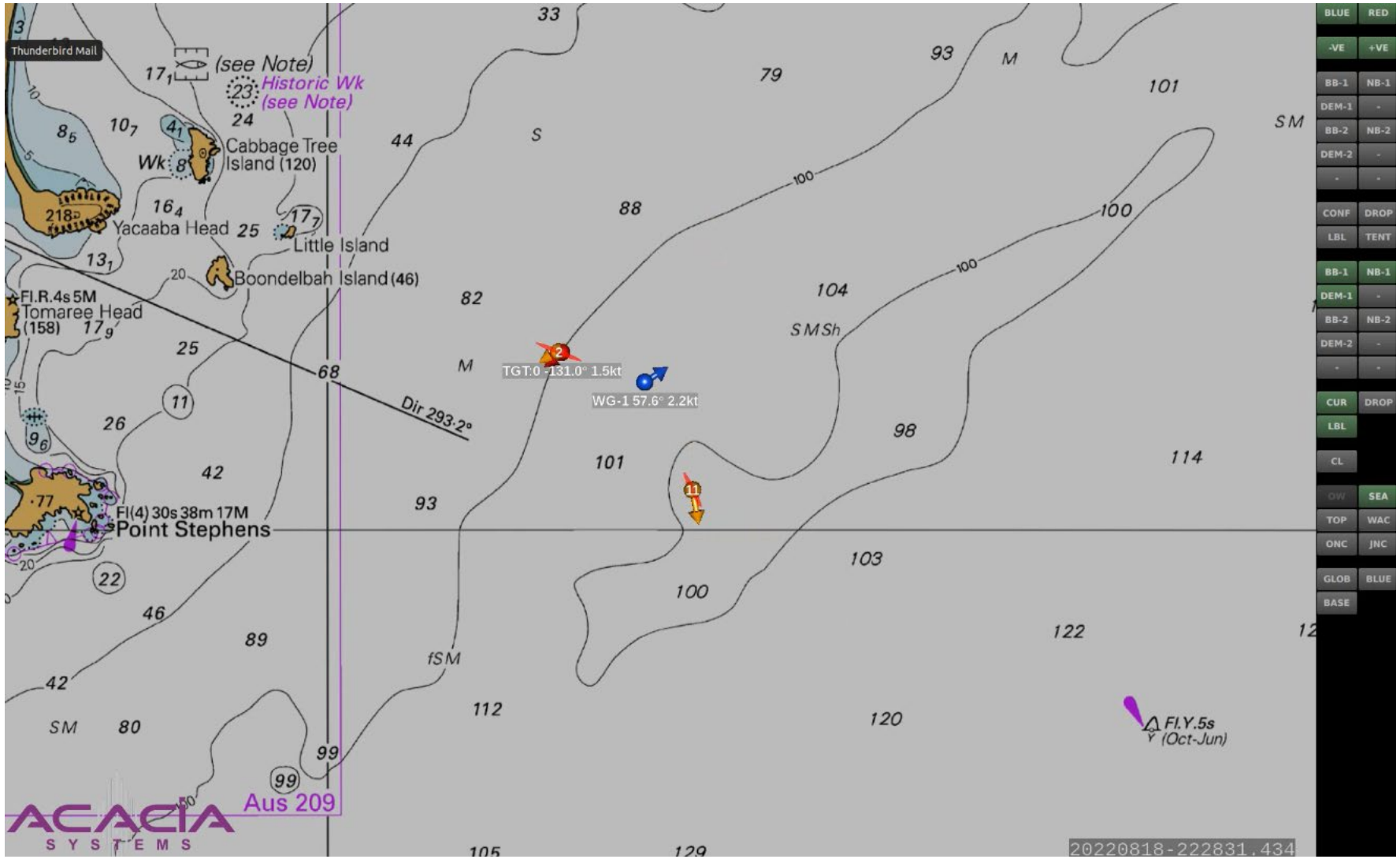


Waveglider uncrewed surface vessel

Atlas sonar processor & SEA thin line towed array

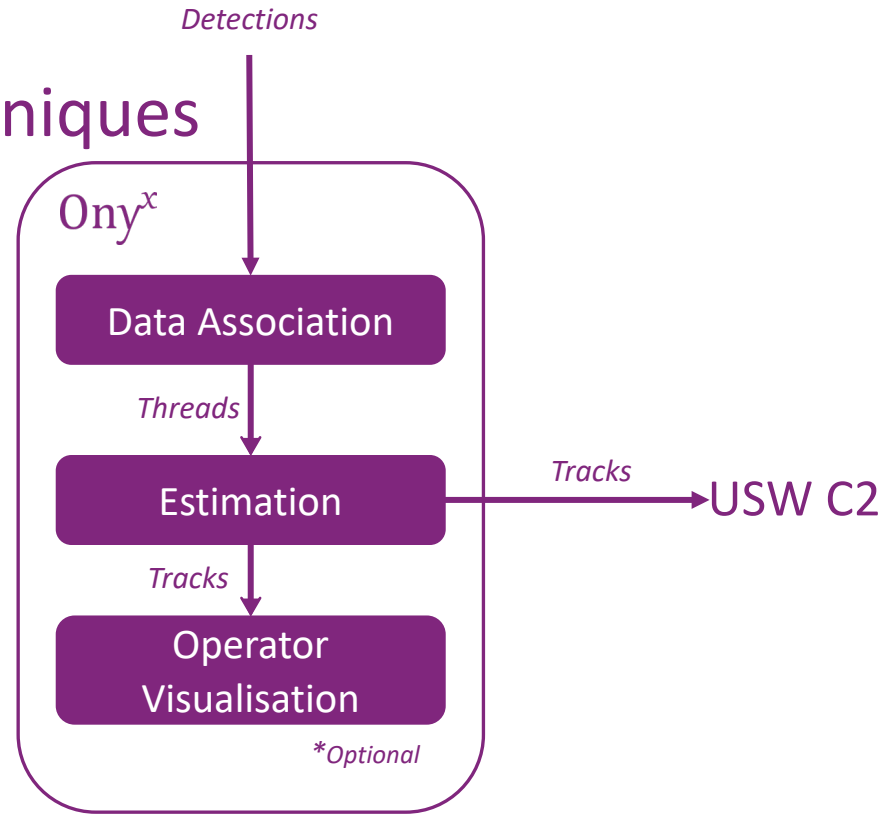
Ony^{x} Automatic target detect, track and localisation

Sea Trials


Thunderbird Mail
(see Note)
Historic Wk
(see Note)
Cabbage Tree
Island (120)
Yacaaba Head
Little Island
Boondelbah Island (46)
Fl.R.4s 5M
Tomaree Head
(158)
Dir 293·2°
Fl(4) 30s 38m 17M
Point Stephens
TGT:0 -131.0° 1.5kt
WG-1 57.6° 2.2kt
Fl.Y.5s
(Oct-Jun)
Aus 209
20220818-222831.434
BLUE
RED
-VE
+VE
BB-1
NB-1
DEM-1
BB-2
NB-2
DEM-2
CONF
DROP
LBL
TENT
CUR
CL
SEA
TOP
WAC
ONC
JNC
GLOB
BASE

Partners we are looking for

- Enhanced data association and estimation techniques
- Acoustic classification
- Anything else that can help



ESPY OCEAN

ESPY EARTH

Activator Proposal

Capabilities

Experts in satellite data analysis:

ESPY OCEAN

- Marine Vessel Detection - Dark vessels (no electronic signature)
- Detection & identification of pelagic fish schools

ESPY EARTH

- Terrestrial & Agricultural Monitoring
- Longitudinal Methane Monitoring
- Biodiversity Mapping & Weed Detection Research

QUANTUM OF PHYSICS

- Education for the Space Future

Your presenter - Ian Dewey

- Physical oceanographer, pure mathematician
- Satellite image analysis with RANRL in Pyrmont, Sydney
- Mathematical modelling with the Shell Company
- ASW with DSTO (Seahawk, P3, FFG)
- Mathematical modelling with ANL (shipping line)
- Co-founder and CEO of ESpy Ocean
- Currently completing a Masters in the AI prediction of Great White Shark movements
- Finalist in the 2021 Space industry awards, Innovator of the Year category.

Capabilities

- ESpy has a suite of multispectral image analysis algorithms that can detect and analyse dark vessels.
- ESpy have been working on wake analysis for a number of years with Fisheries NSW

Proposed Research Team

ESpy Ocean

Ian Dewey
- Team lead
- Physical oceanographer, programmer

Jill Dewey
- Project Manager
- 20 years expertise

Ruby Holman
- Analyst
- Physicist

TBA
- Analyst
- Physicist

SAAB

Nathaniel Shearer

TBA

Adelaide Uni

Molly Hennekam
- Drone Manager
- Director URAF

Bertram Ostendorf
- Image analysis support
- Associate Professor

Flinders University

Maria Parappilly
- Physics/technology support
- Professor

Other Key Expertise

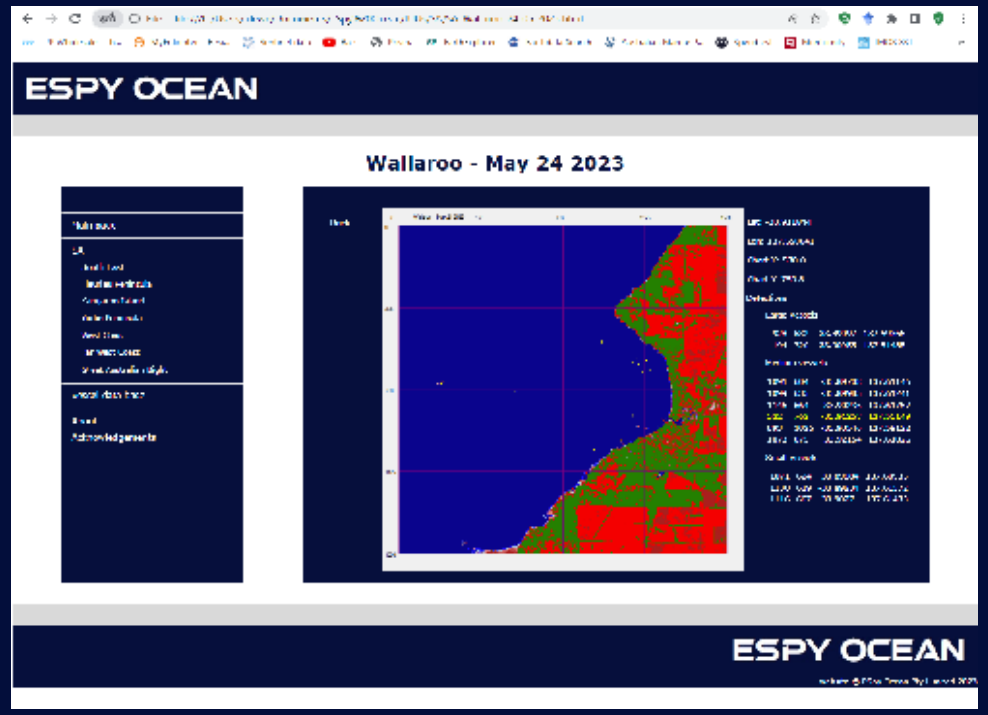
Sampson Hollywood
- Sea trials manager

Jiuyong Li
- AI Support
- Professor (UniSA)

Developments

Since last DIP round

- ESpy now have an in-house AI vessel analysis tool
- Ongoing project development internationally



Background

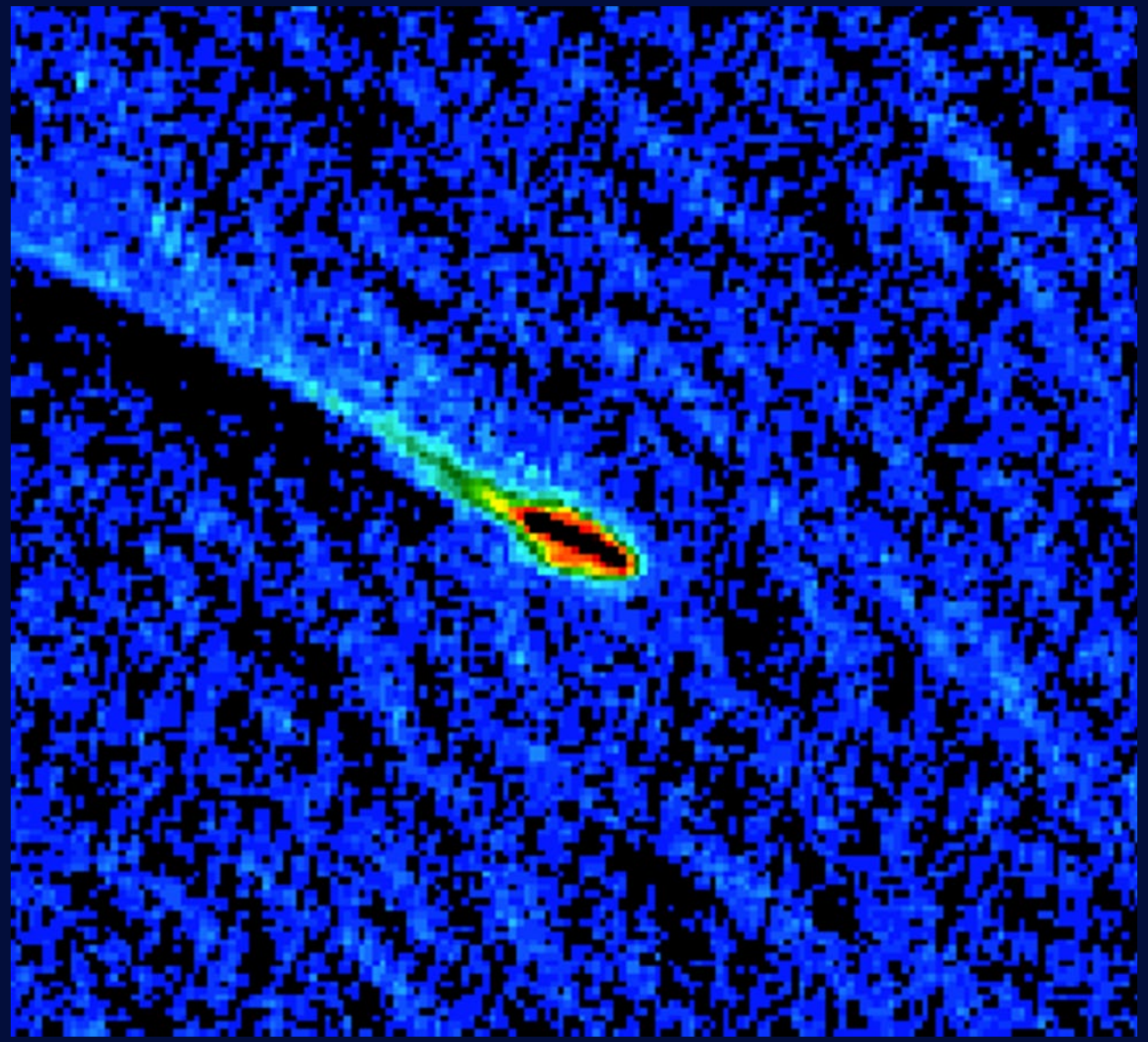
- ESpy Ocean can find dark vessels through the analysis of anomalies in multispectral images (patented)
- ESpy have been analysing wakes for 12 months
- ESpy can classify vessels and determine their movements based on wake structure

Future

- ESpy is ready to partner for large area detection and analysis

Thank you

Questions?



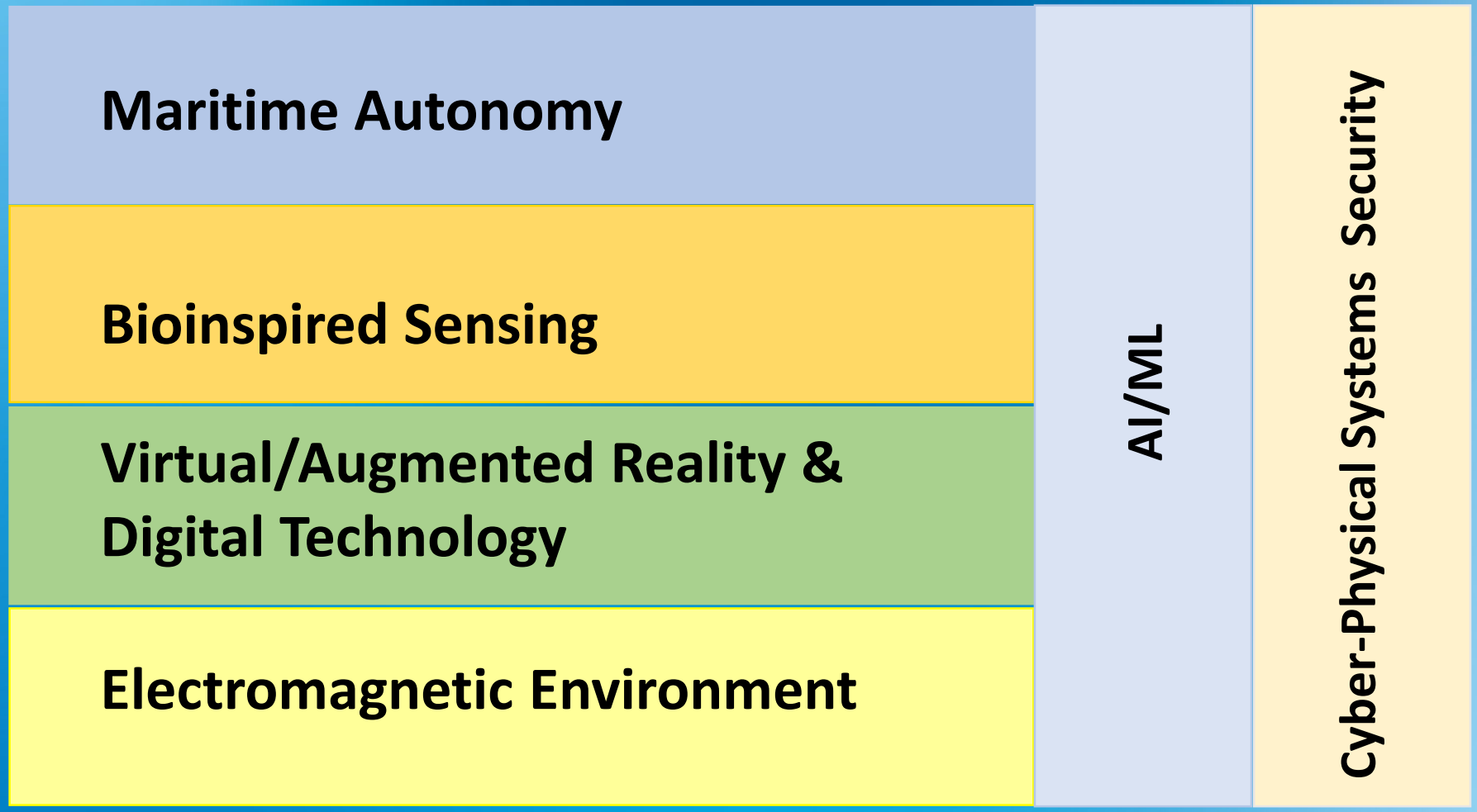
Flinders UNIVERSITY

Centre for Defence Engineering Research & Training

Prof Karl Sammut
(karl.Sammut@flinders.edu.au)

Flinders University | Centre for Defence Engineering Research & Training

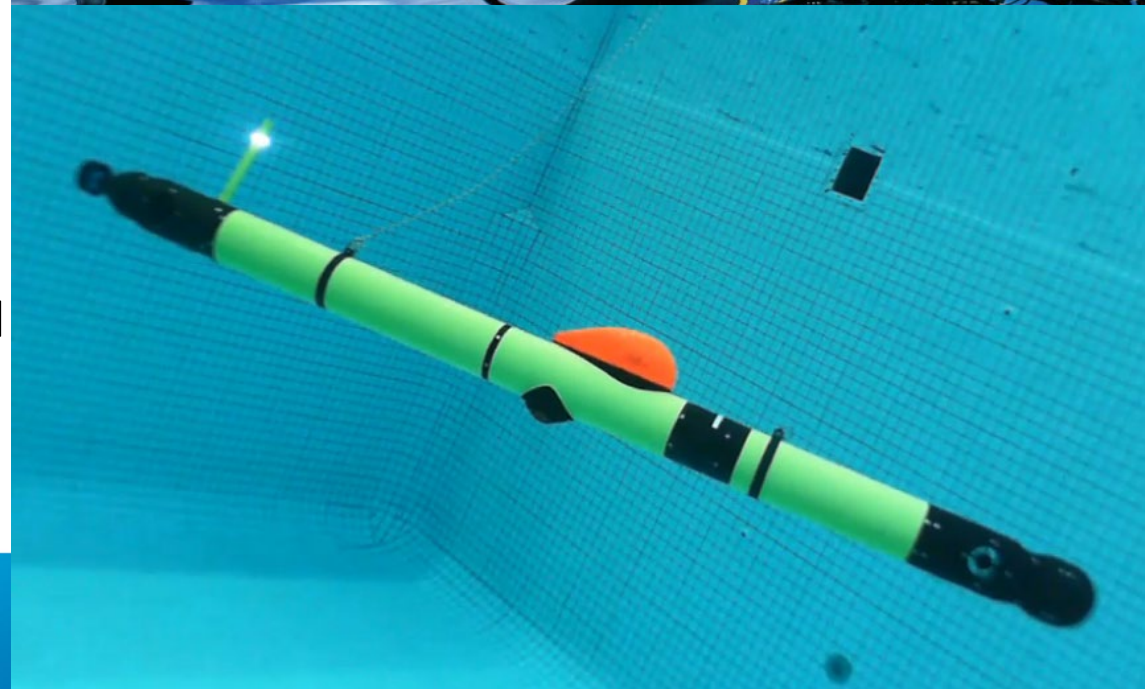
12 Academic staff
5 Postdocs
16 Ph.Ds



Maritime Autonomy

Expertise: CDERT provides advanced scientific and engineering research and development capability for developing autonomy and specialised hardware for UUVs and USVs. Research strengths include

- Developing algorithms and frameworks for enabling effective collaboration, competition, and communication among multiple agents
- Enhancing Trusted Autonomy by providing explanations for agent decisions and behaviours, enabling operators to understand their intentions, reasoning, and learned policies
- autonomous decision-making using multi-objective optimization
- ML based control systems for robust control to unmodelled dynamics and fault tolerance to actuator/platform failure
- acoustic/optical signal processing to enhance object detection and classification in turbid environments



Maritime Autonomy Applications Areas

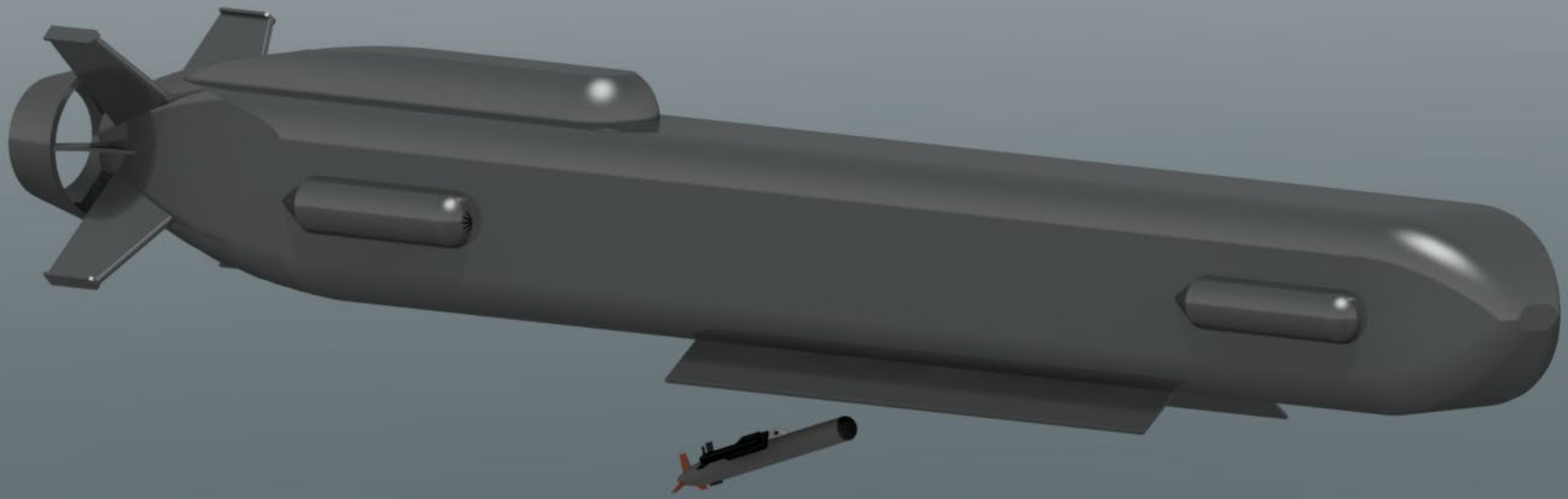
Uncrewed Underwater Vehicles

- Undersea inspection vehicles, including hovering UUVs for ship hull and subsea platform inspection and seabed crawler vehicles for mine counter measure operations in the surf zone.
- Autonomous launch and recovery systems and guidance algorithms for XLUUV, and submarine TTLR.
- Autonomous guidance systems for underwater docking with static/towed docking stations.

Uncrewed Surface Vessels

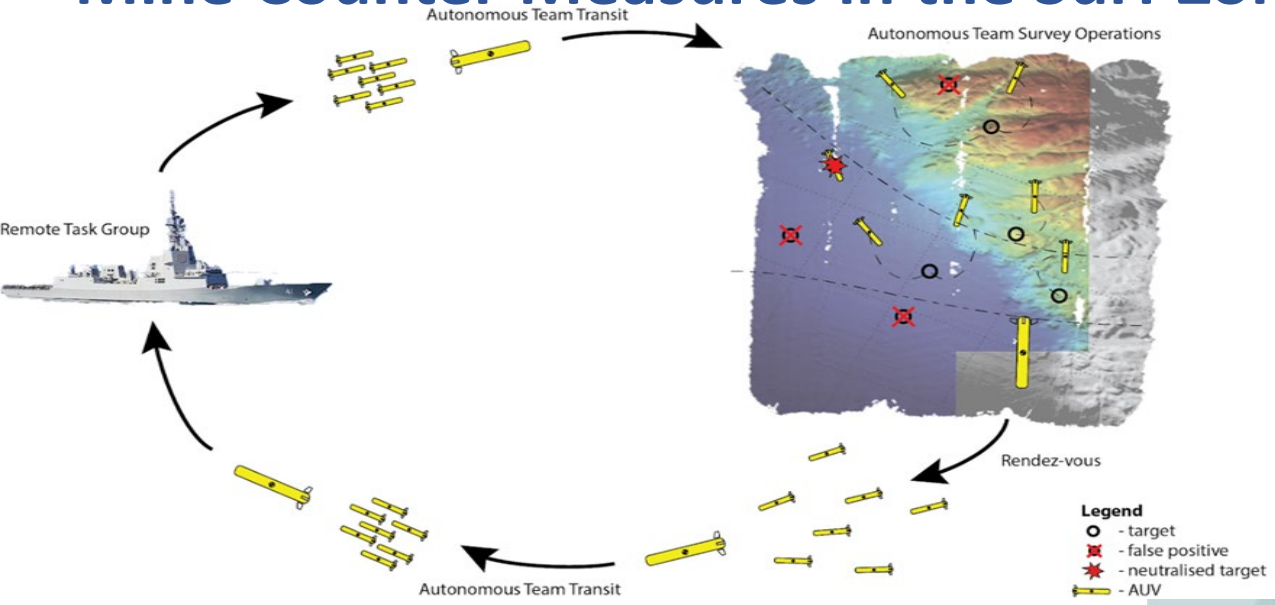
- ColRegs compliance for USVs operating in proximity to other manned/uncrewed vessels.
- Mission planning and coverage scanning for harbour/coastal surveys.

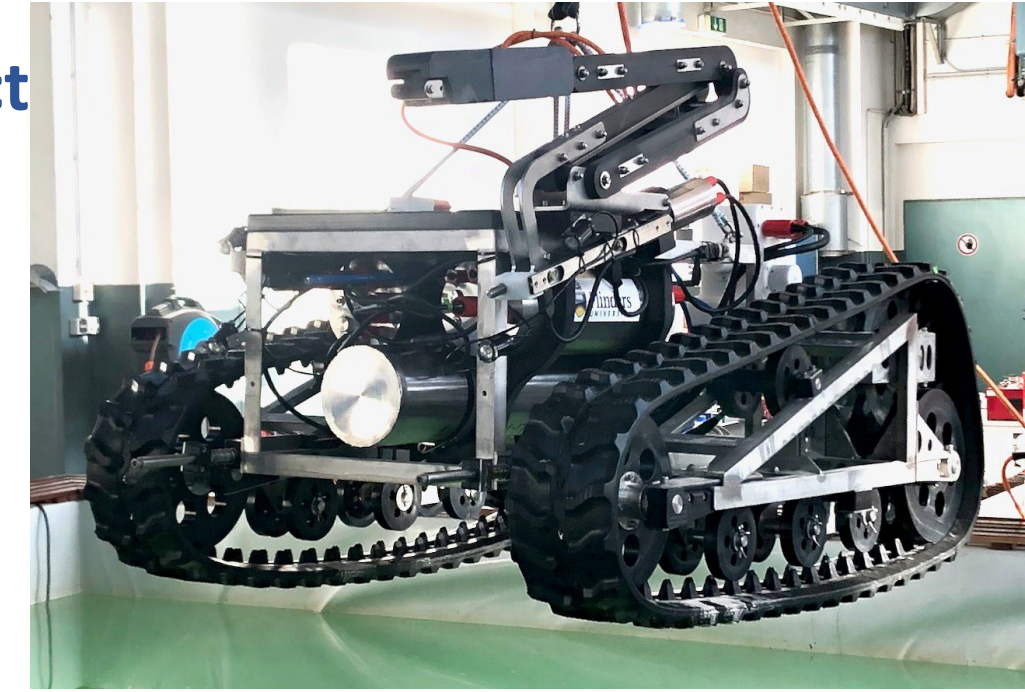
UUV Autonomous Launch and Recovery Systems for XLUUV



Research Activities – Development of machine learning based approximation of turbulent flow fields around XLUUV/submarine mothership for safe berthing of underwater vehicles

Mine Counter Measures in the Surf Zone Project





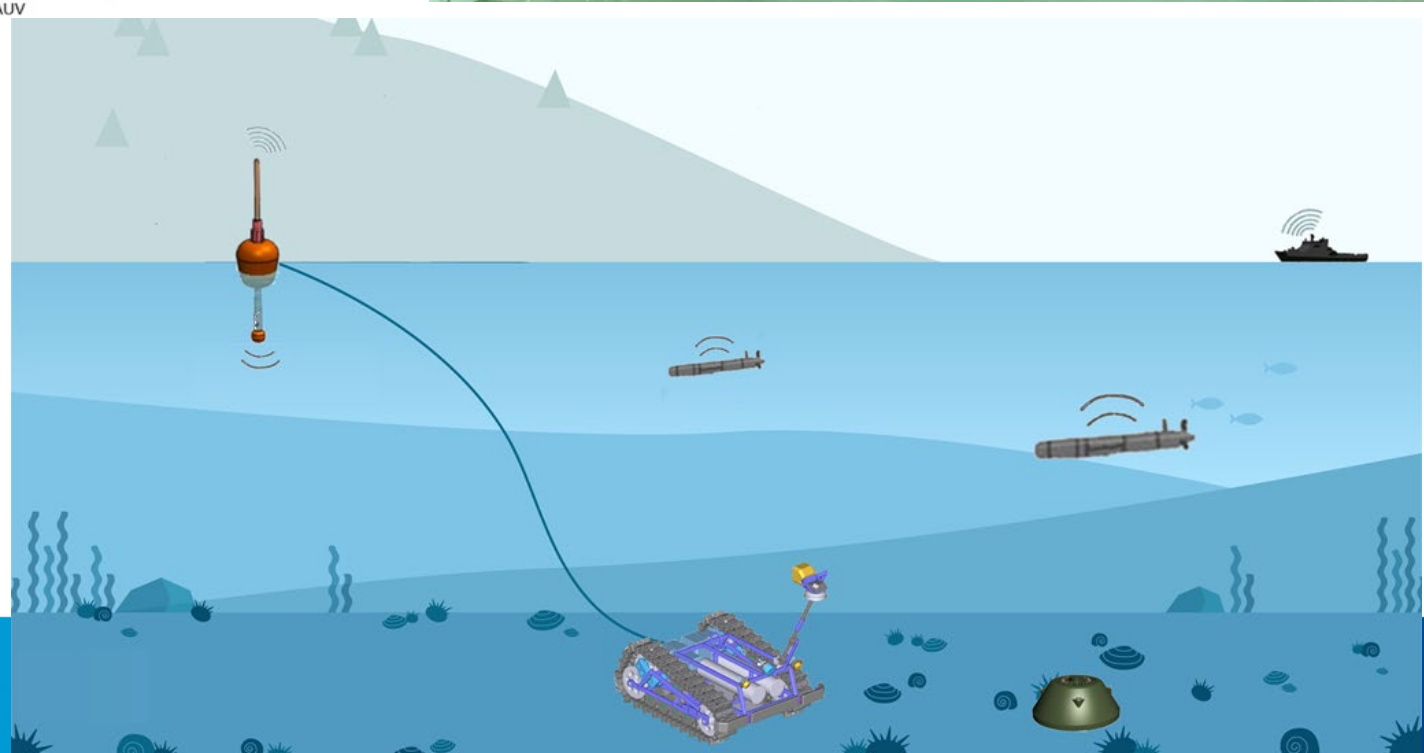
Amphibious landing zone mine clearance using heterogenous teams of underwater robots rather than mine clearance divers.

TRUSTED AUTONOMOUS SYSTEMS
DEFENCE CRC

Mission Systems · ineni · Australian Government Department of Defence Science and Technology

Flinders University · The University of Sydney

Western Sydney University · UTS



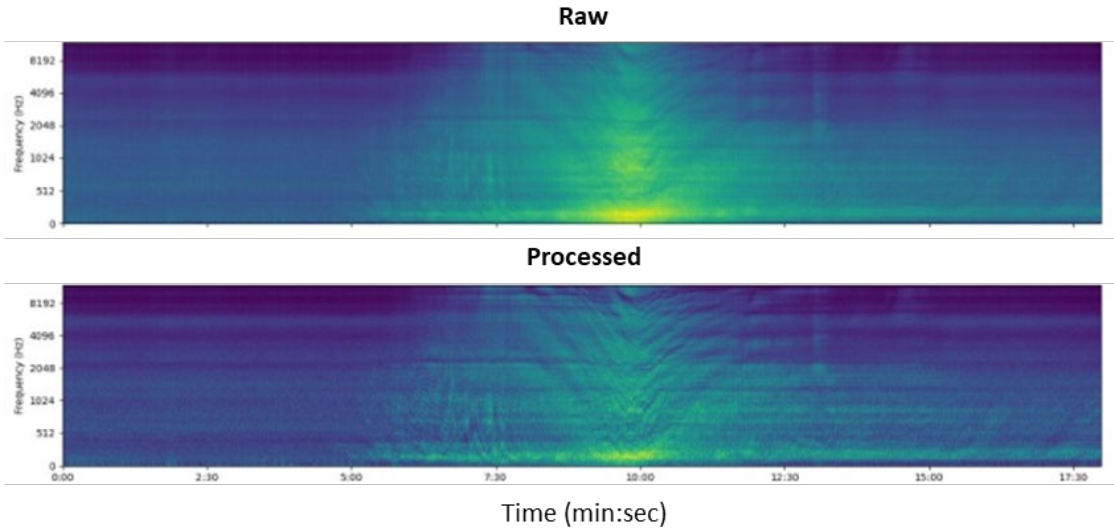
Acoustic/Optical Sensors and Signal Processing

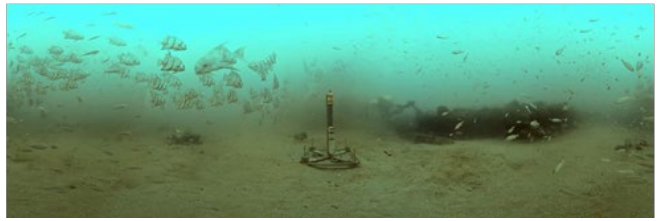
Research strengths and directions include.

- Bioinspired signal processing (BISP) techniques for filtering out of background clutter and noise - applicable across a range of modalities.
- ML techniques for detection/classification of anomalies.

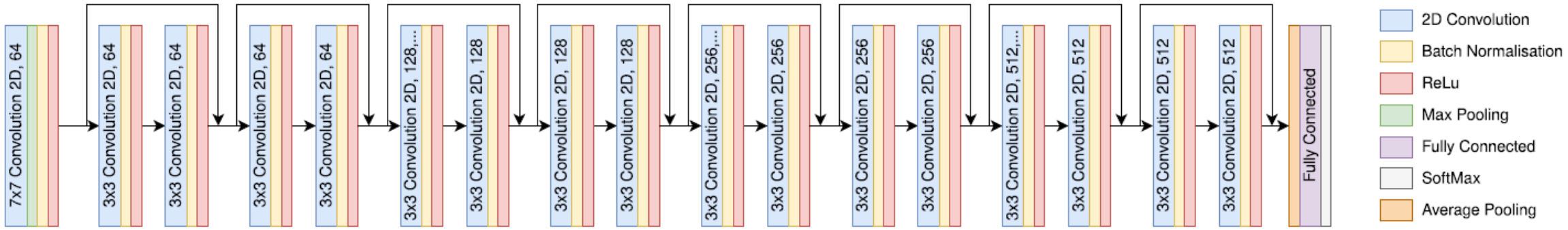
Applications include:

- Enhancement of hydrophone/sonar signals
- Acoustic/non-acoustic detection, tracking and classification of marine vessels

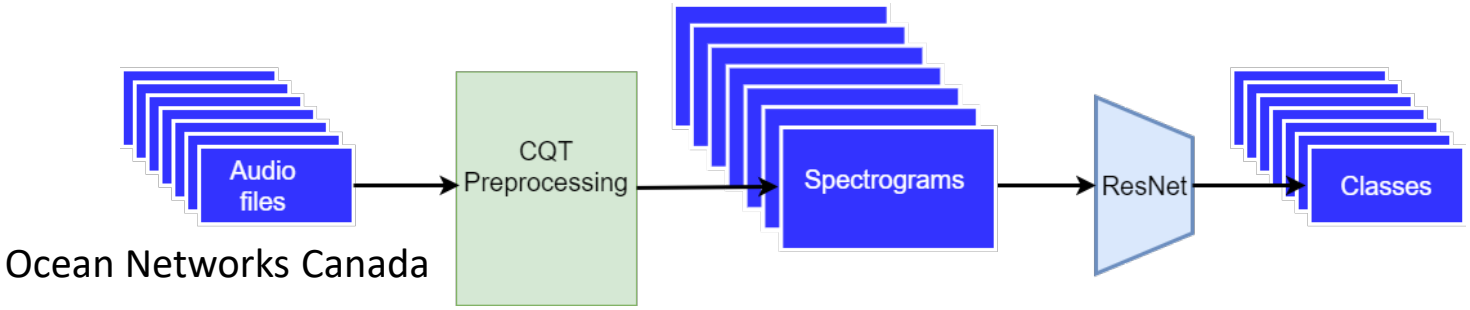




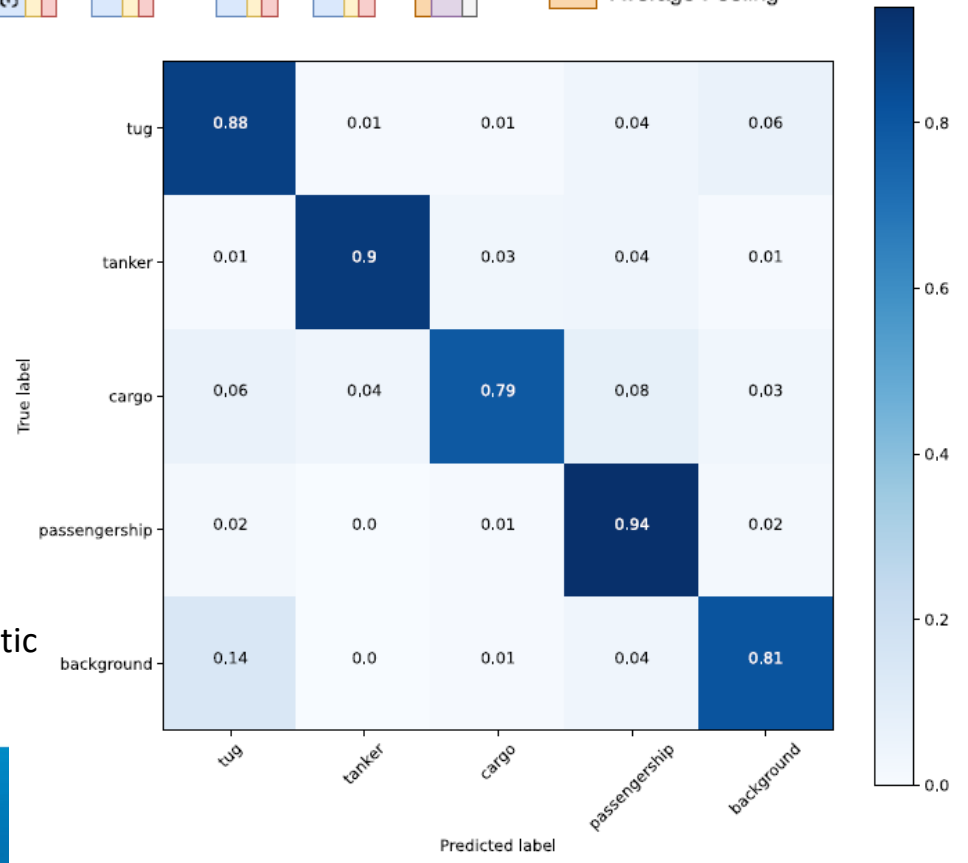
Deep Learning Methods for Vessel Classification from Hydrophone Data



ResNet18 Model Architecture



Ocean Networks Canada



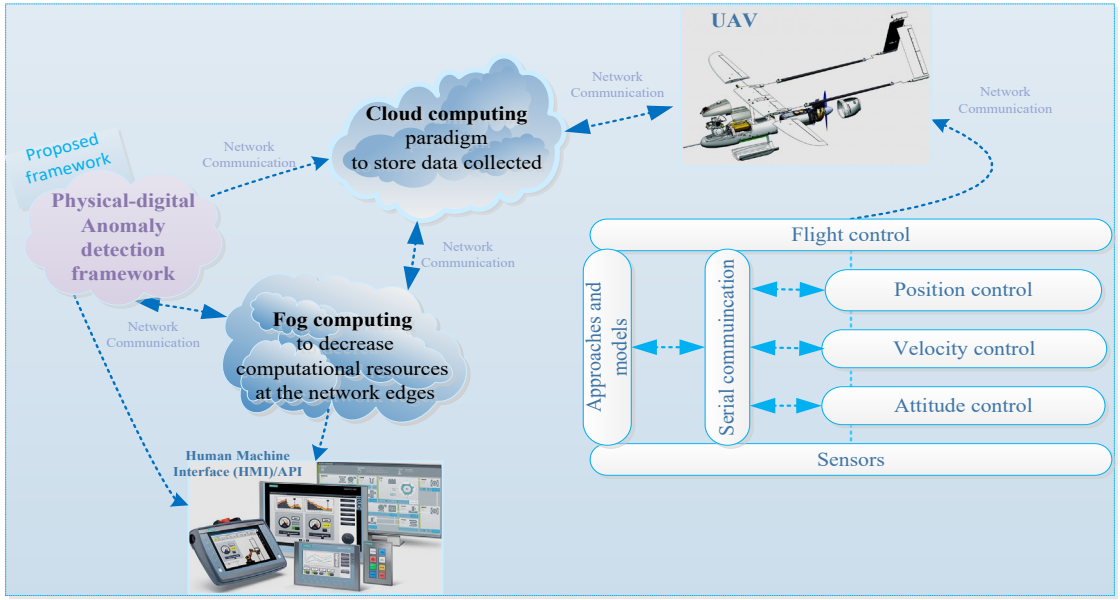
L. C. F. Domingos, P. E. Santos, P. S. M. Skelton, R. S. A. Brinkworth and K. Sammut, "An Investigation of Preprocessing Filters and Deep Learning Methods for Vessel Type Classification With Underwater Acoustic Data," in IEEE Access, vol. 10, pp. 117582-117596, 2022

Research on Cyber Physical Systems security

Identifying malicious attacks through anomaly detection in ways that will make unmanned vehicles, unattended sensors, and mission-critical systems resilient to cyber-attacks

Developing an effective intrusion detection framework for targeted ransomware attacks in Brownfield Industrial Internet of Things

Protection of data privacy based on artificial intelligence in Cyber-Physical Systems (CPS)



Biofouling Prevention/Inspection/Removal

ARC Training Centre For
BIOFILM RESEARCH
& INNOVATION

- Development of novel antifouling coatings – essential for persistent sensors/vehicles, UUV docking stations
- Machine Learning based visual identification/classification of biofouling
- Development of autonomous ship hull crawler vehicle for removal of biofouling – removing requirement for diver and operator.

[Haldeman et al., 2016]

[Bigorre et al., 2017]

[Brett Hobson ©2006 MBARI]

INSIGHT VIA ARTIFICIAL INTELLIGENCE

COMPANY OVERVIEW

Insight Via Artificial Intelligence (IVAI) is an innovative Adelaide based SME with extensive experience in the research, development and deployment of artificial intelligence, machine learning, virtual/augmented reality and data analytics technologies.

Our focus is on advancing the state-of-the-art in trusted artificial intelligence and on developing AI that augments human capability.

We value collaboration and have proven capability to translate research into real world solutions for our clients. IVAI has a broad customer base, applying our capability across Defence, Government, Health and Industry sectors.

CONTACT

Ian Will
Executive Director
0422 531 417
ian.will@ivai.com.au
www.ivai.com.au
Suite 811, 147 Pirie St,
Adelaide, SA 5000

CAPABILITY

Research & Development

- Proven expertise in explainable Artificial Intelligence, Machine Learning, Computer Vision, Natural Language Processing, Virtual and Augmented Reality and related technologies.
- Human/Machine interface optimisation

AI Solution Development & Implementation

- Helping organisations to unlock the value in their data.
- Delivering optimal AI/Data Science solutions quickly and effectively using bespoke or industry standard platforms.

Products & Services

- Plan, build, deploy & manage AI systems profitably, ethically and responsibly using our innovative platform.
- AI augmented VR and AR product development.
- Advanced analytics for cybersecurity applications.

Education & Training

- Managing AI: Tailored training courses for C-Suite, Boards and Project Managers.
- Effective AI enhanced VR/AR training solutions.

Advancing human-machine teaming with trusted AI

DISCRIMINATORS

- Undertaking research at the frontiers of AI.
- Adopting innovative approaches to challenging problems.
- Creating force multipliers through interactive AI.
- Explainable and transparent AI compliant with Defence and Government ethics frameworks.
- An innovative platform to manage the entire AI project lifecycle.
- VR/AR scenario development and validation supported by latest psychological and human-factors research.
- PhD qualified research and development team.
- Australian owned and operated.
- Defence Industry Security Program (DISP) members.

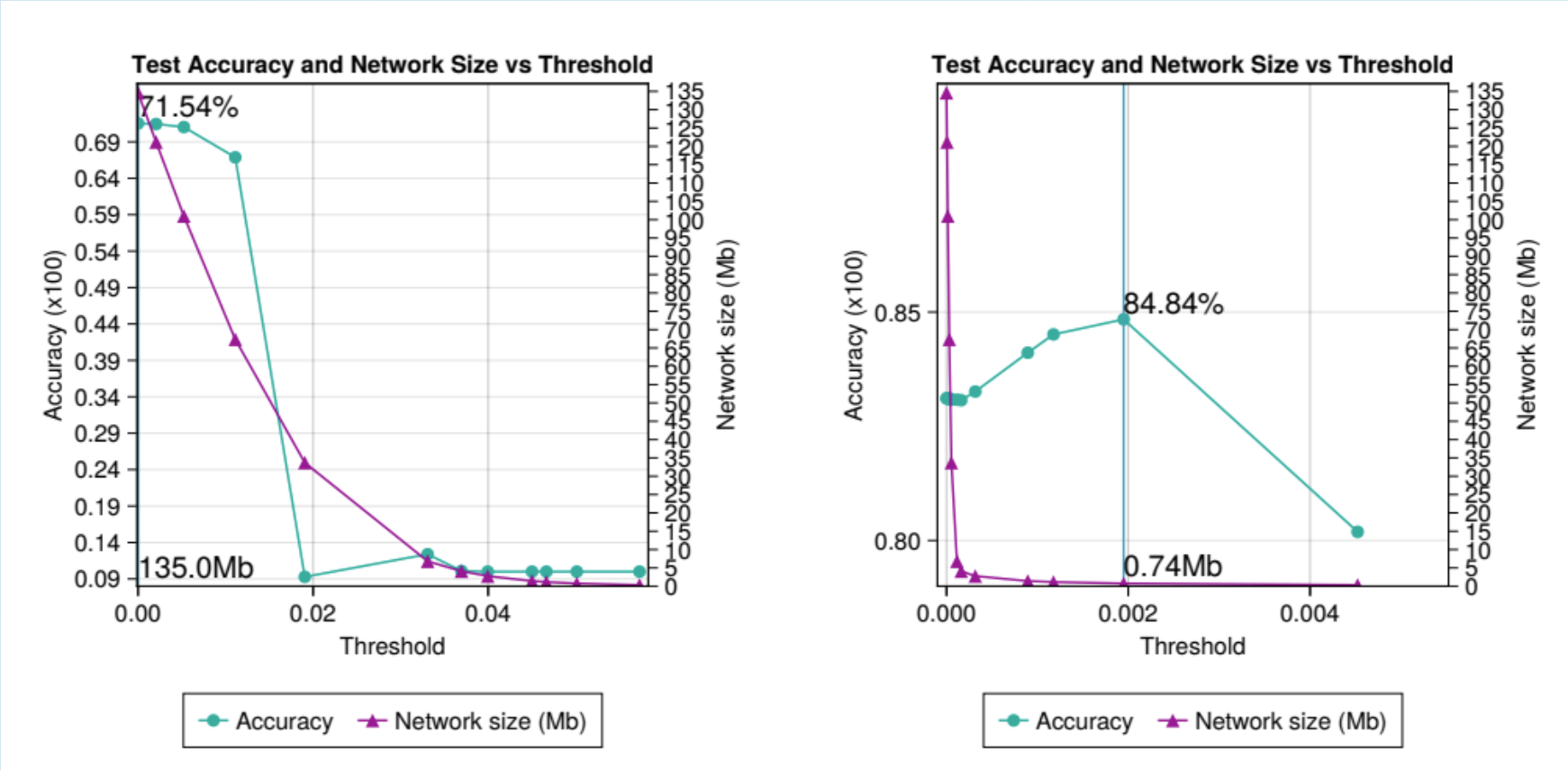
PARTNERS & CLIENTS

DEFENCE INNOVATION PARTNERSHIP
Australian Government Department of Defence
THE UNIVERSITY of ADELAIDE
University of South Australia
SAHMRI South Australian Health & Medical Research Institute
Defence Industry Security Program
ACSC Australian Cyber Security Centre
DST GROUP
DEFENCESA
Government of South Australia

- Contemporary AI-based signal processing systems are based on deep neural network models.
- The models have large file sizes and transmitting the models in a contested battlespace and is not tenable and will not meet the operational outcomes.
- We developed a new technique for training and compressing AI-based signal-processing models that retain state-of-the-art accuracy while massively reducing the AI model file size.
- Using this new technique, it would take less than two minutes to transmit the optimised AI model over a 56 Kbps connection.

Sample Results

Experiments conducted on CIFAR-10 Dataset

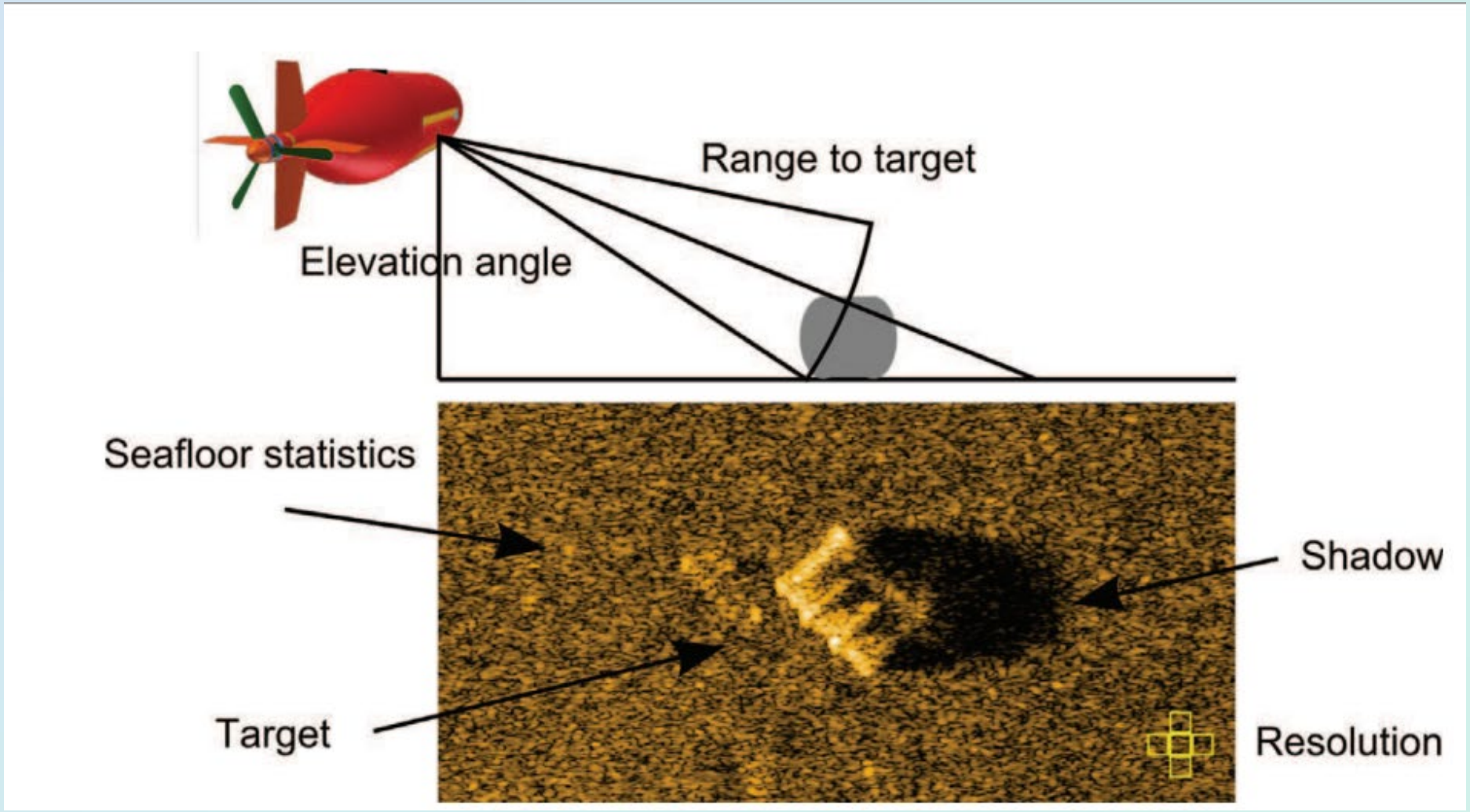


(a) Compressing a Deep Network trained **without** our learning algorithm.

(b) Compressing a Deep Network trained **using** our learning algorithm.

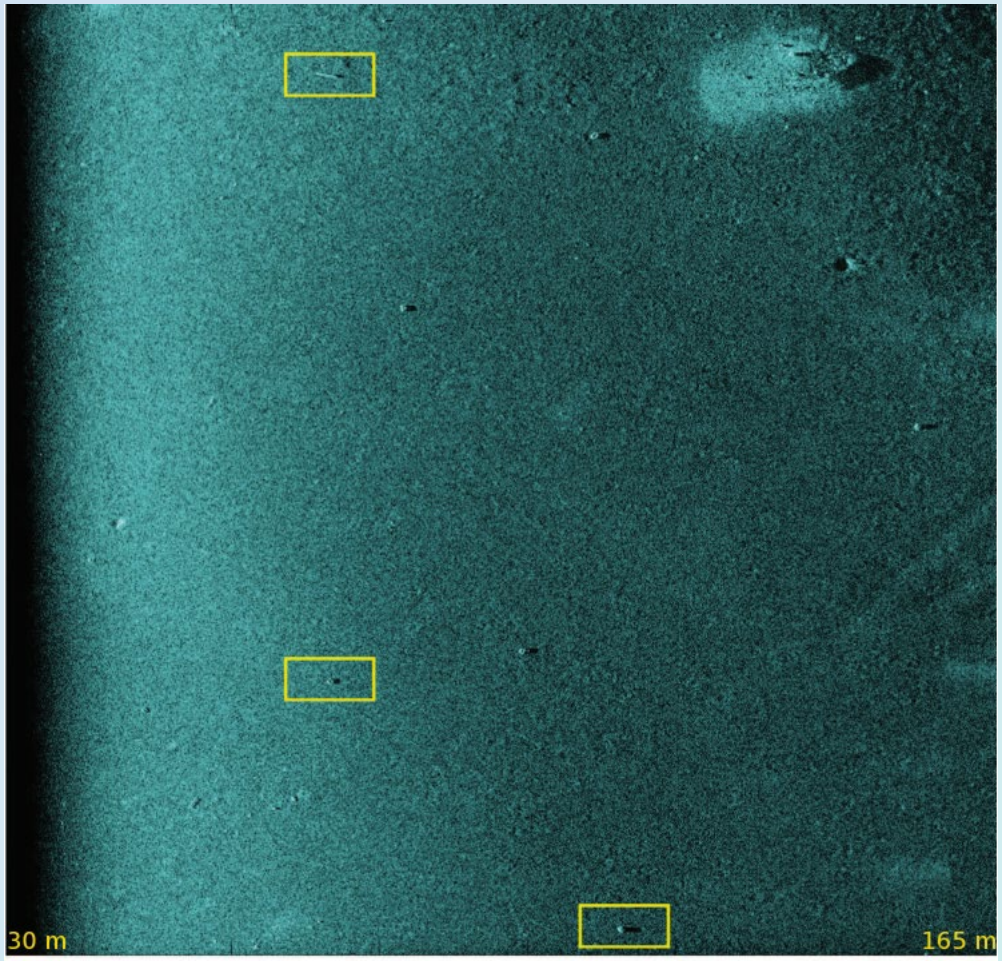
Trade-off between test accuracy versus network size for a VGG-16 model trained **without** our custom learning method, versus the same model trained **using** our custom learning method. Note the accuracy axis in **(b)** corresponds to a much higher range.

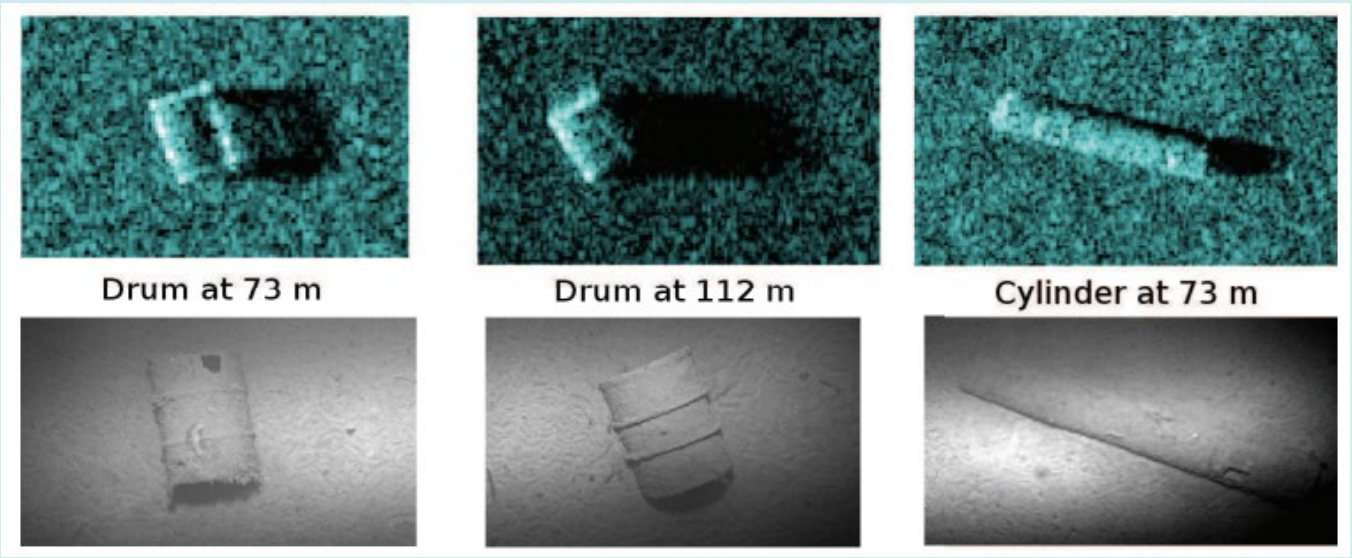
Synthetic Aperture Sonar



Edgar, R. (2011). Introduction to Synthetic Aperture Sonar. Sonar Systems. doi:10.5772/23122

Synthetic Aperture Sonar

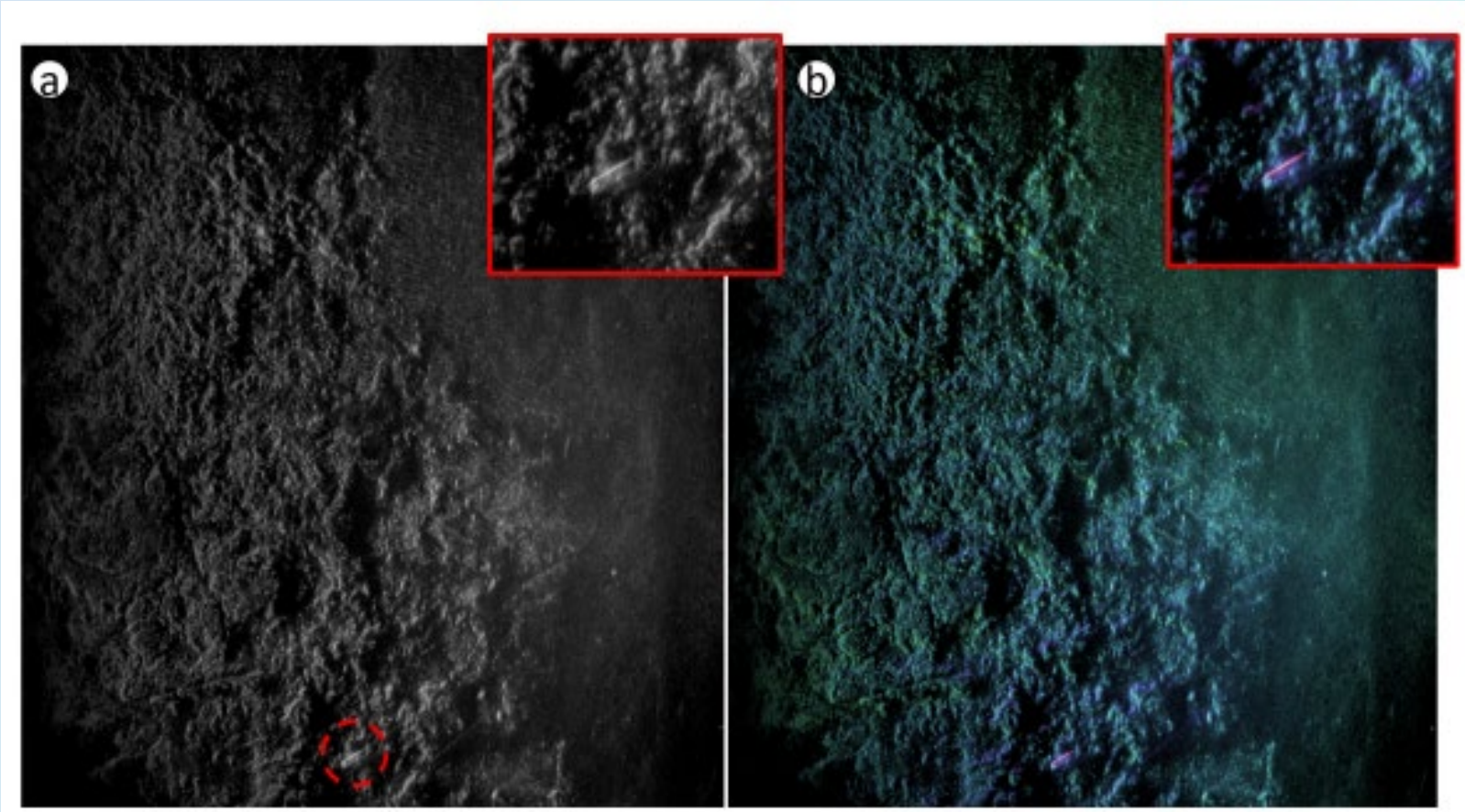




SAS is complex-valued but typically converted to real-valued magnitude representation that is subsequently used for various signal processing and pattern recognition tasks.

Edgar, R. (2011). Introduction to Synthetic Aperture Sonar. Sonar Systems. doi:10.5772/23122

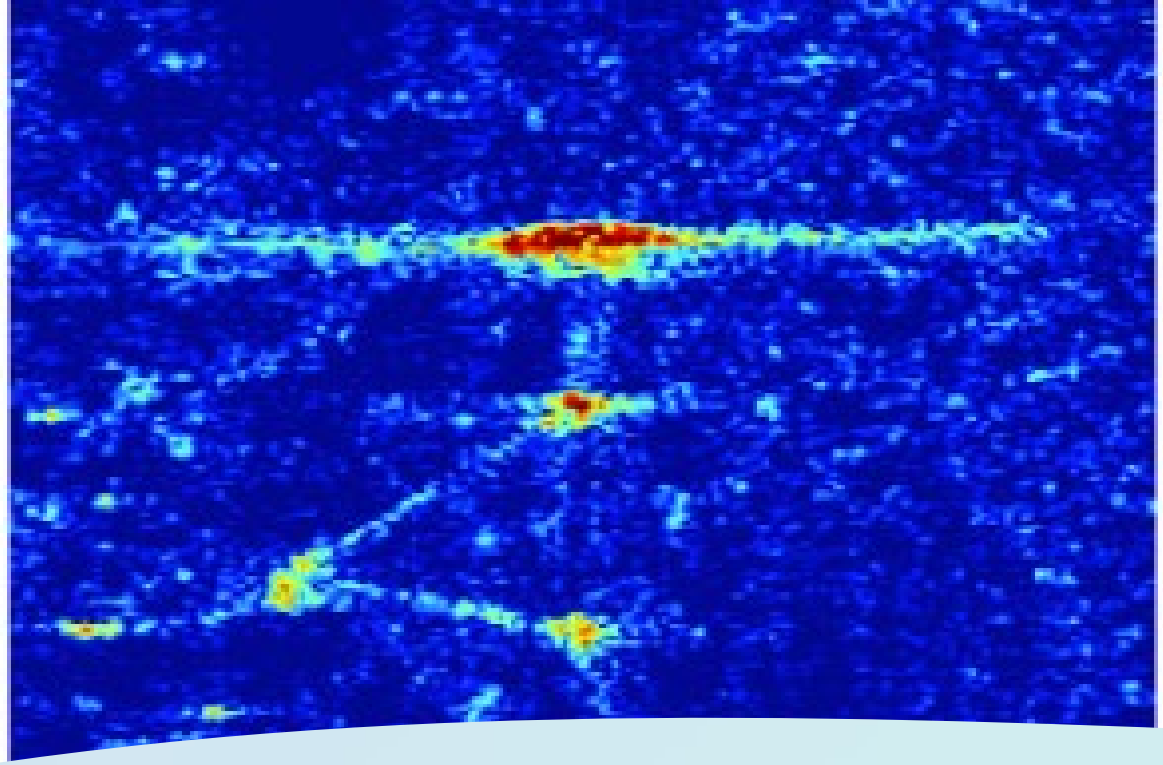
Both Magnitude & Phase Information is Pertinent



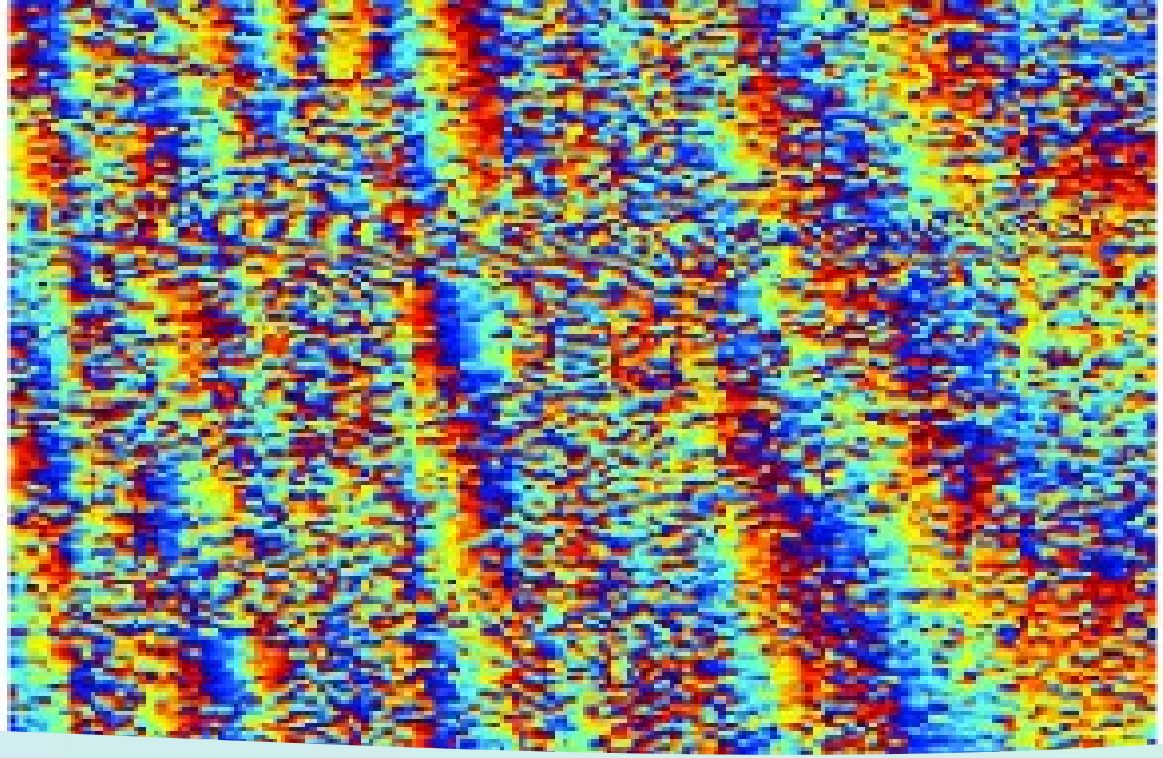
Phase information, which is related to the signal travel time and in turn, the distance travelled.

Aspect-dependent nature of sonar returns off objects can be detected in the frequency domain (whereas the integration of this information to create magnitude imagery effectively obscures this key phenomenon.

Plotnick, D. S., & Marston, T. M. (2018). Utilization of Aspect Angle Information in Synthetic Aperture Images. IEEE Transactions on Geoscience and Remote Sensing, 1–9. doi:10.1109/tgrs.2018.2816462



Magnitude



Phase

An endfire cylinder with deployment chains attached as visualized by SAS magnitude and phase information (range increases down the page). Published research showed that objects like these can be detected from phase information alone.

Williams, D. P. (2019). Final Report SERDP Project MR18-1444,
NATO STO Centre for Maritime Research and Experimentation (CMRE)

Proposed Solutions

Rapidly Updating ML Models with Limited Bandwidth

- Sonar data exhibits strong environmental dependence, predominantly on seafloor conditions
- ML model may need to be adapted for new sensors

Enable Deep Learning in the Frequency Domain

- Unified approach to exploting **magnitude and phase** information in an SAS image
- We are developing new CNN architectures for **end-to-end training** in the **frequency domain**.
  - Key ingredients are **new activation functions**
- Potential for fast classification with small memory footprints


priori
analytica
Knowledge of the
reasoned facts

Who Are We?

priori analytica

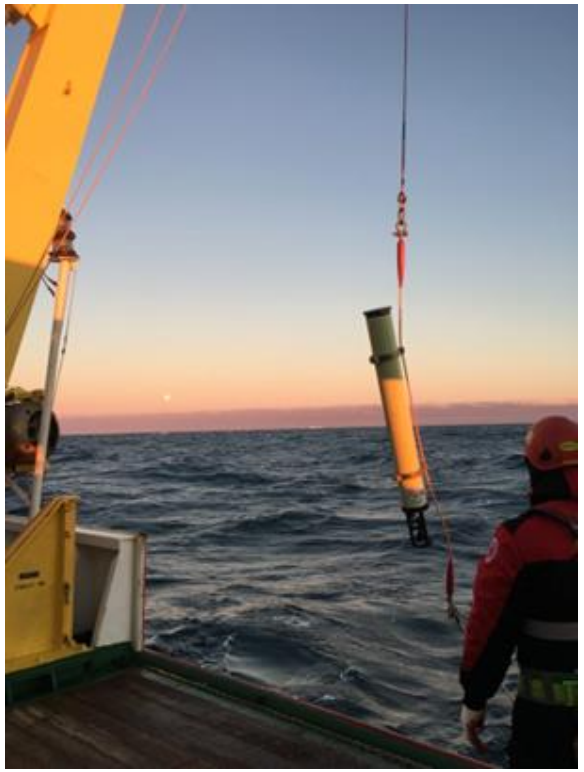
- We use Machine Learning (ML) algorithms and eXplainable Artificial Intelligence (XAI) to build “Advanced Operational Analytics” solutions.
- Forged in the SA Oil & Gas sector, we serve defence customers with Deep Learning vibration analytics & corrosion predictive maintenance.
- Recently won the United States Navy ‘Sea, Air, Space 2023’ Department of Navy, Office of Small Business Programs Showcase.

Automated Undersea Acoustic Classification:

priori analytica

The Concept

- Use AI/ML to acoustically detect & classify ocean vessels
- Initial target hardware: Low-cost seabed deployed battery-powered passive hydrophones
- Why now?
  - Increased strategic importance
  - Background technology is mature
  - Human operator shortage
  - Relatively poor performance of existing automated solutions



Automated Undersea Acoustic Classification:

priori analytica

The Challenge

Data

- Increasingly Complex Hydroacoustic Environment
- Class Imbalance
- Sample Size
- Access / Sensitivity

Compute

- Restricted power & hardware cost environment
- Minimal network access / bandwidth
- Adversarial ML attack vectors

Automated Undersea Acoustic Classification:

priori analytica

The Solution

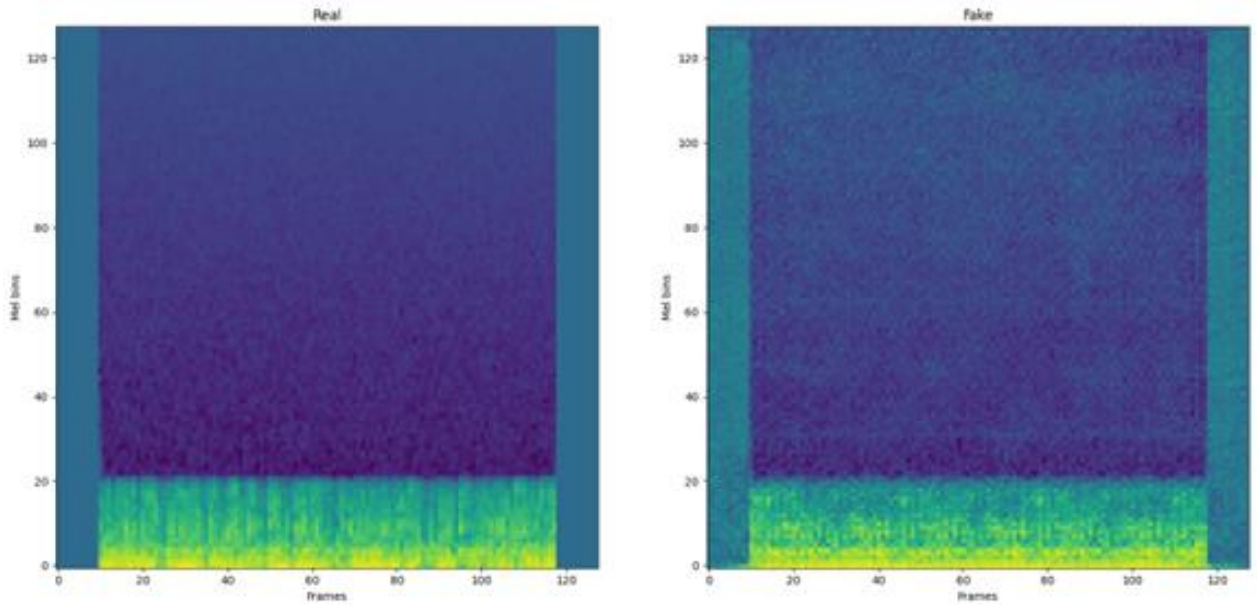
- 1000s of years of open access continuous passive hydrophone data
- New algorithms:
  - Dynamic ML Signal-Background Separation
  - Generative ML
  - New Adversarial ML research
- Edge inference

Automated Undersea Acoustic Classification:

priori analytica

Generative ML

- Rebalance class imbalance
- Increase sample size
- Transfer learning of observed vessels into new acoustic environments
- Augment observed vessel samples with different parameters
- Increase system TRL without full data access



priori analytica

Partnerships & Key Clients

NAVY

L3HARRIS™

Ascent

Beca

REPSOL

AngloAmerican

APEX ENERGY AUSTRALIA

stepchange global

RESONATE SYSTEMS

Dedicated Systems

Defence Teaming Centre
Connecting • Developing • Advocating

DEFENCE INDUSTRY & INNOVATION

Axant ADVISORY

SOUTH AUSTRALIA

Quantum Magnetometers

Defence Innovation Partnerships Activator

Dr Fred Baynes

QUANTX'S PURPOSE AND CAPABILITY

VISION
A secure future built on precision and integrity

MISSION
To be a globally leading provider of precision technologies that enhance communications, navigation, surveillance and defence systems

TECHNOLOGIES
Precision Timing and Quantum Sensing

HEAD COUNT
20 people

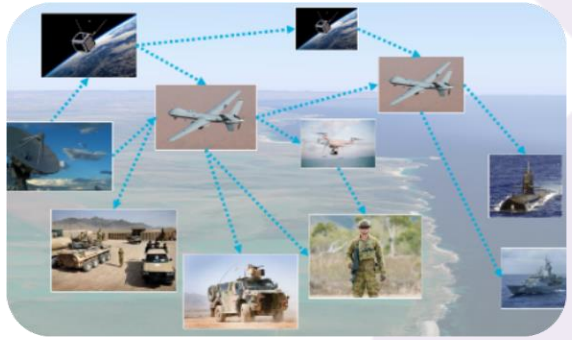
FACILITY
LOT 14 - 1000sqm
Operations, R&D, Engineering, Production and Testing

SECURITY/QUALITY
Current DISP Entry lvl (seeking level 2 in 2023)
ISO9001 (2023)

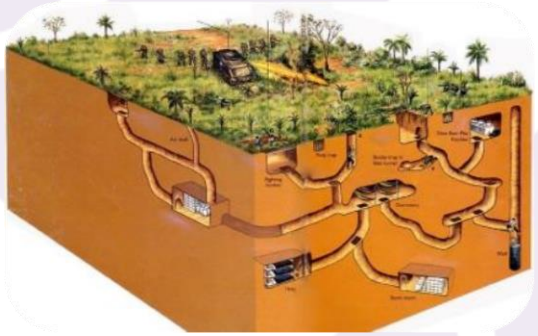
DEFENCE CAPABILITIES - where QuantX sensors provide value:

1 Enhanced HF & Microwave Radar

2 Assured PNT



3 ASW and LAND ISR



Value proposition

Enhanced detection/tracking in contested environments, cluttered backgrounds, uncooperative targets.

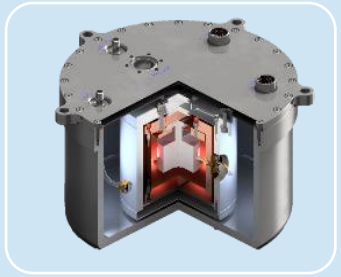
Resilient operations In GNSS-degraded or denied, GNSS-unavailable (undersea, underground)

Enhanced detection/tracking of covert targets and change detection

DEVELOPING SOVEREIGN PRODUCT PORTFOLIO

World-leading high-precision technologies

1 Sapphire Oscillators



Cryoclock
Low Noise Oscillator

Purest signal available on the commercial market

- Up to 10,000x better oscillator performance
- Improved target detection when there is strong Earth return clutter
- Low-RCS target detection with high-power high-sensitivity OTHR
- Slow-moving targets and targets of all speeds with low projected Doppler more easily detected

TRL-8

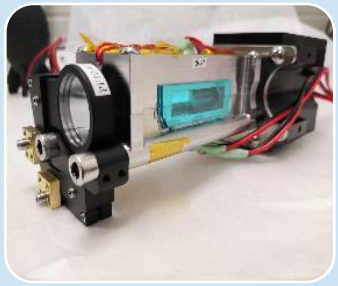
X-LNO
Ultra-Low Noise Microwave Oscillator

Producing a world-leading ultra-low phase noise reference signal in the X-band region

- Detection and tracking of fast-moving objects at a distance

TRL-5

2 Optical Atomic Clocks & Synchronisation



C-roc
Compact Rubidium Optical Clock

GPS quality, precision timekeeping, at low SWaP, and a stable holdover

- Ultraportable
- Long Holdover – up to 1 month
- Terrestrial platform retrofit
- Integration with existing clocks
- Space-payload being developed

TRL-5

T-SYNC
Time Transfer Synchronisation

Providing secure, precision time and frequency network

- Network Synchronisation
- Space-based services

TRL-5

3 Optical Pumped Magnetometers

Q-MAG
Quantum Magnetometer

Ability to measure extremely small anomalies in the magnetic field on Earth and in orbit.

- ASW, underwater mines, underground tunnels / munitions / buried IED's / hazards.
- Deployment – drones, UUV, tripwire, handheld.

TRL-4

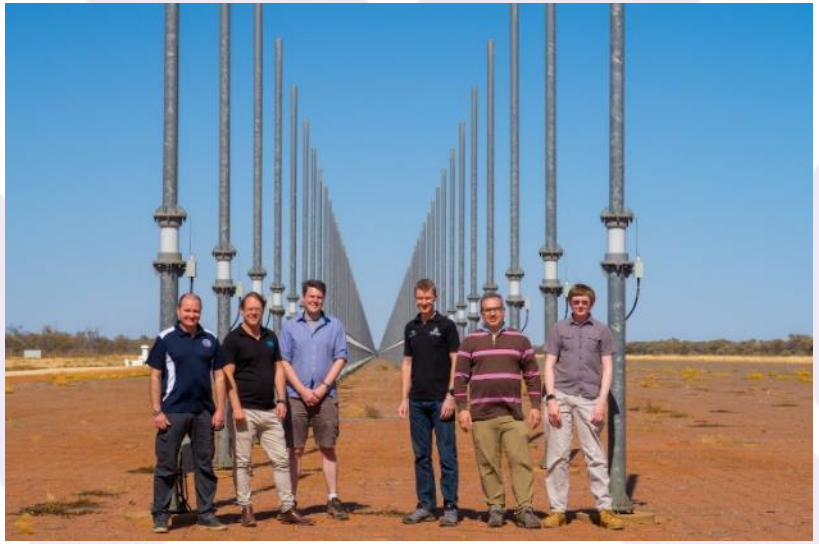
FLAGSHIP PRODUCT: CRYOCLOCK

Provides up to 10,000x improved frequency performance c.f. existing technology in JORN

7 years in development through the Defence innovation pathway

AIR2025 JORN Phase 6 upgrade

DEVELOP,
T&E,
INTEGRATION.



KEY MILESTONES

2023 2025 2027 2029 2030

Product delivery + install | 25-yr DLM Service

1st of type
3off
~12off

BAE SYSTEMS

Australian Government
Department of Defence
Defence Science and Technology Group

Australian Government
Department of Defence
Capability Acquisition and Sustainment Group

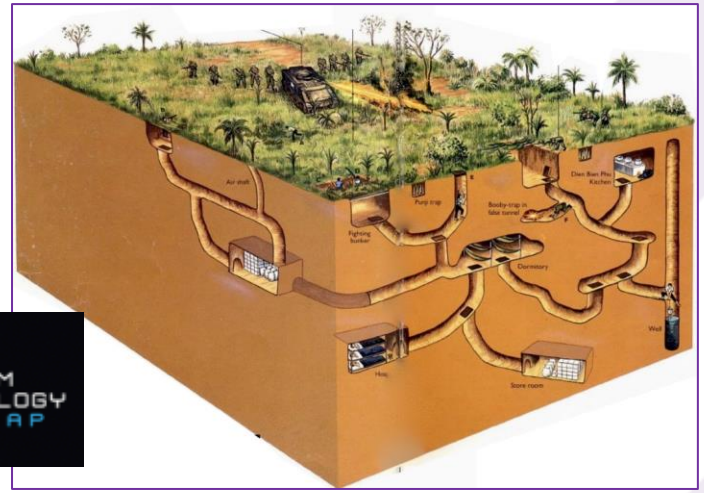
DEFENCE INNOVATION HUB

QUANTUM MAGNETOMETER USE CASES

Sea-bed Magnetometer Array

- Stationary array, slow moving target
- Optical interrogation – covert detection

Surface Magnetometer Array

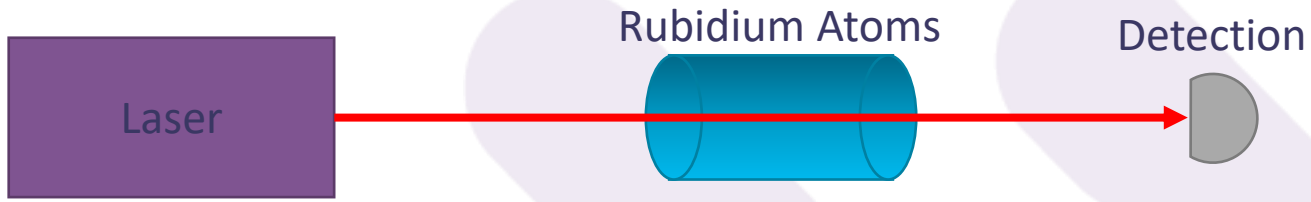


- Stationary array, slow moving target
- Working with Robotic & Autonomous Systems Implementation & Coordination Office (RICO), Future Land Warfare, Land Capability Division

UAV/UUV Magnetometer

- Fast moving array, slow moving target
- Low SWaP

Quantum Magnetometers



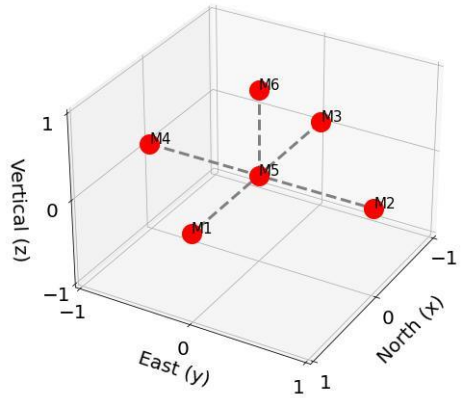
- Optically pumped magnetometers – laser interacts with Rubidium atoms to prepare them in correct quantum state
- Atoms precess with Larmor frequency $f_L = \gamma B$ where γ is the gyromagnetic ratio and B is the magnetic field strength
- Measure f_L and get B, γ is a fundamental physical constant
- No calibration, inherently accurate, no drift, low SWaP, better sensitivity – great for networking !

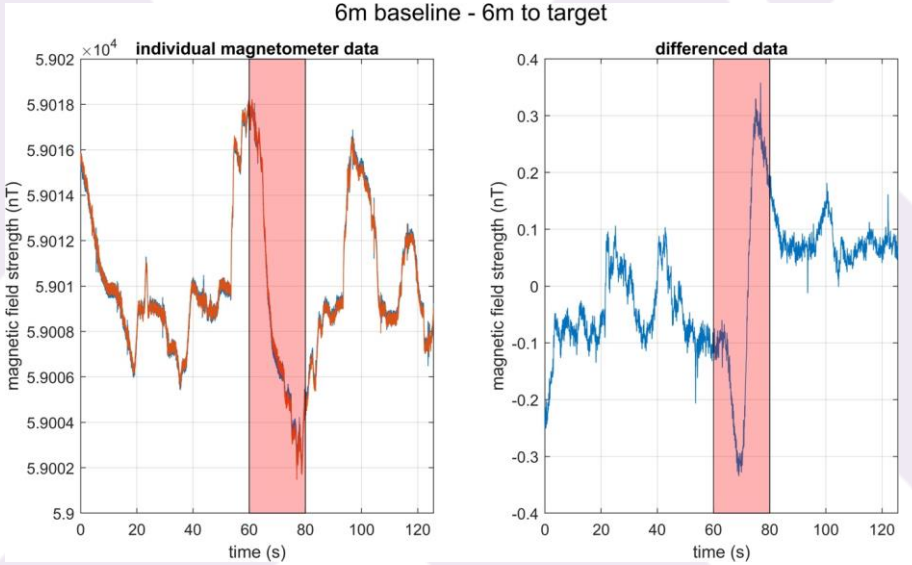

(a)


(b)

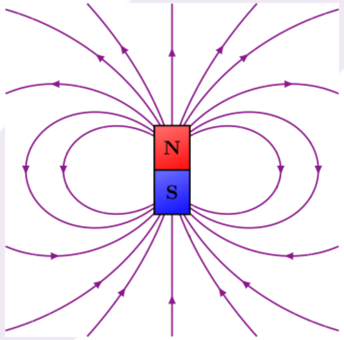
Background Magnetic Fields

- Earths field fluctuates in time and space
- We are using a scalar sensor to detect the total magnetic field
- Use common mode reject to remove the effect of the earths magnetic field – differencing approach

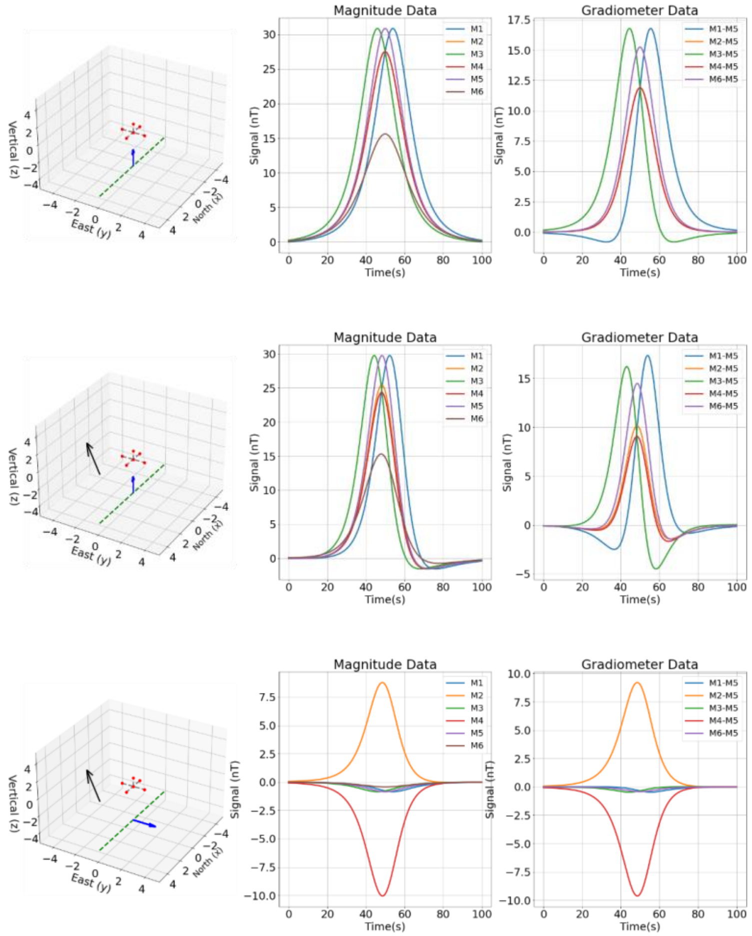


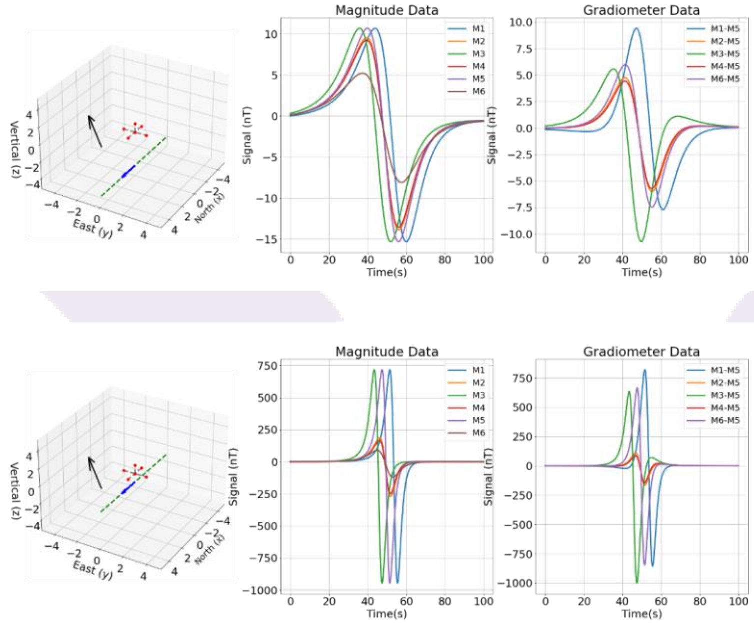


Target Dipole Orientation



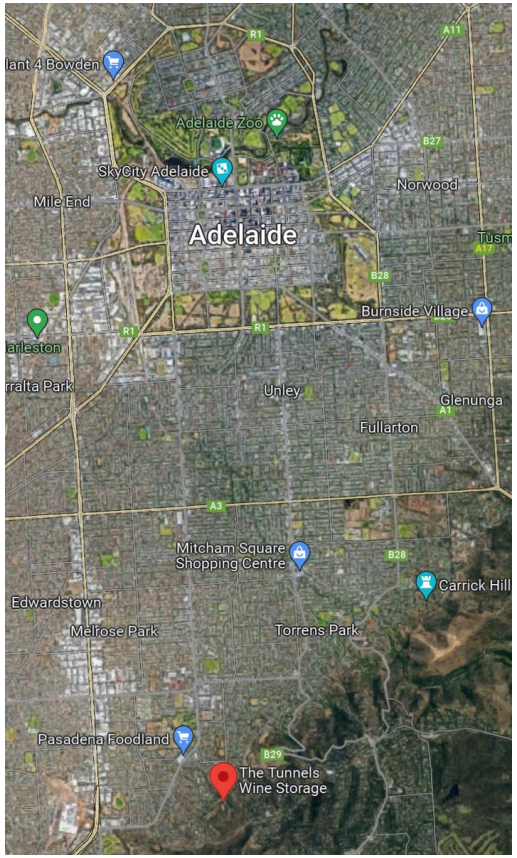
- We detect the sum of the Earth's field and the target field
- Target orientation (dipole orientation) effects the signal

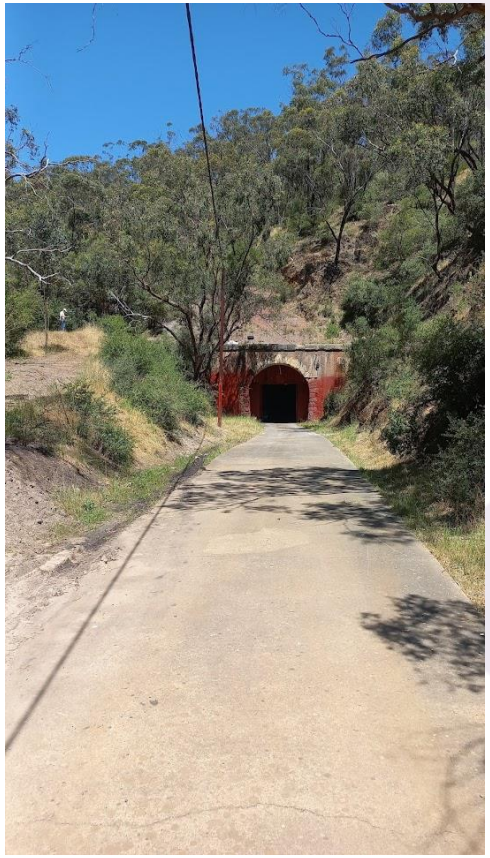


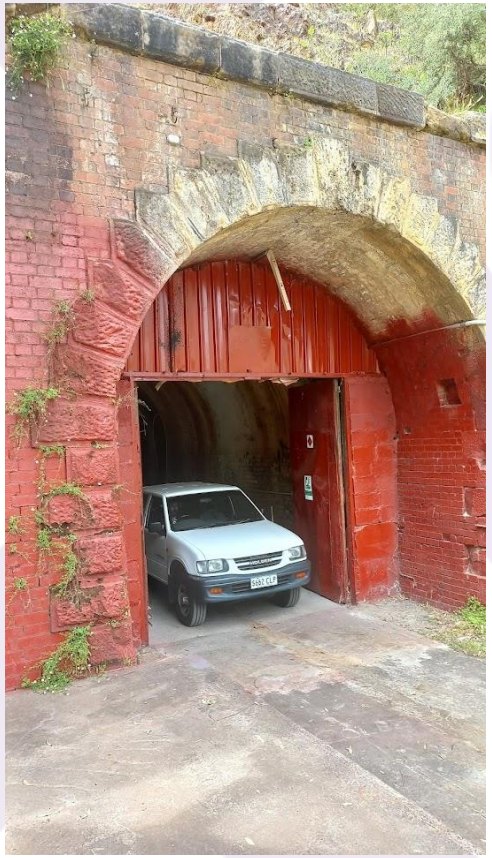


Wine Tunnel Field Trials

- Old Adelaide – Melbourne railway tunnel
- 300 m long
- Accessible bushland on top of tunnel to deploy magnetometer array and drive car back-and-forth in tunnel as target



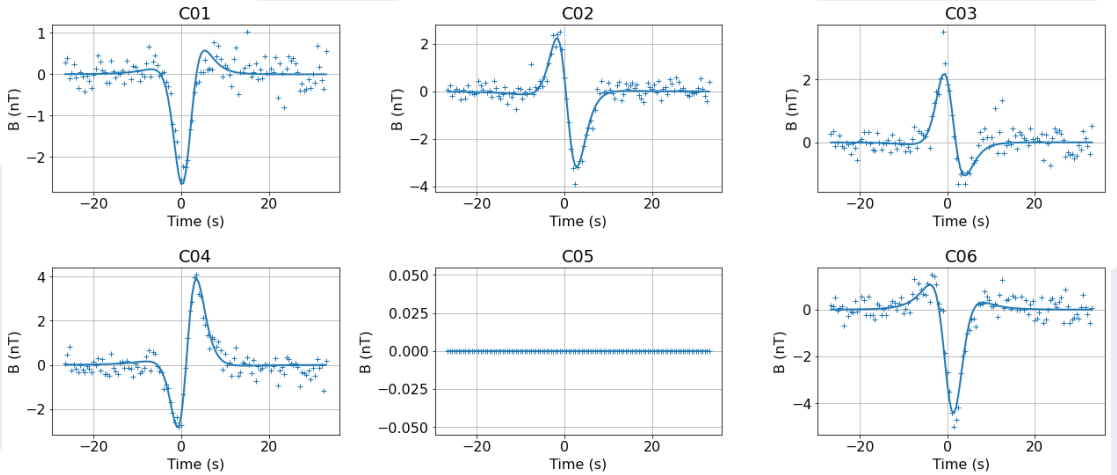




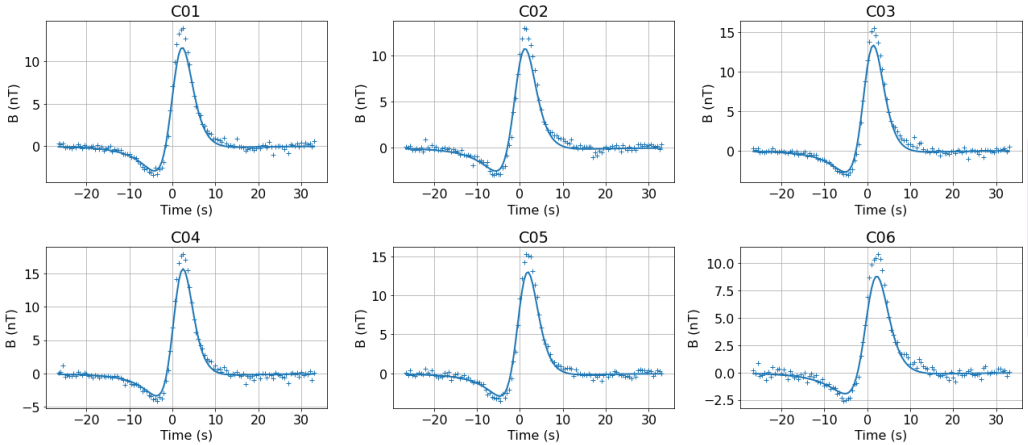
Wine Tunnel Trials

14 m above tunnel

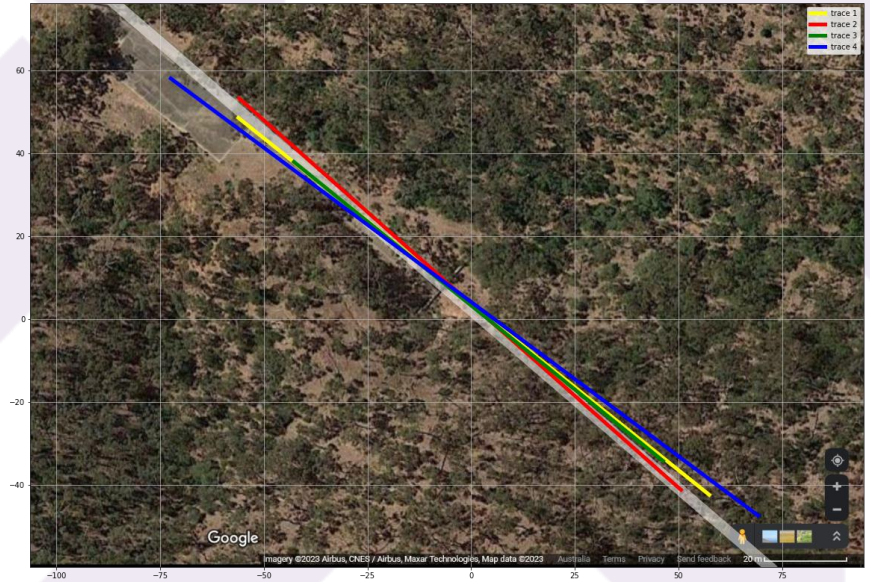
Differenced



Magnitude



Tracking

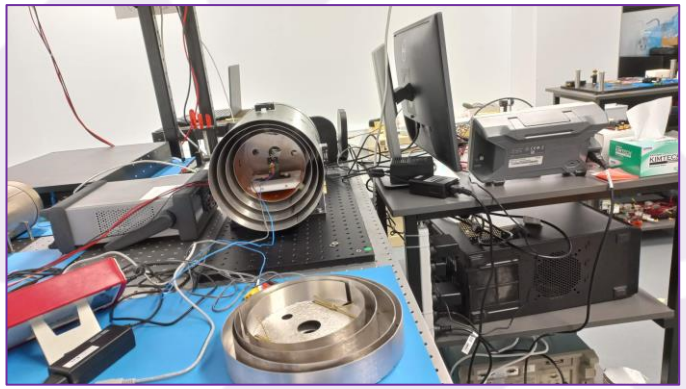


On-going Work

- Developing quantum magnetometers for UAV applications using gradiometer approach
- Understanding of ocean magnetic background and detection range estimates
- Field trails as proof of principle
- Machine Learning approaches to target detection
- Development of much higher sensitivity, low heading error QuantX Labs magnetometers

DJI Matrice 600 (5 kg payload)

Measuring the ocean magnetic background



Magnetically shielded environment for testing