















UWA Defence Capability Statement

WESTERN AUSTRALIA IS PART OF THE DYNAMIC
INDO-PACIFIC REGION AND IS NATIONALLY SIGNIFICANT
IN THE DEFENCE AND SECURITY OF AUSTRALIA.

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A close-up photograph of a person wearing a blue lab coat and blue nitrile gloves. They are holding a clear glass petri dish with both hands, looking directly at it. Inside the petri dish, there are several distinct, reddish-brown bacterial colonies of varying sizes. The background is dark and out of focus.

Health, Medical & Biosecurity





DEFENCE RESEARCH CAPABILITY CATEGORY: **HEALTH, MEDICAL & BIOSECURITY**

UWA Competitive Advantage

- Capability to handle and manipulate security sensitive biological agents (SSBAs), in vitro testing of novel drugs, virulence screening of biological threat agents at Physical Containment (PC) level 2 laboratories and extensive experience in PC3 experimental and in vivo studies.
- Antimicrobial resistance including developing medical countermeasures to deadly human fungal bio-warfare and bio-terrorism agents, and antibacterial targets and therapies to specific bacteria.
- Development of superior sensing technologies for detection of, and methodologies to rapidly identify, decontaminate and eliminate security-sensitive, dangerous biological agents.
- Identify, decontaminate and eliminate critical bio-warfare and bio-terrorism threats to food security and food exports.
- Identification of naturally self-decontaminating materials, relevant to the sterilisation of military equipment (vehicles, armament, clothing etc.) following overseas deployments.
- Human Performance Optimisation through injury management, spinal cord repair, soft tissue regeneration, enhanced cooling from hyperthermia, mechanisms of and delay of muscle fatigue.
- Chemical measurement of stress, assessment tools for screening and early detection of mental health problems and remote health provision using wearables.

Infrastructure and expertise for the rapid development of medical countermeasure technologies and products to provide effective protection of Defence personnel from a range of chemical, biological and radiological threats, pandemics and emerging infectious diseases.



Outcomes and Impact

- UWA researchers are focused on identifying new antibiotics that are capable of treating a broad range of bio-warfare agents with a reduced chance of developing antimicrobial resistance.
- UWA has funding partnerships with UK Ministry of Defence, Singapore Ministry of Defence, Defence Science Technology Group.

Capabilities and facilities

- Researchers have extensive experience in containment level 3 work (PC3) and experience in Biosafety Level 2 and 3 work in both experimental and animal laboratories.
- Capability to handle and manipulate security sensitive biological agents (SSBAs), in vitro testing of novel drugs, also including virulence screening at PC2.
- Capability to develop medical countermeasures and antimicrobial resistant technologies in chemical and biochemical laboratories (Bayliss Building).

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Multi-Disciplinary **Material Sciences**





DEFENCE RESEARCH CAPABILITY CATEGORY: **MULTI-DISCIPLINARY MATERIAL SCIENCES**

UWA Competitive Advantage

- Expertise in infrared (IR) materials and detector technologies, and microelectromechanical systems (MEMS) providing optical MEMS-based infrared sensing technologies for spectroscopy and/or imaging.
- Functional materials (intelligent or smart metals), specifically shape memory alloys and magnetoelastic materials. These materials are lightweight, solid-state alternatives to conventional actuators such as hydraulic, pneumatic, and motor-based systems.
- Granular materials and fracture formation.
- Ultrafine and nano powders, nanomaterials and nanostructured ceramics.
- Polymers, geopolymers, ceramics and composites.
- Explosives.
- New impact-resistant carbon fibre composites, composite-metal adhesive bonding, and composite repairs.
- Optics, photonics, microwave electronics and communication systems.
- Alloy development for 3D printing of metals using selective laser melting, resulting in superior material properties.
- Sensor development and fabrication expertise includes sensors of both fundamental and complex parameters, using new materials, sensor readouts and data analysis and networking sensors into intelligent arrays. Sensor development spans a wide range of modalities;
 - » electromagnetic (infrared (NIR, SWIR, MWIR and LWIR), hyperspectral, terahertz band, magnetic biosensing, optical/fibre optical systems, detecting weak electrical signals in littoral and estuarine waterways, low-noise sapphire microwave oscillators.
 - » Gravitational.
 - » Single-chip gas, chemical, pressure and temperature sensors.

Advances in materials technologies on the critical path to the delivery of many new and potentially disruptive Defence capabilities. Exploring materials and processes that support advanced manufacturing.

UWA is at the forefront of international research, leading renowned university labs and research labs of major aerospace & defence industry players, including military/government contractors. Our expertise includes advanced optoelectronic and microelectromechanical sensor technologies and fabrication of infrared and x-ray/gamma-ray detectors.



- » Advanced microelectronic, optoelectronic and photonic materials, devices and systems
- » Developing low to zero power sensor systems, leveraging energy harvesting to power remote sensors connected through a low power radio network.
- » Investigating nano-porous silicon for MEMS-based sensors and technology for long-wave thermal imaging applications.
- Developing a software platform to analyse and visualise the unique 3D terahertz datasets produced in partnership with terahertz hardware manufacturers and application developers. Terahertz frequencies provide structural information and can image through plastic, paper and fabric, with applications in defence and security such as detecting concealed weapons or hazardous substances through clothing and packaging.
- Electromagnetic interference shielding composites using 3D printing

Outcomes and Impact

- Non-woven Kevlar fibre veils for interfacial toughening and electrochemical corrosion resistance, and resin pre-coating for composite repair and stronger adhesive bonding with metals.
- More efficient, less expensive and more adaptable lubricants, heat transfer fluids, solvents for electrodeposition, and electrolytes in batteries and capacitors, suitable for environmentally harsh conditions (eg, aeronautical, space, and mining industries).
- Low cost sensing technologies designed for real-world applications with foci including the environment, infrastructure monitoring and airborne remote sensing.
- Intelligent processing of sensor data and data reduction techniques.
- A new class of sensors operating in the IR part of the spectrum that provide unique multi-spectral sensing capabilities with reduced size, weight and power requirements. Applications in multi-spectral imaging, night vision, and standoff spectroscopy sensors, with a strong focus on intelligence, surveillance and reconnaissance (ISR) applications in defence and security.
- Modelling to support optical system evaluation, and radar cross-sectional studies using finite-difference time-domain (FDTD) models, in collaboration with the Submarine Optronics Group within DSTG.

- First in the world to demonstrate the ability to 3D print amorphous parts of any size, superconducting components, and low-modulus beta-titanium alloys. Developing new high strength-to-weight structures and measuring the strain rate properties of 3D printed solid and porous structures for impact/blast protection applications.
- Electromagnetic interference shielding composites using 3D printing: This research investigated the development and evaluation innovative methods for the use of conductive cementitious composites as an electromagnetic interference shield in the 3D printing concept. New testing methods have been developed to determine the best conductive components to use in the design of cementitious composites for shielding and 3D printing that shows the best promise. The conductive cementitious composites have the potential to provide electromagnetic shielding that is cost-effective in terms of construction, operation, and maintenance compared to conventional approaches.

Capabilities and facilities

- The WA node of the Australian National Fabrication Facility (ANFF) at UWA provides state-of-the-art facilities and expertise in IR technology and MEMS systems design and advanced fabrication and manufacturing capabilities for industry and broader research communities. These capabilities are in high demand and unique in Australia.
- The Microelectronics Research Group runs a completely vertically-integrated facility, from materials growth, through device design, fabrication and testing, to packaging and sub-system assembly. In collaboration with other world-leading organisations, it is also actively involved in the development of new and emerging semiconductor materials including mercury cadmium telluride (next generation IR detectors) and Group-III nitride technologies (high performance electronics and UV detectors).

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Ocean and Maritime Science and Engineering





DEFENCE RESEARCH CAPABILITY CATEGORY: **OCEAN AND MARITIME SCIENCE AND ENGINEERING**

UWA's experts provide a competitive advantage in areas related to:

- Reliable prediction of currents, waves and temperature from the deep ocean to the shoreline via data ingestion and sophisticated modelling.
- Development of novel techniques for the measurement of ocean currents, waves, and nearshore bathymetry from remotely sensed observations.
- Capability in observing, modelling and understanding the fine-scale ocean variability that affects underwater navigation and sound propagation, including realistic non-linear internal wave modelling tools relevant to submarine navigation and communication.
- Statistical tools for quantifying uncertainty from ocean observations and numerical models that allow the development of operational decision-making tools.
- Detailed observational, modelling and prediction capabilities in nearshore and littoral areas relevant to defence operations.
- Application of novel distributed sensors, data-driven engineering and machine learning approaches to interpret and predict the dynamic response of marine craft and floating systems.
- Optimisation of the design of marine craft based on improved understanding of fluid-structure interaction and the development of novel non-linear models of dynamic systems.
- Expertise in quantifying the hydrodynamic forces on subsea vehicles in a range of environmental flow conditions using model scale testing and/or Computational Fluid Dynamics.
- Understanding and predicting extreme responses, as is applicable to survivability of offshore systems and marine craft in extreme conditions.
- Expertise in offshore soil structure interaction and offshore anchoring dynamics.
- Ocean renewable energy (wind, tidal, wave), including resource assessment, energy capture optimisation and distribution.

Scientific and technical expertise and innovative technologies to enhance the operational performance and survivability of defence platforms in the maritime domain, particularly in and around the Indian Ocean.

UWA has 170 experts from disciplines including marine science, oceanography, ocean engineering, hydrodynamics, geotechnics, environmental management, economics, commerce, law and policy, communications, history and archaeology. In many areas within the marine domain UWA's expertise is unique within Australia.



Outcomes and Impact

- Development of tools to maximise operability in the ocean across a range of environments from the deeps to beaches and estuaries
- Development of sensor packages, algorithms, and the underlying knowledge to rapidly assess and predict environmental conditions, understand and predict vessel behaviour and fatigue, and exploit ocean energy sources to power offshore and remote assets.
- Development of subsea technologies for instrument deployment at depths of 10,000m.

Capabilities and facilities

- Ocean Glider Facility operates a fleet of autonomous, underwater ocean gliders to make oceanographic measurements across the continental shelf.
- HF Radar Facility measuring surface currents around Australia.
- A large pool of state-of-the-art field oceanographic and bioacoustic equipment.
- Munderoo-UWA Deep-Sea Research Centre operates deep sea benthic landers, full ocean depth rated cameras, oceanographic sensors and sampling equipment.
- Remote sensing platforms, sensors, and algorithms to measure ocean properties from the seabed to surface.
- The Coastal and Offshore Engineering Laboratory, which includes a 54 m long wave flume

and the UWA 'O-tube' facility, which is a unique large-scale recirculating flume test facility capable of simulating underwater wave and current conditions.

- Centre for Offshore Foundation Systems provides solutions to worldwide offshore foundation needs through sophisticated modelling and experimental facilities.
- National Geotechnical Centrifuge Facility is a world leading facility working on a wide range of onshore and offshore geotechnical solutions.
- Watermans Bay Facility: laboratory for marine research with state-of-the-art laboratories and pumped seawater.
- Woodside OceanWorks is an innovative space to bring industry and academia together
- Marine Energy Research Australia supports the development of ocean renewable energy in Australia and worldwide.

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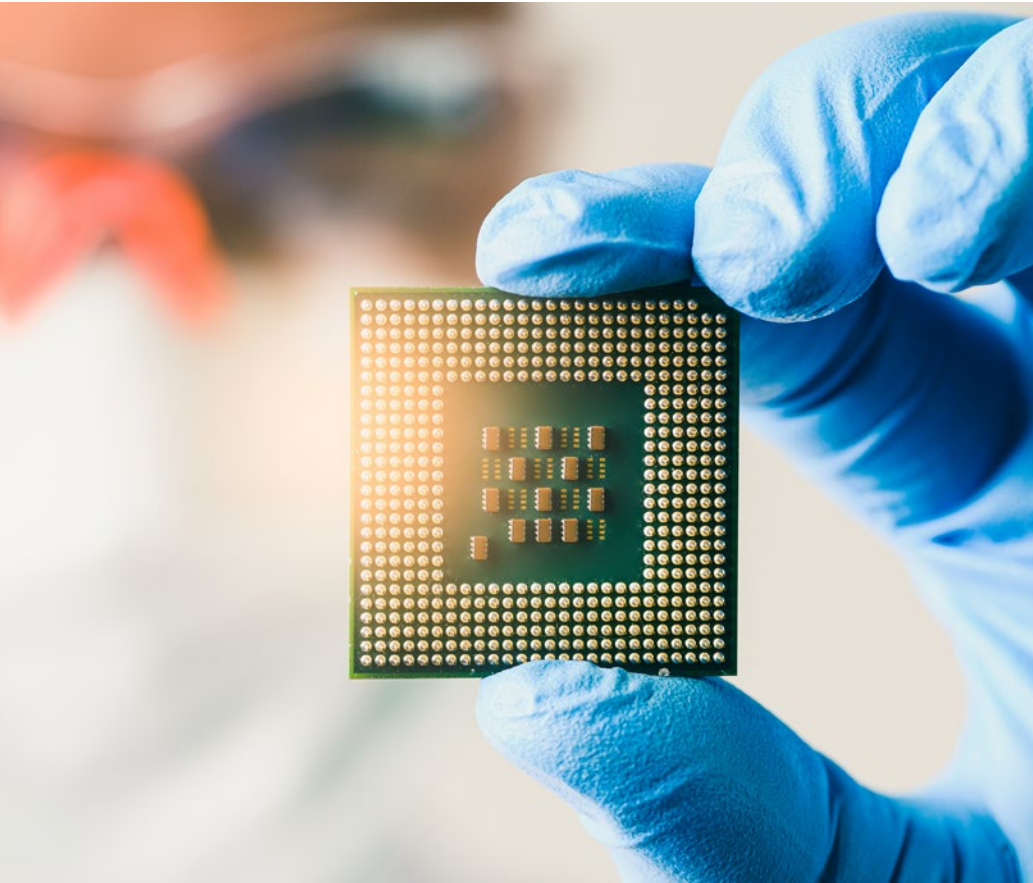
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Quantum Technologies





DEFENCE RESEARCH CAPABILITY CATEGORY: **QUANTUM TECHNOLOGIES**

UWA Competitive Advantage

- Precision patented technology based on hybrid photon-spin polaritons, which could in principle be used for highly sensitive measurements of the magnetic field, or wideband agile low-noise oscillators for radar and datacomms.
- Expertise in low-noise precision and quantum measurements, low temperature physics and hybrid quantum systems.
- Advanced mathematical methods and numerical techniques to model the dynamics of quantum systems and investigate quantum algorithms providing new possibilities for communication and data processing.
- New smaller sensors based on quantum and magnetic technologies with faster and more energy efficient electronics for communications, data processing/storage and for field-, substance-, gas- and bio-sensing.
- Miniaturized gravity gradiometer with improved performance and capable of being deployed from unmanned fast-moving platforms like UAVs, both airborne and submersibles.
- Interferometric Electromagnetic Gradiometer is ultra-sensitive and measures electromagnetic signatures created by submarines when they are silent and no acoustic tracking is possible. The system can be easily fit into fast moving unmanned submarine hunters such as drones, UAVs & AUVs.
- Microwave sensors that are ultra-sensitive and can localise radio frequency magnetic fields into a tiny volume with a range of applications.
- Precision oscillators and clocks including the world's best microwave oscillator which has been used in the most precise and sensitive defence radar systems, developed by Raytheon.

Development of new quantum sensor and quantum communications technologies that deliver unprecedented sensor performance and communications security. UWA are world leaders in low-noise precision measurement involving frequency, time and quantum systems.



Outcomes and Impact

- Developed the lowest noise microwave measurement and oscillator technology (including sapphire oscillators at room temperature and cryogenic temperature) in the world, necessary for application in the best precision frequency systems, such as atomic clocks and atomic qubits, resulting in systems operating at the quantum projection noise limit. These inventions were responsible for the products sold by Poseidon Scientific Instruments Pty Ltd (now owned by Raytheon) and are at the heart of all their defence radar.
- Developed technology to transfer stable frequencies over free-space, useful for timing, GPS navigation and datacomms applications. Variations of this technology have also been used in advanced radar systems, and to build ultra-sensitive sensors to detect magnetic, electric and gravitational observables.
- Patented novel hybrid opto-mechanical technology to miniaturise a device to measure gravity gradients, useful for the detection of tunnels.
- Patented a new type of quantum hybrid sensing element for an intrinsic gravity gradiometer (IGG) for use in sensing variation in a gravity field at a location.
- An ultra-stable and accurate atomic optical lattice clock was built, and the signal derived from its cryogenic sapphire oscillators (the ground clocks) will be compared with satellite clocks as part of the European Space Agency's mission Atomic Clock Ensemble in Space (ACES).

This pioneering development will allow orders-of-magnitude better timing and synchronisation of clocks around the globe.

Capabilities and facilities

Research Groups involved in this work include:

- [The Astrophotonics Group at ICRAR](#)
- [Quantum Clock flagship program](#)
- [The Quantum Information, Simulation and Algorithms \(QUISA\) Research Centre](#)

Facilities include:

- [The Quantum technologies and Dark Matter Lab \(QDM Lab\)](#)
- [ARC Centre of Excellence for Engineered Quantum Systems \(EQUS\)](#) and [QUANTX Labs](#)
- UWA Magnetic Characterisation Facility
- UWA Centre for Microscopy, Characterisation and Analysis
- The local node of the Australian National Fabrication Facility

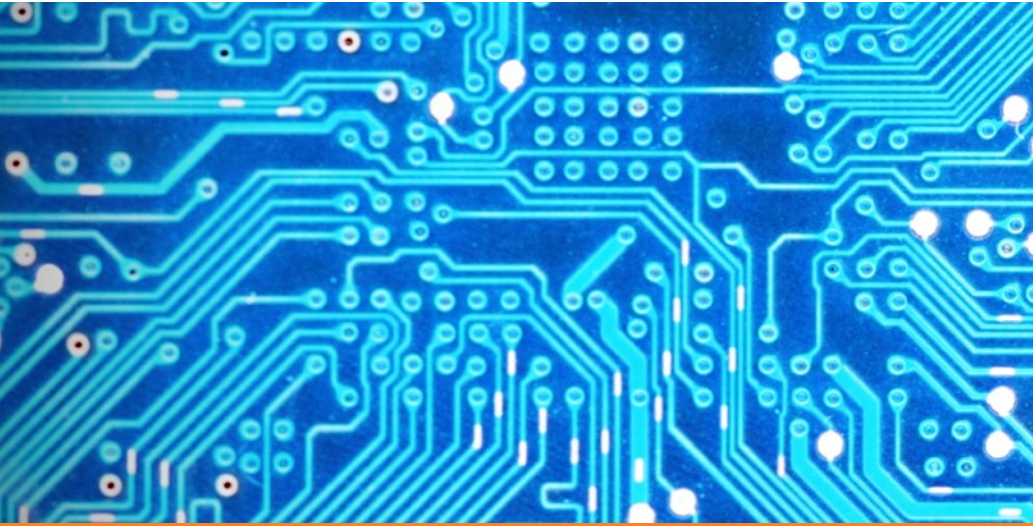
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A close-up photograph showing a person's hands holding a square microchip (likely a CPU or GPU) over a complex circuit board. The scene is lit with blue and orange light, creating a high-tech atmosphere. The background is blurred, focusing attention on the chip and the hands.

Trusted Autonomous Systems, AI & **Automation**





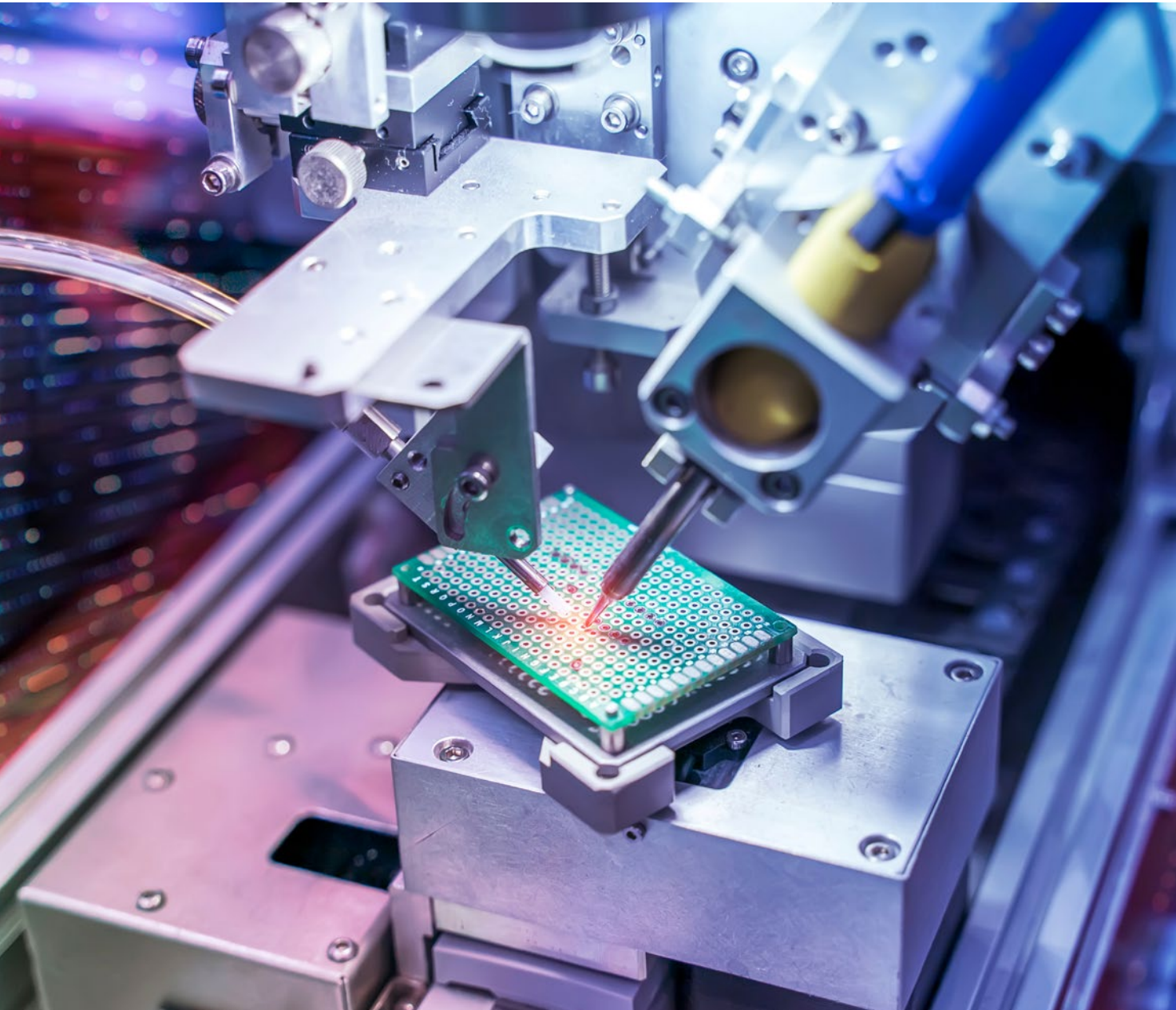
DEFENCE RESEARCH CAPABILITY CATEGORY: **TRUSTED AUTONOMOUS SYSTEMS, AI & AUTOMATION**

UWA Competitive Advantage

- Expertise in natural language processing, machine learning, human-automation teaming and explainable AI.
- Developing advanced algorithms for improved automation, collaborative reasoning and decision-making processes in human-machine teams.
- Measuring human trust in automation, designing for transparent automation, and the computational modelling of how humans allocate attention and make decisions when teamed with automation.
- Computational systems that adapt to or learn from the data, knowledge or environment in which they are working. These systems employ evolutionary, learning, optimisation and modelling techniques to solve or improve performance on complex problems. Current projects in the AI area include:
 - » applications of multi-objective evolutionary algorithms.
 - » evolutionary optimisation and design.
 - » hypervolume calculation for multi-objective optimisation.
 - » trust and social network analysis.
 - » integrating wind sensor and range finder scope information to automatically adjust the scope and thus accuracy of projectile direction in a rifle.
- Techniques that allow systems to sense and move within their own environment in either a fully self-directed or human-guided fashion.

Effective integration of information across machines (AI, automation) and humans (human-automation teaming) to achieve decision superiority on the modern battlefield. Applications include surveillance and reconnaissance, and real-time information processing, to enable military operations to be planned and executed with reduced risk to personnel and expensive platforms.

UWA researchers from diverse disciplines including computing and information systems, engineering, statistics and the psychological science work to enhance interactions between humans and machines to achieve human-automation teaming decision superiority on the battlefield.



Outcomes and Impact

- Robotics and automation research with proven applications in defence, mining and energy, medicine, advanced manufacturing and agriculture.
- Autonomous mobile robots, include intelligent driving and walking robots, autonomous underwater vehicles, and uninhabited aerial vehicles (reflecting outcomes from multidisciplinary collaboration between AI, computer vision, control robotics, signal and image processing robotics and automation).
- Extracting useful information and patterns (e.g. knowledge graphs) from large collections of industry data.
- Best practice guidelines for designing transparent and usable AI/ automated work systems (human-machine teaming)

Capabilities and facilities

Research Groups involved in this work include:

Task simulation facilities (e.g., submarine command and control, uninhibited vehicle management, maritime/air contact classification, air traffic control, driving) for human-automation teaming experimentation (human-in-the loop studies)

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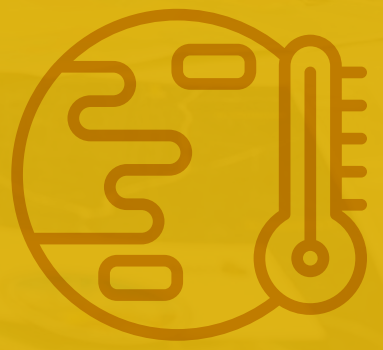
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Climate and Environmental Security





DEFENCE RESEARCH CAPABILITY CATEGORY: **CLIMATE AND ENVIRONMENTAL SECURITY**

UWA Competitive Advantage

- Multidisciplinary teams to address not only technical and biological aspects of the environment, but also economic, social, behavioural, policy and decision-making aspects.
- Expertise across the key environmental issues, including climate change, renewable energy, soil degradation, land restoration, water, vegetation, pollution and natural hazards.
- Research into the Economics of natural hazard events including how to measure the intangible social and environmental outcomes and their mitigation options, and integrate these in decision support platforms that weigh up the financial, social and environmental benefits and costs of mitigation decisions.
- Research into coastal ocean influence on climatic, biological and geological processes, Aquatic Ecology and Ecosystem Studies. With a focus on the study of water resources (water and wastewater), ecological engineering and environmental engineering, with an emphasis on the development of innovative technologies.
- Integrated Coastal Analyses and Sensor Technology (ICoAST) is developing technologies and workflows, collecting and analysing data from drones and autonomous vessels of nearshore variables including bathymetry, waves and currents. These data are key for understanding coastal ocean processes, marine habitat dynamics, and have a range of defence applications.
- Research on the occurrence, roles and food-security implications of dangerous fungal, bacterial and viral threats in food crops, livestock pastures and plant produce in Australia to ensure the security of associated livestock and food chains.
- Research on nutrient uptake and ion toxicity in the soil-plant-water-microbe continuum, including work on major nutrients, micronutrients and toxic ions, aluminium, arsenic, zinc and sodium.

Research and expertise on environmental issues and climate change that will facilitate the planning and effective implementation of the Defence response to climate related threats. This includes research on climate change, renewable energy, water, pollution and natural hazards.

UWA has world-recognised researchers active in climate and environmental research from a variety of discipline areas, including physical sciences, biological sciences, engineering, medicine, and social sciences.



Outcomes and Impact

- Identification and elimination of threats from the evolution of dangerous new races of fungal and bacterial toxin profiles resulting from increasingly changing climates and farming systems.

Capabilities and facilities

- UWA's Oceans Institute, the Institute of Agriculture, the Centre for Environmental Economics and Policy, and the Centre for Energy.
- Strong operational and scientific links with the multidisciplinary Cooperative Research Centre for Water Sensitive Cities (CRCWSC) established in 2012.

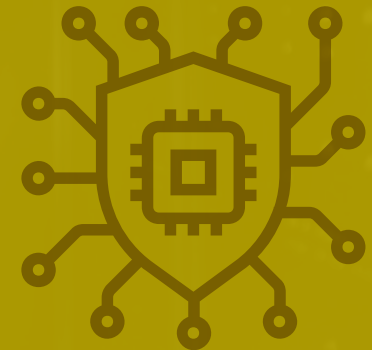
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Cyber and Information Warfare





DEFENCE RESEARCH CAPABILITY CATEGORY: **CYBER AND INFORMATION WARFARE**

UWA Competitive Advantage

- Researchers from multi-disciplinary teams including psychology, human factors, social and behavioural science, economics, computer science, and cybersecurity.
- Research toward secure, assured and resilient information systems as relied on by Defence, including; Moving Target Defence, Network modelling and analysis, anomaly detection and malware analysis.
- Using artificial intelligence (AI) and deep learning to improve the detection and mitigation of misinformation and fraud.
- Experimental and computational simulations to precisely determine the effects of misinformation on cognition and behaviour.
- Design of pre-bunking and de-bunking interventions to reduce the impact and spread of misinformation.
- Predicting the outcomes of collective human behaviour (e.g., information transmission and transformation).
- Research into human culture, cultural evolution, and culture change including communication, social influence and misinformation management in social media).

Research and development to identify and address the threats to Australia's defence and national security presented by information and communications technology dependencies and vulnerabilities.

UWA has world-leading expertise in conducting research on human information processing and transmission, the mechanisms of social influence, and, more broadly, culture and its evolution. This helps agencies identify false information, conspiracy theories, and online radicalisation, anticipate its spread and impact, and develop strategies to counteract malign informational influence.



Outcomes and Impact

- Misinformation impacts on cognition and behaviour and mitigation strategies including effectively debunking misinformation, reducing misconceptions, and better preparing people for future misinformation.
- Fostering information and media literacy, critical thinking.

Capabilities and facilities

- Design of pre-bunking and de-bunking interventions.

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Defence and Security
Policy, Law and Ethics





DEFENCE RESEARCH CAPABILITY CATEGORY: **DEFENCE AND SECURITY POLICY, LAW AND ETHICS**

UWA Competitive Advantage

- Strategic defence analysis and national security policy law and ethics.
- Political decision making and effective diplomacy.
- Economics and effective resourcing of defence services.
- Geo-politics, international relations and law, geography, alliances, capabilities and strategic ends, including energy security and supply lines, and security of other critical resources and related economic needs.
- Determinants of terrorism.
- Indo-Pacific security.
- Laws of the sea and transnational crime such as maritime piracy, illegal fishing and trafficking.

Analysing, assessing and articulating Australia's strategic ambitions, including Defence capabilities, relies on a thorough understanding of its social, ethical, legal, political and economic needs.

UWA's expertise in Defence and Security Policy, law and ethics analyses and investigates Australia's strategic ambitions, economic position and defence needs. Similarly, UWA has significant research capacity in understanding the global security landscape, particularly in the Indo-pacific region including Australia, China, Indonesia, India, Korea, east Africa and the United States.



Outcomes and Impact

- Black Swan Strategy Papers with analysis and strategic insights into defence and security in the Indo-Pacific region.

Capabilities and facilities

- Host to the Perth USAsia Centre, a leading think tank focusing in geopolitical issues, policy development and building strategic affairs.
- Host to the Defence and Security Institute that focusses UWA's expertise in defence and security research, engagement and education to develop Australia's sovereign defence capabilities.

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Indian Ocean Maritime Security and Defence





DEFENCE RESEARCH CAPABILITY CATEGORY: INDIAN OCEAN MARITIME SECURITY AND DEFENCE

UWA Competitive Advantage

- UWA's location in Perth, Australia's Indian Ocean capital, has facilitated a depth of expertise on the strategic significance Indian Ocean region including research in the natural, human and social sciences.
 - Maritime security and defence research include the geopolitics of the Indian Ocean and the broader Indo-Pacific region.
 - The politics and security of states on the Indian Ocean littoral through Southeast Asia, South Asia, the Middle East, and East Africa.
 - The security implications of the Ocean's role as a commercial and energy superhighway.
 - The role of the ADF in general and the RAN in particular in the defence of the Indian Ocean and its multiple maritime chokepoints.
 - The United States' evolving strategy toward the Indian Ocean region and consequences of increasing geostrategic tension and US-China superpower rivalry.
- The economic importance of the trade, strategic oil and energy supplies which flow through the Indian Ocean Region.
 - Key strategic assets and vulnerabilities for both Western Australia and Australia, such as the Gorgon and North West Shelf oil and gas fields, most of the nation's iron ore, and significant rare earth mineral deposits (key to diversifying global markets currently dominated by China) all sit on the Indian Ocean.

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The Indian Ocean is a commercial and energy superhighway with multiple chokepoints. Its maritime security and defence require information and expertise about the security of the Indian Ocean and the broader Indo-Pacific region; security and geopolitics of its littoral states; consequences of rising tensions between rivaling superpowers; and the role of the military in its defence.



Integrated Intelligence, **Surveillance and Reconnaissance**





DEFENCE RESEARCH CAPABILITY CATEGORY: **INTEGRATED INTELLIGENCE, SURVEILLANCE AND RECONNAISSANCE**

UWA Competitive Advantage

- Infrared Imaging Array technologies with applications in: Night vision and security; Remote weapons targeting systems; Intelligence, surveillance, and reconnaissance (ISR); Missile detection systems; Missile guidance and targeting; Space situational awareness; and Remote sensing.
- Optical micro-electro-mechanical systems (MEMS) based technologies with applications in: Stand-off detection of improvised threats; Multi-spectral remote sensing and imaging; Space situational awareness; Target signature recognition and identification; Optical waveguide switching for electronic warfare; High sensitivity magnetometers; Gas, chemical, and bio sensing.
- Modelling and measurement of the effects of the atmosphere on free-space light propagation.
- Modelling of the effect of atmospheric scintillation in satellite/ground optical communications.
- Remote Sensing and Sensing Networks research groups with robotics and automation expertise in:
 - » sensor networks and data integration
 - » image analysis and recognition systems
 - » automatic target detection, recognition and tracking
 - » audio-visual biometrics dealing with authenticating persons accessing sensitive data or secure areas
 - » acoustic array design and signal processing
 - » acoustic scene classification
 - » audio source separation and enhancement – spoofing and counter-measures

Collection and integration of information from ISR sources and tactical systems in real or near real time to support decision making. Interoperability with allies. Automated information processing and reasoning. Distributed multi-domain networks. Human and Artificial Intelligence (AI) interaction.

Successful military operations rely on effective and integrated Intelligence, Surveillance and Reconnaissance.



- » GIS and remote sensing including via satellite and drones that involve use of remotely sensed data and drone-collected information
- » rigid body motion, flocking and collective motion
- » monitoring dynamic systems with incomplete information
- » statistical analysis of key events
- » spatial analytics
- » analytic and differential geometry
- » very large-scale data analytics.
- Information Systems/Technology including economic and quantitative analysis.
- Compliance Monitoring for Anomaly detection (CMAD) in complex environments including the stock market, energy and petroleum industry; engineering asset management; aerospace and defence.
- Information management including, knowledge management, decision support, Agent technology, e-Commerce, Artificial Intelligence applied to Business, and Asset Management work flow decision support.
- Research into creating nanomaterials for camouflaging 3D objects including expertise from biology, physics, visual psychology, art, and computer vision.

Outcomes and Impact

- Investigative forensics (effectively DNA barcoding), including trace botanical DNA provides spatio-temporal biomarkers to supply evidence on the relationships and movements of materials and people of interest.
- New data processing and modelling techniques and systems are being developed to make sense of big data including algorithms to identify features of interest and then mining to discover the underlying patterns and structure. Research in data management, optimisation and analytics at the exa-scale contributes to the following areas:
 - » real-time streaming, processing data at the time of acquisition for cleaning and efficient storage.
 - » data representation, designing quality representation frameworks for efficient storage, retrieval and servicing of data.
 - » unstructured data, designing efficient methods for pre-processing and integrating different types of data (numerical, textual, images, audio, video).
 - » integration data from many different sources.
 - » cleaning raw data to minimise inconsistencies that prevent automatic analysis.
 - » Data modelling involving mathematical, statistical and computational methodology is used to understand complex systems and processes and problems. Applications include;
 - » decision making for reliability and asset management, with a focus on longitudinal and time-to-event methodology, particularly designing remaining useful life models for machinery.
 - » behaviour and stability of complex systems, or example the effect of renewable energy generation in distributed power networks.
 - » predicting crowd dynamics and social interaction, the spread of disease among remote communities, or the spread of bushfire through varied terrain.
 - » computer vision and pattern recognition, tomography and geometric methods, combined with machine learning to analyse image-based data sets, to map out and identify data patterns for interpretation.
- Low cost sensing technologies designed for real-world applications with foci including the environment, infrastructure monitoring and airborne remote sensing.
- A new class of sensors operating in the IR part of the spectrum that provide unique multi-spectral sensing capabilities with reduced size, weight and power requirements. Applications in multi-spectral imaging, night vision, and standoff spectroscopy sensors, with a strong focus on ISR applications in defence and security.

Capabilities and facilities

- UWA is a member of the Pawsey Supercomputing Centre, which operates multiple supercomputers, data-intensive machines and storage systems that use the most advanced technologies available.
- The International Centre for Radio Astronomy Research (ICRAR), which supports the development of the world's largest radio telescope, the Square Kilometre Array (SKA). ICRAR's engineering program specialises in antenna design, radio-frequency engineering, electromagnetic compatibility, high-performance computing, digital systems and software engineering.
- The School of Biological Sciences has capabilities in:
 - » identification of biological material through DNA barcoding.
 - » identification of complex pollen mixtures through DNA metabarcoding.
 - » biogeographic interpretation of botanical data, and comparison of species composition across samples.
 - » method development in forensic applications of DNA barcoding and metabarcoding.
- The Microelectronics Research Group runs a completely vertically integrated Facility for sensors, from materials growth, through device design, fabrication and testing, to packaging and sub-system assembly.

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Space Capabilities





DEFENCE RESEARCH CAPABILITY CATEGORY: **SPACE CAPABILITIES**

UWA Competitive Advantage

- End-to-end design, construction, data processing and science extraction for the Square Kilometer Array (SKA).
- Specialisation in antenna design, radio-frequency engineering, electromagnetic compatibility, high-performance computing, digital systems and software engineering.
- Space situational awareness and surveillance including tracking near earth asteroids and natural debris through The Zadko Observatory and studying surface degradation of satellites.
- World-leaders in stable laser transmissions through the turbulent atmosphere for fundamental and applied science, and laser communications.
- Developing ground-to-space laser links for high-precision optical metrology, laser communications from spacecraft, and quantum key distribution experiments.
- Atmospheric effects and optical propagation projects with NICT, DSTG, and also the US Navy laboratories (the Space and Naval Warfare Systems Command, SPAWAR).
- Ongoing collaborations and projects with space industry and research partners including the European (ESA), Polish (POLSA) and Japanese (JAXA) Space Agencies, French Space Agency (CNES) and national metrology institute (SYRTE), Goonhilly Earth Station, Ariane Group, Numerica Inc., Thales Alenia Space, SmartSat CRC, the Australian Space Agency, and Defence.
- Development of a space lubricant that does not evaporate in a vacuum.

De-risking Defence's dependence on space-based systems through technical expertise and enhanced capability agility. Innovative, reliable and resilient space constellation technologies across communications, Position, Navigation and Timing (PNT) and Intelligence, Surveillance and Reconnaissance (ISR) for deployed forces, Defence and National Security.

Space is now a warfighting domain that is becoming increasingly congested and contested.



Outcomes and Impact

- Ground-station support from CubeSat to Deep Space missions.
- Space debris monitoring using either UWA facilities or facilities hosted by UWA.
- Launch tracking capacity (in collaboration with ESA and Airbus).
- Detector and sensor development.
- Advanced space data analysis tools.
- Successful delivery of the Murchison Widefield Array (MWA) and several SKA verification systems.

Capabilities and facilities

- Pawsey Supercomputing Centre, which operates multiple supercomputers, data-intensive machines and storage systems.
- Western Australian Space Centre (WASC) hosts NASA's satellite laser ranging facility, one of only two stations in the Southern Hemisphere.
- UWA has developed the necessary expertise and specialised equipment to operate a dedicated Astronomy and Space Instrumentation Lab.
- UWA operates Gingin observatory which hosts rapid response, launch tracking and space debris tracking facilities and the Zadko telescope.
- Western Australian Optical Ground Station (WAOGS), the first laser ground station in the southern hemisphere, based on a 0.7m robotic telescope installed at the UWA campus.

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Enhanced Human & Team Performance





DEFENCE RESEARCH CAPABILITY CATEGORY: **ENHANCED HUMAN & TEAM PERFORMANCE**

UWA Competitive Advantage

- Collaborating on cognitive science and human factors-based innovations with the ADF and DST to maximise the resilience, responsiveness and adaptability of ADF individual operators and teams.
- Measurement of individual and team process and performance, workload, situation awareness, and perceptions of system trust and usability.
- Behavioural Insights for Technology Adoption in identifying which behaviours may constrain the adoption of new technologies to help address Australia's strategic challenges.
- Optimising operator task load and predicting risky behaviour using adaptive technology.
- Human perception and attention research to develop battle-ready platforms; including, development of visualisation tools; developing and evaluating augmented reality and virtual reality.
- Human-in-the-loop testing of innovative work design concepts in the submarine Control Room Use Simulation Environment (CRUSE) to achieve ADF undersea decision superiority
- Kinanthropometry and physiological function in challenging environments including body temperature regulations in hot and humid environments.
- Human and organisational factors and their role in maintenance dependability and reliability on Submarines in collaboration with the RAN.
- Combatting misinformation.

Enhancing personnel resilience and capability, including superior training and preparation for the strenuous cognitive and physical tasks associated with operations, or through significant improvements to cognition, endurance and protection during operations.

UWA conducts research to understand and enhance interactions between humans, technology and the operational environment to maximise individual and team process, cognition, and performance. This can provide decision-superiority and operational advantage across varied domains of warfare (air, maritime, land, space and information/cyber).



Outcomes and Impact

- Reliable and valid measures of situation awareness, workload, team process, and performance for Defence application.
- Personnel selection and training interventions to improve soldier situation awareness, workload management and battle-readiness.
- Empirical evidence-bases for best practice (work design) in ADF human-automation teaming settings.
- Evaluation of operator workload and performance under different technology concepts for augmented reality displays in battlefield environments.
- Innovative human-machine interfaces that optimise the integration of advanced robotics platforms with human counterparts.

Capabilities and facilities

Research Groups involved in this work include:

- Sensory Neuroscience, Attention and Perception (SNAP) Laboratory

Facilities include:

- Task simulation facilities (e.g., submarine command and control, uninhibited vehicle management, maritime/air contact classification, air traffic control, driving) for individual operator and team-level experimentation (human-in-the loop studies)
- Virtual reality (VR) facilities that simulate augmented display technology for dismounted combatants

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