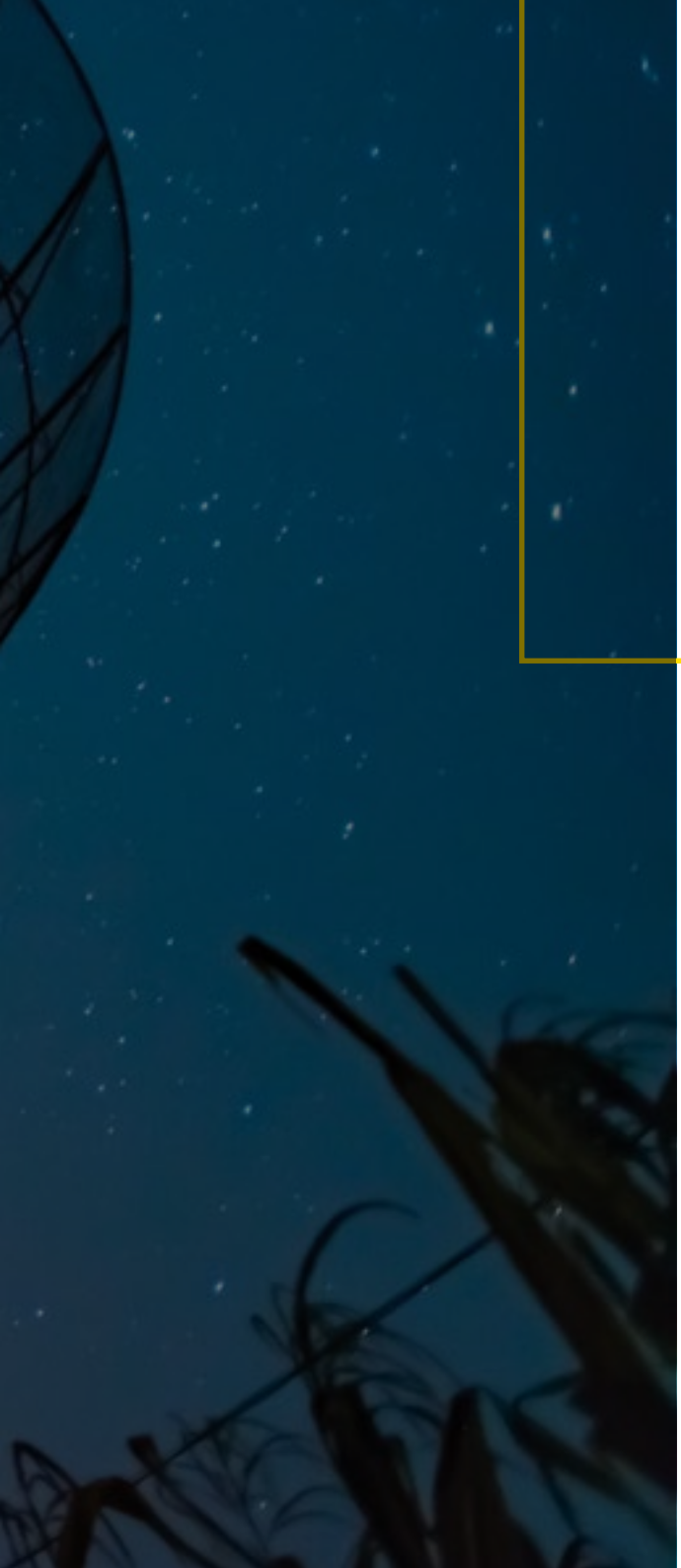
UNSW

Defence Research and Technology

Capability Portfolio

UNSW, Your Defence Research Partner



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FROM THE PRESIDENT AND VICE-CHANCELLOR

UNSW is proud of its contribution to Australia's security through its enduring and evolving relationship with the Australian Defence Force and defence industries.

We have worked with our defence forces over the last 50 years and responded to their changing needs.

When our first students enrolled at the Australian Defence Force Academy in 1968, Australia was in the middle of its involvement in the Vietnam War – a time when field telephones and paper maps were still being used.

Today's servicemen and women operate in a very different era, and they rely on partners to equip them – physically and intellectually – to meet the demands of a constantly changing, high-tech defence environment.

Working across both our Sydney and Canberra campuses the UNSW Defence Research Institute will add a critical dimension to preparing our defence forces across areas as diverse as public sector management and conflict studies; cyber security; space; systems engineering; and logistics.

This Defence Capability Portfolio showcases UNSW excellence in defence research and technology and highlights our work across academia, government and industry, as well as with global policy makers, to create a hub of defence-related knowledge. Our vision is to translate this knowledge into impact which can transform Australian and global societies.

As with so much of the work we are doing at UNSW, collaboration and partnership is key to the success of this venture.

We enjoy close, productive ties with the State and Commonwealth governments. On the industry side we also have extensive engagement with companies like Thales, Raytheon, Northrop Grumman, Lockheed Martin, BAE Systems, Boeing and Naval.

It just makes good sense to centralise experience and knowledge and foster collaboration, from across the country and across sectors, if we are to achieve the best outcomes for the communities we serve. And that is a central pillar of our institution's mission.

We look forward to strengthening existing partnerships and forming new ones in pursuit of this mission.

Professor Ian Jacobs
President and Vice-Chancellor, UNSW

FROM THE DEPUTY VICE-CHANCELLOR ENTERPRISE

The UNSW Division of Enterprise is responsible for facilitating engagement between our academics and partners across government, industry and the defence community. In the last five years we have undertaken close to 100 projects with the Department of Defence through the Defence Science Technology Group, valued at over $16m. This incorporates a vast range of capability and technology across the majority of our faculties including UNSW Canberra, Engineering, Science and Medicine. We engage in all of the eleven key science and technology capability areas identified by DST Group.

UNSW is committed to engaging with our partners to deliver social progress and economic prosperity, generating impact, mutual benefit and value. In support of this mission, through collaboration and innovation the Division of Enterprise aims to bring together the greatest minds within global industry, policy, academia and our community and build a culture of knowledge exchange.

UNSW is known to host Australia's most comprehensive entrepreneurship program and our dedication to establishing the critical elements of an innovation ecosystem underpins the development and potential impact of our on-campus precincts in future industries, health and clinical translation.

We are the only national academic institution with an integrated defence focus centred around our Defence Research Institute. We have state-of-the-art research infrastructure and expertise in defence research areas such as cyber security, space, systems engineering, artificial intelligence, logistics, hypersonics, defence related public sector management and conflict studies. In collaboration with our local and international partners, we have a critical role to play in translating world-class defence and national security research into transformational solutions with enduring impact.

With the release of this Capability Portfolio we invite our partners, both prospective and current from industry, government and the community, to explore just some of the expertise on offerand look forward to exploring opportunities for collaboration, innovation and impact.

Professor Brian Boyle
Deputy Vice-Chancellor, Enterprise, UNSW

AUTONOMOUS SYSTEMS

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Autonomous Field Vehicles

Persistent autonomous operation of commercial-grade field vehicles such as agricultural tractors, bulldozers and other mining vehicles, military vehicles and civil construction vehicles.

Competitive advantage

Patented autonomous vehicle systems technology, which allows vehicles to operate without drivers, increasing productivity and reducing operational costs

- The technology is fully tested and commercial ready
- The machines are highly intelligent and backed by sophisticated multi-sensor data fusion, advanced image processing, and complex non-linear vehicle guidance algorithms

Impact

- Lower cost transport, agricultural and mining operations
- Vehicle operations in high risk environments. e.g IED countermeasures

Successful applications

- Developed and built high precision autonomously-guided construction machinery for Makinex
- Converted Komatsu D65-EX bulldozer to a full autonomous bulldozer in partnership with Komatsu
- Completely developed and patented a sophisticated high-precision broad acre planter for Grains Research and Development Corporation (GRDC)

Capabilities and facilities

- Multi-sensor ground-based and airborne precision 3D terrain mapping systems
- Advanced image processing algorithms for image enhancement
- Advanced and robust vehicle guidance algorithms for all types of drive and steer systems
- Sophisticated data compression and data fusion algorithms

More information

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Travel Choice Simulation Laboratory

A unique laboratory that aims to investigate the travel choice behaviour of car drivers. It is the world's first laboratory in which multiple human drivers are able to drive around and interact in a single, virtual world.

Competitive advantage

- Pioneering work to study individual and group behaviour, and interactions with autonomous systems and data
- Interdisciplinary collaboration with world-leading researchers in travel choice, econometrics, experimental economics, simulation and transport network analysis
- The laboratory is portable, which brings significant potential for international collaboration and allows experiments to be conducted anywhere there is a high-speed internet connection

Impact

- Working towards safer, more efficient road transport systems

Successful applications

- Understand driver choices in autonomous vehicles (Insurer)
- Address the human factors critical to the successful deployment of automated vehicles (Australian Research Council linkage with government agencies, insurance companies and university partners)

Capabilities and facilities

- Eye-tracking and psycho-physiological monitoring equipment
- Five driving simulators and one bicycle simulator, all interconnected and able to interact with driving simulators at a partner university
- Fully instrumented vehicle that can be controlled remotely

Our partners

- Google
- United States Department of Transportation
- Government of India
- Defence Science and Technology
- AustRoads

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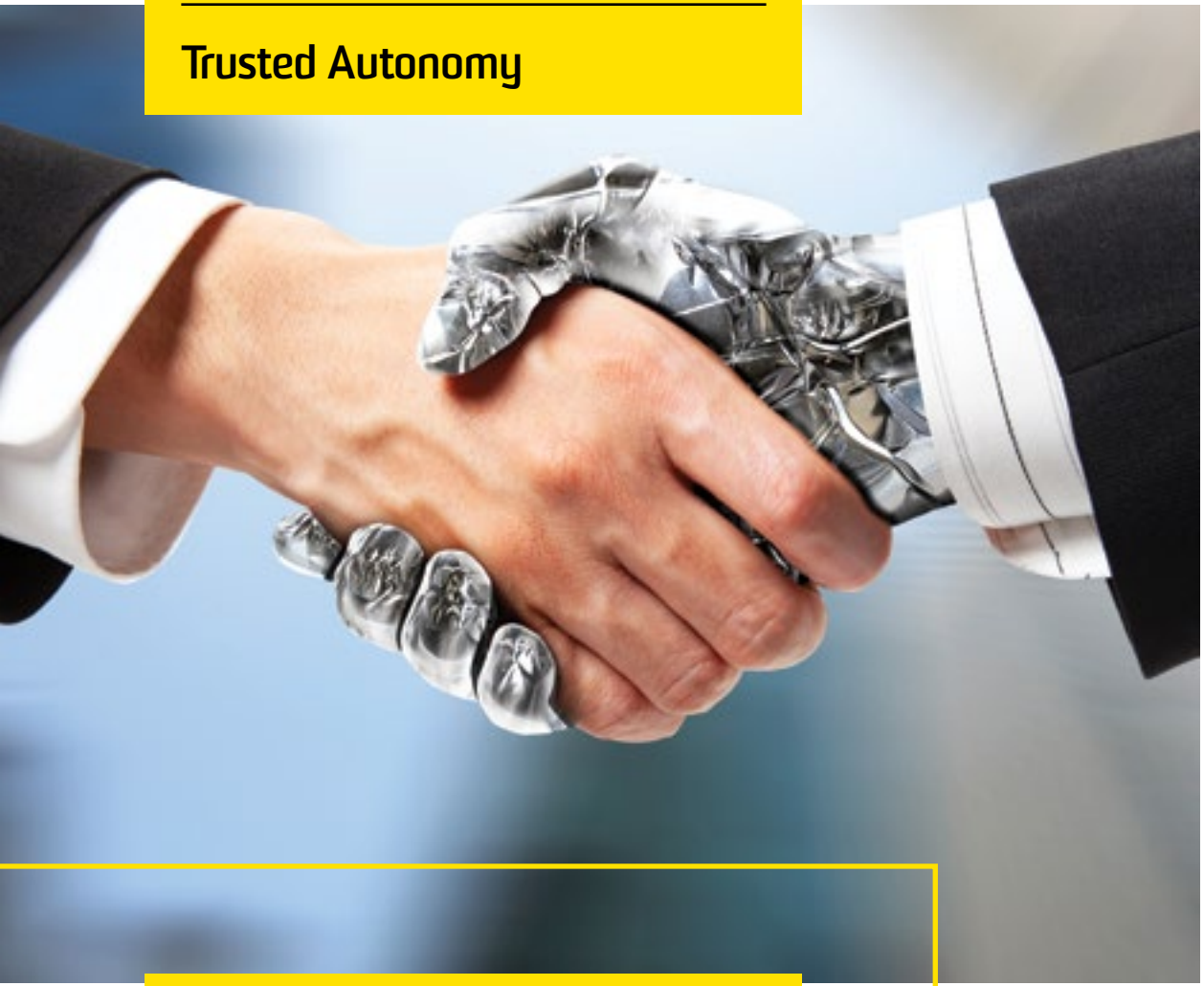
Trusted Autonomy



Trusted autonomy is a game-changing area of defence research centred on understanding and engineering the interaction space between humans and machines.

Competitive advantage

- Unique combination of skills covering robotics, AI, simulation and ethics
- Long-standing and deep ties with Defence
- Outstanding facilities for simulation and robotics
- Focus on trusted human-autonomy teaming

Impact

- More effective solutions to technological challenges including the deployment of autonomous vehicles, activities at the human-machine interface, high-fidelity military simulations and multi-robot operations in unknown and complex environments
- More agile and accurate decision-making cycles

Successful applications

- Swarm-based machine learning with knowledge sharing
- Demonstration of learning-to-fly from scratch on real unmanned aerial vehicles (UAVs) using neural networks and evolutionary fuzzy systems
- Demonstration of visual flight control of UAVs for flight in cluttered areas and landing on moving platforms
- Development of human performance surrogates for high-fidelity military simulations
- Hierarchical deep learning algorithms for robot control

Capabilities and facilities

- Large indoor UGV/UAV flight area and VICON motion capture system
- Distributed simulation laboratory
- Virtual environment and simulation laboratory
- EEG equipment for monitoring human cognitive state

Our partners

- Australian Army
- The Commonwealth Scientific and Industrial Research Organisation (CSIRO)
- Department of Defence Science and Technology (DST)
- Air Force Office of Scientific Research
- US Army
- Indonesian Institute of Sciences

More information

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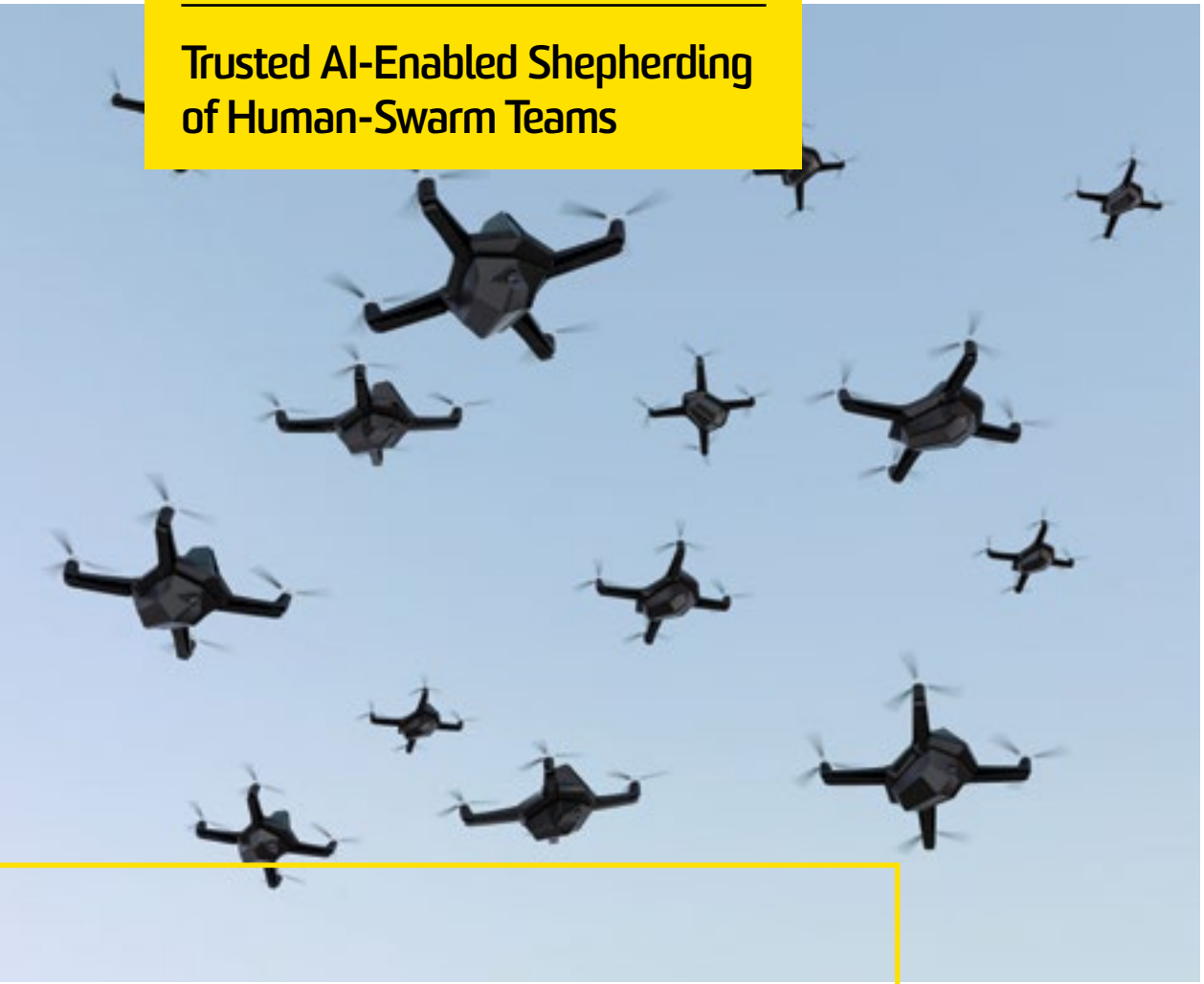
Trusted AI-Enabled Shepherding of Human-Swarm Teams



Technology to enable trusted inter-operation between humans and swarms of autonomous systems and platforms. Shepherding is the ability to guide, influence or reshape a group of autonomous systems towards a goal with optimised efforts to the shepherd and the group.

Competitive advantage

- A unique fully-distributed human-swarm and swarm-on-swarm systems exist that can scale arbitrarily to any size with minimum complexity. This technology achieves this in a structured, verifiable, trustworthy and scalable manner
- Multidisciplinary team with the capacity and facilities to prototype concepts theoretically, through simulation and on real-platforms
- Novel architectures to enable efficient, low-CPU, and highly smart AI-enabled swarm systems

Impact

- Enable commanders to take responsibility of large (semi-) autonomous heterogeneous swarms in a trusted, verifiable, and accountable manner
- CPU and power efficient, highly smart AI-enabled swarm systems
- Autonomous real-time management of the human-swarm relationship
- Scalability of human-swarm logic
- Transparent, explainable, and adaptive swarm control-logic
- Trusted human-swarm operations

Successful applications

- Autonomous coordination policies in ground-air unmanned systems interaction
- Autonomous learning, reasoning and decision-making in dynamic heterogeneous swarm environments
- Distributed contextual awareness for multi-agent systems and its application to military land vehicles

Capabilities and facilities

- Indoor Unmanned Aerial Vehicle (UAV) testing facilities
- High-fidelity simulation environments including air traffic management and modelling of uninhabited all-domains vehicles (UxVs)
- A variety of unmanned ground and air vehicles

Our partners

- Defence Science and Technology (DST)
- US Office of Naval Research
- US Air Force Office of Scientific Research
- US Army International Technology Center Pacific (ITC-PAC)

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Intelligent Human-Machine Cooperation

Developing interpretable data mining, machine learning and deep learning algorithms—as well as designing systems and interfaces—to enable novel ways of human-machine interactions, including an improved understanding of challenges such as trust, explainability and resilience that improve human-autonomy partnership.

Competitive advantage

A deep understanding of:

- Human behaviour analysis from heterogeneous digital footprints
- Anomaly detection: identifying rare or unusual events or observations
- Information filtering: teaching machines how to proactively discover an item of interest and making computers aware of situations to assist humans to make better decisions
- Brain-computer interface: building a direct communication pathway between the human brain and an external device in the outside world

Impact

- Advanced algorithms for improved automation and better support for human-autonomy partnership
- Advanced data analysis for improved collaborative reasoning and decision-making process

Successful applications

- Trust-aware distributed AI autonomy
- Context-aware intent prediction for human-autonomy cooperation
- Improving resilience of autonomous cyber defence systems with self-healing
- Opinion fraud detection
- Thing-of-interest recommendation in the Internet of Things
- Human abnormal activity detection
- Mining Internet of Things intelligence

Capabilities and facilities

- GPU-accelerated Data Analytical Platform
- More information

Our partners

- Data61
- US Navy Office of Naval Research
- Department of Defence, Science and Technology (DST)
- Data to Decisions Cooperative Research Centre (CRC)

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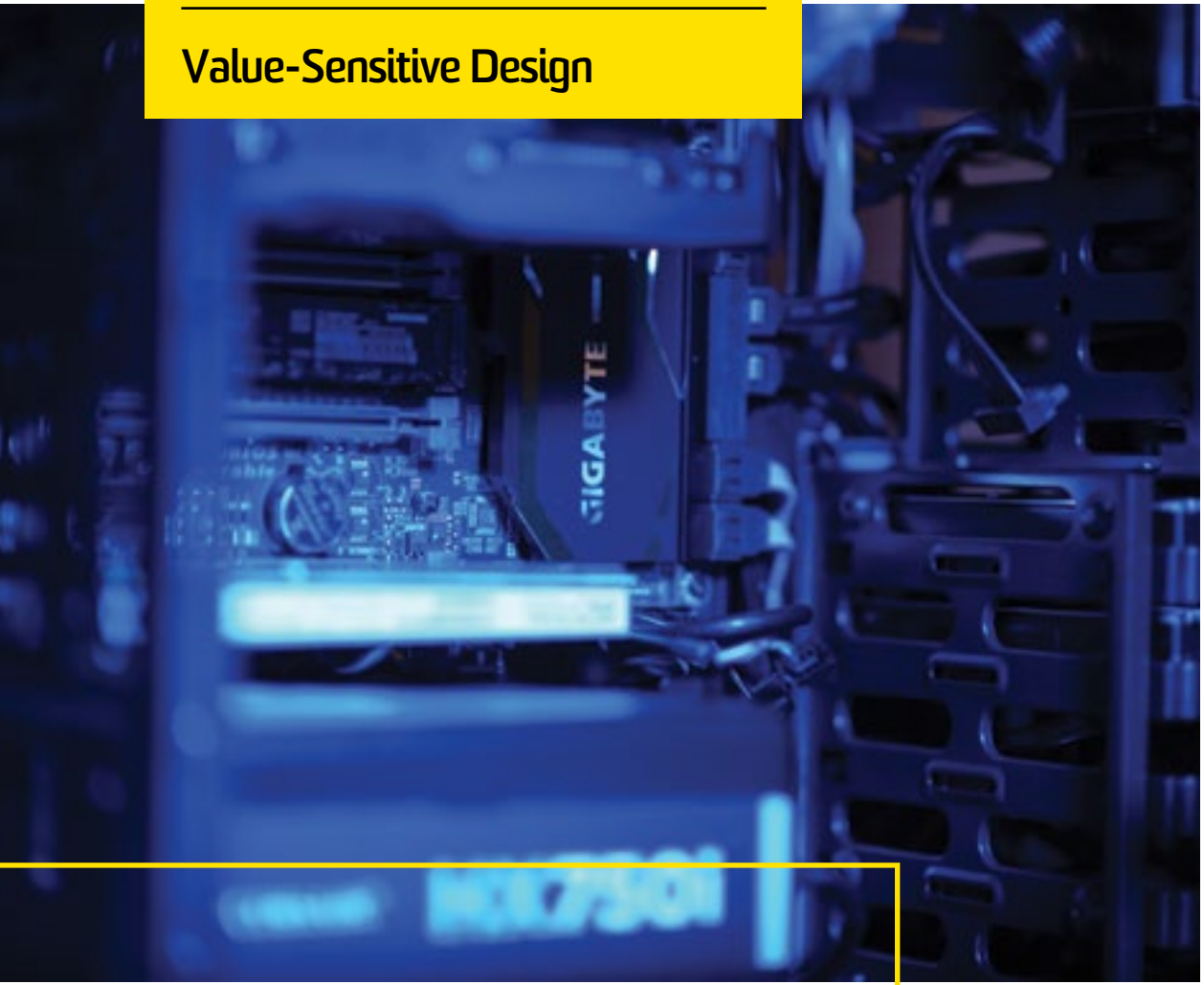
Value-Sensitive Design



Design is a value-driven activity, although the ethical, legal and social values often remain implicit and unarticulated. We specialise in teasing out these values with a unique methodology to build robot/AI, cyber and human enhancement systems that are more effective, efficient and better accepted by users, clients and the public.

Competitive advantage

- Australia's first and only team dedicated to inserting specific organisational values into emerging military and security products or services with the aim of enhancing outcomes and user experience
- Expertise influencing the regulation of emerging technologies at the national and international level, including United Nations regulatory efforts
- Demonstrated experience positively managing the media's coverage of specific technologies
- A unique value-sensitive design method proven to yield better design outcomes than non-value sensitive processes

Impact

- Prevent technology from being misused, underutilised or disused
- Provision of enhanced understanding of user requirements in the capability development lifecycle
- Better alignment of technology with societal values, limiting negative PR

Successful applications

- Currently conducting a $1 million study of the ethical and legal implications of the US DoD's development of drones
- Delivering a multi-million-dollar long-term program for an Australian Defence partner embedding ethics and law into the design of future autonomous weapons

Capabilities and facilities

- An interdisciplinary and international team of ethicists, lawyers, sociologists, cognitive scientists and engineers, many with active security clearances
- Access to cutting-edge tools – social robotics, small aerial imagery drones

Our partners

- The Australian and US Departments of Defence

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COMMUNICATIONS, DIGITAL, QUANTUM AND CYBER

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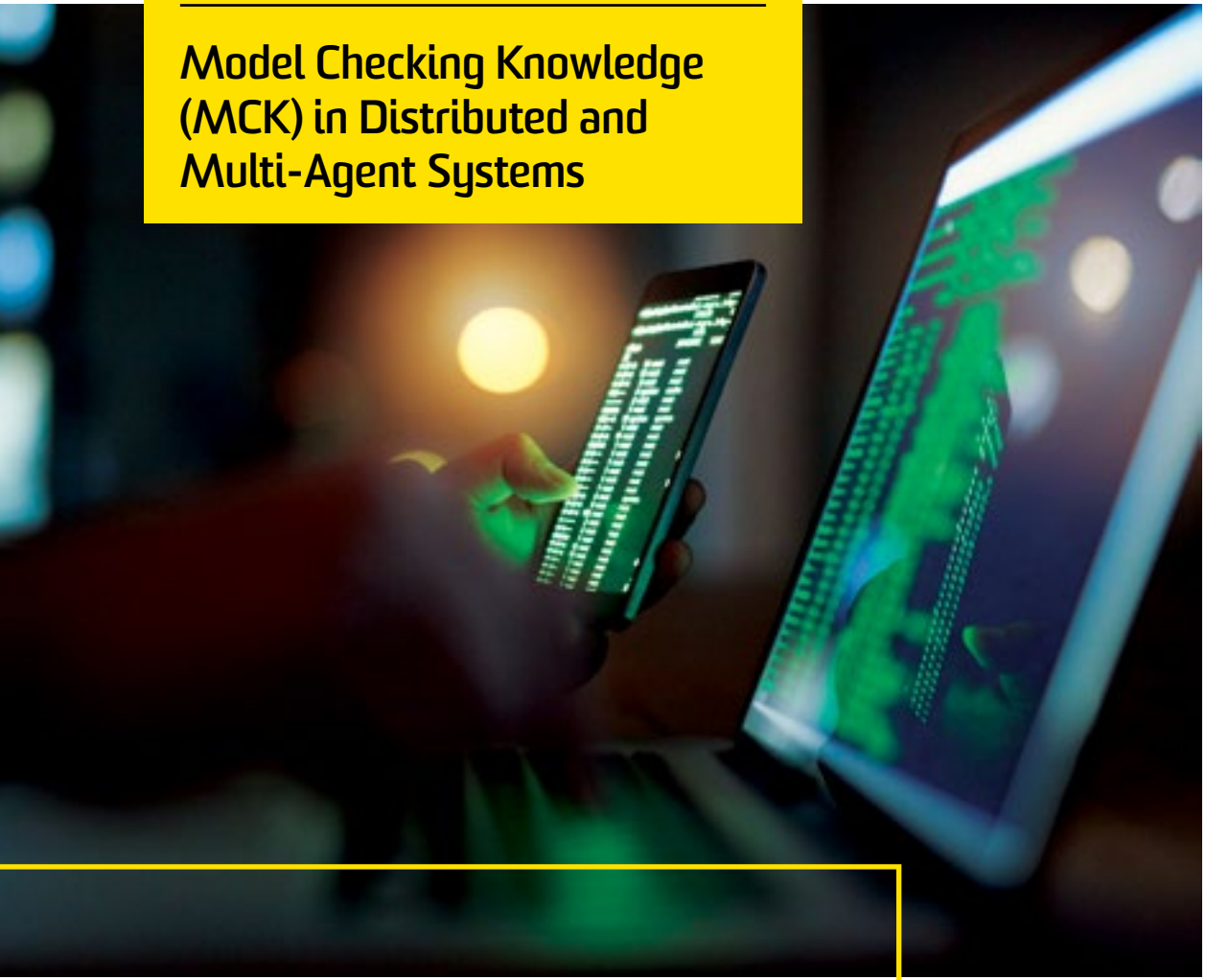
Model Checking Knowledge (MCK) in Distributed and Multi-Agent Systems



Model checking methodology automates the verification of computer software and hardware designs, based on algorithms that enable complete analysis of all possible behaviours of a system. Standard model checkers only consider how a system state evolves; whilst MCK model checker analyses how the knowledge of system components evolve over time.

Competitive advantage

The MCK model checker is one of only a few comparable systems internationally, and unique in the range of semantics-of-knowledge and model checking algorithms that it supports. It features:

- Observational, clock and perfect recall semantics of knowledge (subjective) probabilistic knowledge specifications
- Binary decision diagram based and bounded model checking algorithms, and
- Synthesis of implementations of knowledge-based programs

Demonstrated applicability of the technology to a range of applications, including detecting non-optimal use of information in computer hardware designs, analysis of computer security protocols, and verification of pursuit-evasion scenarios.

Impact

- Improved software reliability and security

Successful applications

- Model Checking Knowledge and Probability, Defence R&D Canada
- Security Protocol Optimization and Verification by Epistemic Model Checking, US Air Force AOARD grant
- Independence-based Optimization of Epistemic Model Checking, US Air Force AOARD grant

Our partners

- The MCK model checker has been licensed to Rationative Systems Inc.

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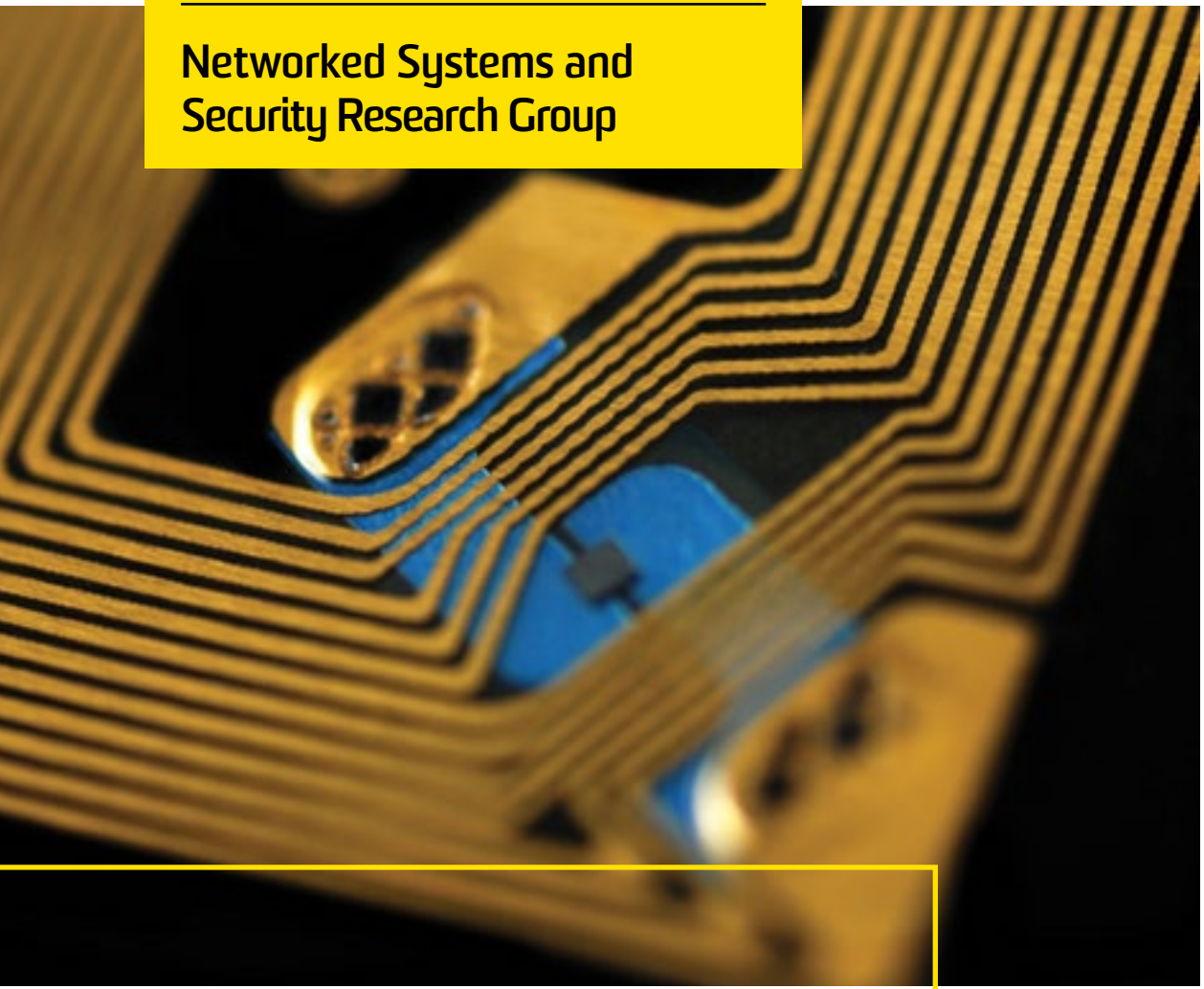
Networked Systems and Security Research Group



A leading capability in the development of Internet of Things (IoT) technologies over the past decade with long-lasting collaborations with a number of industry partners.

Competitive advantage

- Holistic approach that encompasses apps, protocols, security, analytics and device management
- Expertise in building and deploying practical IoT systems, including:
- Design, implementation and evaluation of energy-efficient wireless communication protocols
- Blockchain technology for IoT
- Security protocols for end-to-end communication and over-the-air programming
- Biometrics and authentication
- Privacy-enhancing technologies
- Wearable IoT technologies for human activity recognition
- Device-free sensing with WiFi
- Batteryless sensing, and
- IoT for sport analytics

Impact

- Better integration of the physical world with computer-based systems

Capabilities and facilities

- Comprehensive laboratory facilities with state-of-the-art IoT devices

Our partners

- Defence Science and Technology (DST)
- NEC
- Google
- Tata Consulting Services
- Institute of Infocomm Research, Singapore
- WBS technology (smart buildings with LPWAN)
- Virtual Vehicle Research Centre, EU
- Data 61, CSIRO

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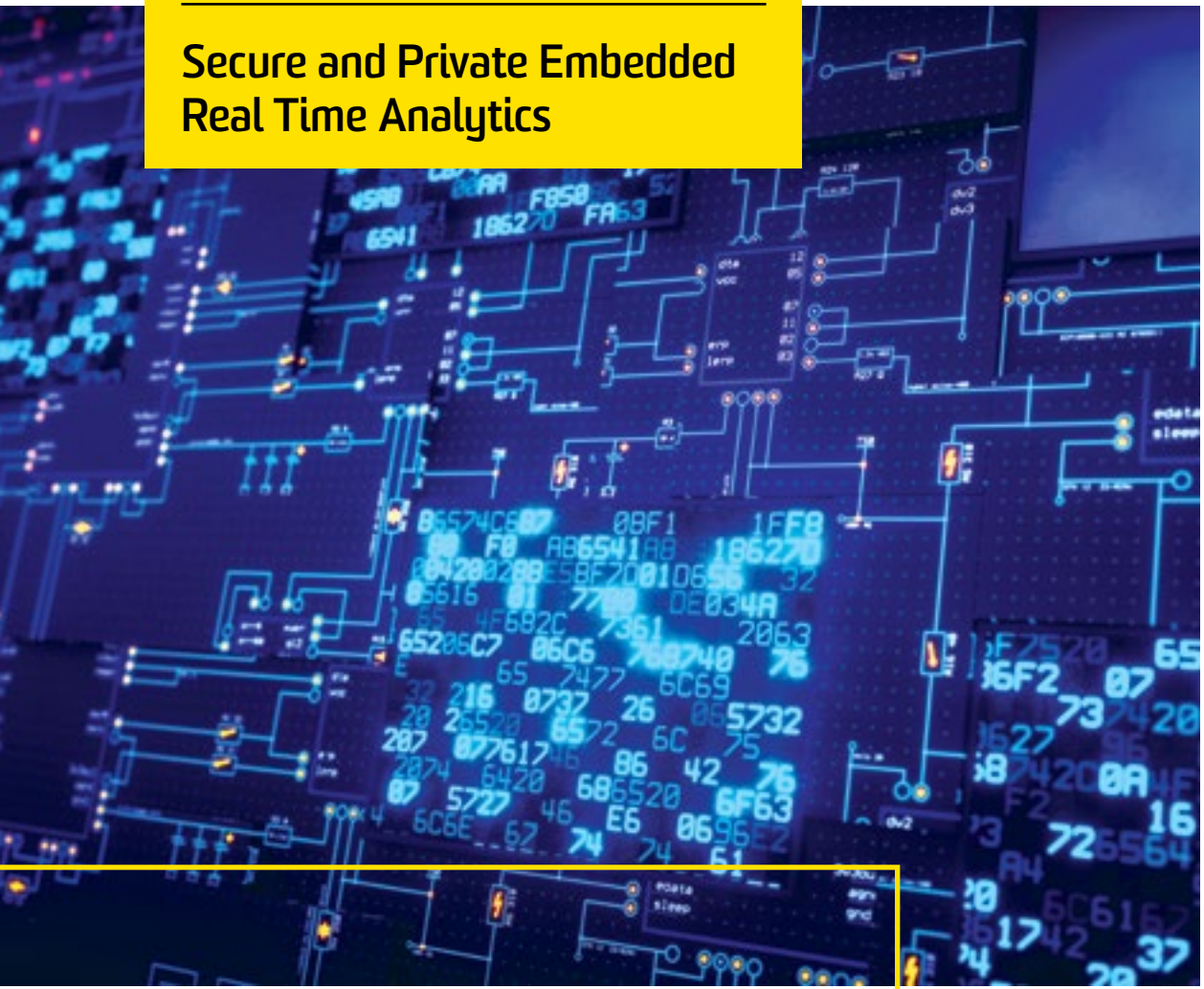
Secure and Private Embedded Real Time Analytics



Robust machine learning algorithms in embedded devices to obtain novel insights and enable real-time decision making while ensuring system security and the privacy of users.

Competitive advantage

Fundamental and multidisciplinary expertise in real-time embedded analytics for Internet of Things (IoT) and networked systems that can provide:

- Novel business, environmental and system insights through seamless non-invasive monitoring
- Security of networked systems
- Minimal privacy risk for users, and
- Improvements in the overall performance and usability of networked systems

This technology has demonstrated widespread application in:

- Detection of malicious mobile apps
- Real-time continuous identification of individuals and machines
- Energy efficient sensing of user activities
- Detection of anomalous operation of networks and devices
- Voice biometric systems and countermeasures to spoofing attacks

Impact

- Better security and improved usability of networked systems

Successful applications

- Automatic inference of user emotion and mental state
- Creation of a 'breathprint' for continuous user identification and authentication

Capabilities and facilities

- State of the art laboratories equipped with a multitude of sensors, wearables, and state-of-the-art equipment for signal capture and analysis

More information

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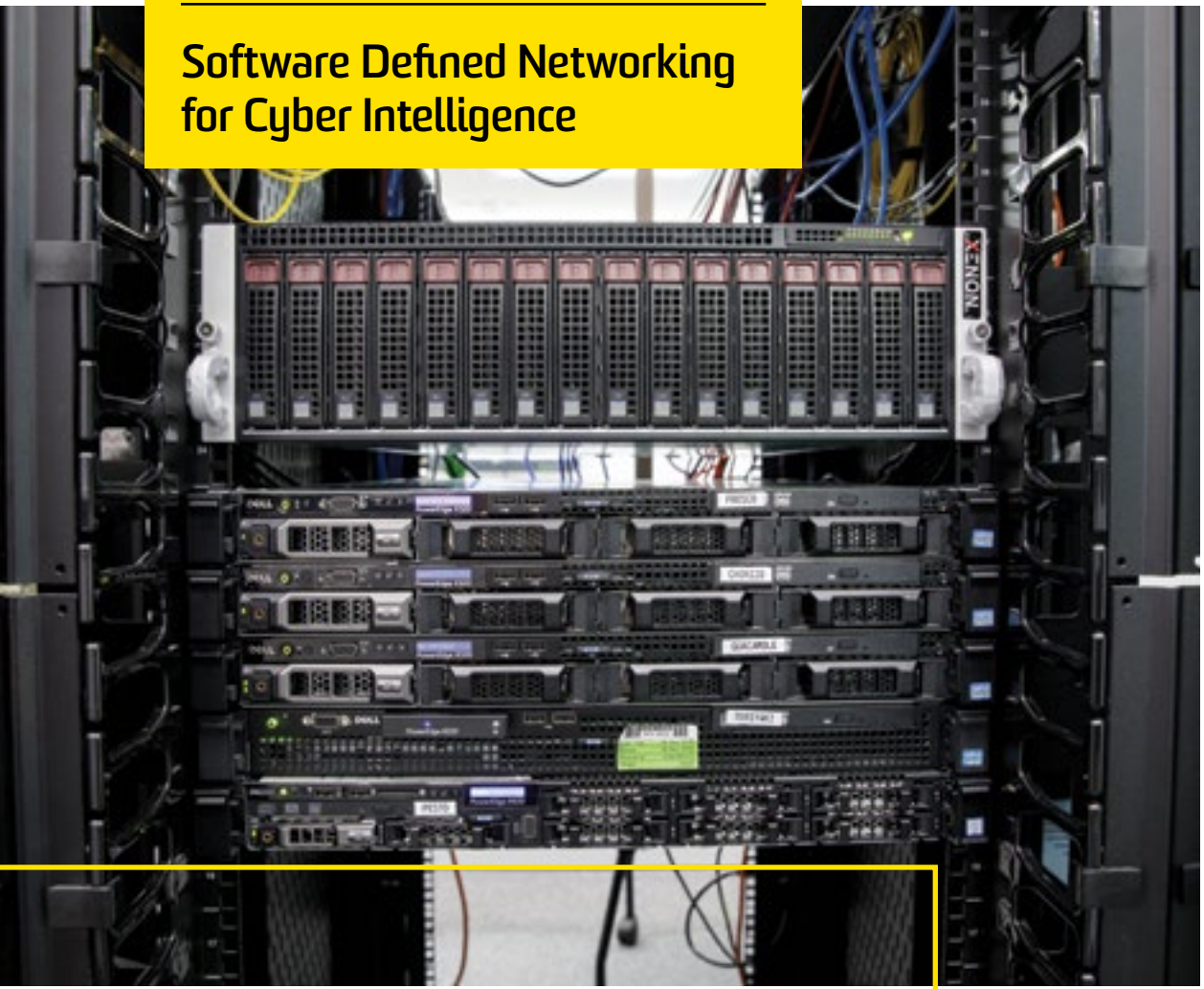
Software Defined Networking for Cyber Intelligence



Software Defined Networking (SDN) enables improved visibility, management and control of networks using software decoupled from switching hardware. Use-cases include analytics of video traffic in carrier networks and flexible cyber-security for enterprise networks.

Competitive advantage

Research, development and commercialisation expertise in:

- Improved network telemetry and analysis for fine-grained asset and threat visibility
- Automation and orchestration of network operations for enhanced security
- Experience in operational deployments and commercial trials of on local area networks through to carrier scale networks
- End-to-end solutions with full ecosystem integration
- Patent protected technology

Impact

- More reliable and secure communications
- Detection of intrusions into and exfiltration from Defence Networks
- Network activity monitoring of embedded devices in contained environments like submarines
- Detection and quarantining of compromised devices in battlefield environments

Successful applications

- SDN solutions in trials with Optus, Asre Telecom, AmLight and Cenic
- Intellectual property being incorporated into Cisco switches
- Real-time visibility into individual video streams in a Tier-1 carrier network
- Flexible inter-domain inter-connects for research networks in USA
- Real-time health monitoring of complex Internet-of-Things (IoT) environments

Capabilities and facilities

- Large-scale SDN test-bed spanning 10 Australian organisations
- Fully-equipped SDN lab with state-of-the-art hardware and software

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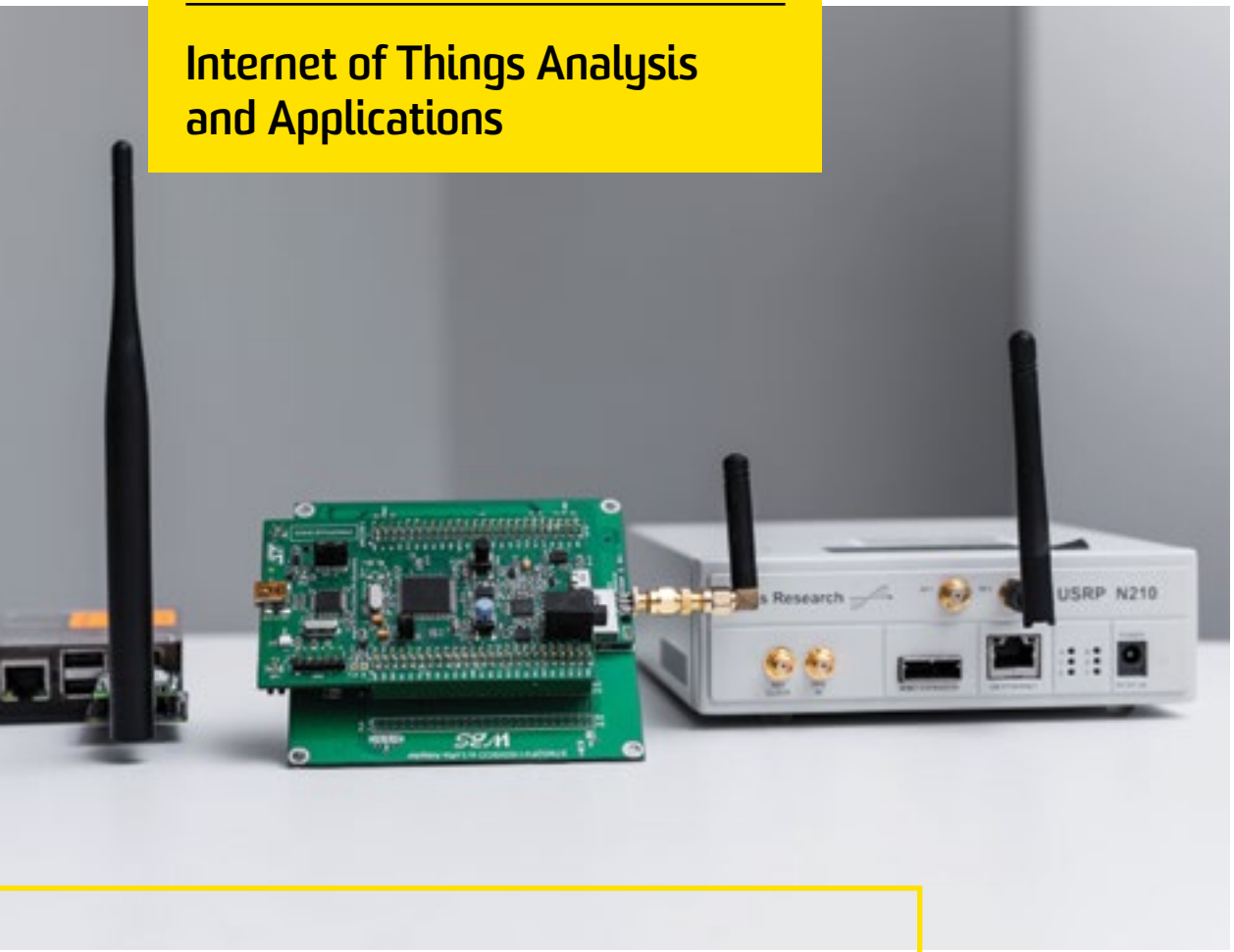
Internet of Things Analysis and Applications



The Internet of Things (IoT) presents enormous opportunities to improve interaction with our immediate surroundings. Fully realising this potential requires sophisticated information analysis, with a focus on data mining and deep learning, human activity recognition, information filtering, and brain computer interfaces.

Competitive advantage

- Predictive human behaviour modelling—covert human activity recognition and indoor human movement tracking
- Brain computer interface—deep learning for decoding brain activities and enabling device control via brain signals
- Large-scale (1000+ sensors), long-term industry system deployment experience in a variety of environments such as buildings, rainforest, farms and lakes

Impact

- Improved automation and better support in a complex environment
- Breakthrough technology outcomes realised through sensor processing, including advances in biometric (face, gait) recognition and wearable systems

Successful applications

- Deep learning for fault detection and localisation in distributed systems, CERA Project
- Opinion fraud detection
- Thing-of-interest recommendation in the Internet of Things
- Human abnormal activity detection
- Smart buildings and environments
- User-friendly authentication for wearable devices, Australia Centre for Cybersecurity
- Battery-free wearable systems

Capabilities and facilities

- LPWAN test-bed in an industrial building
- GPU-accelerated IoT data analytical platform

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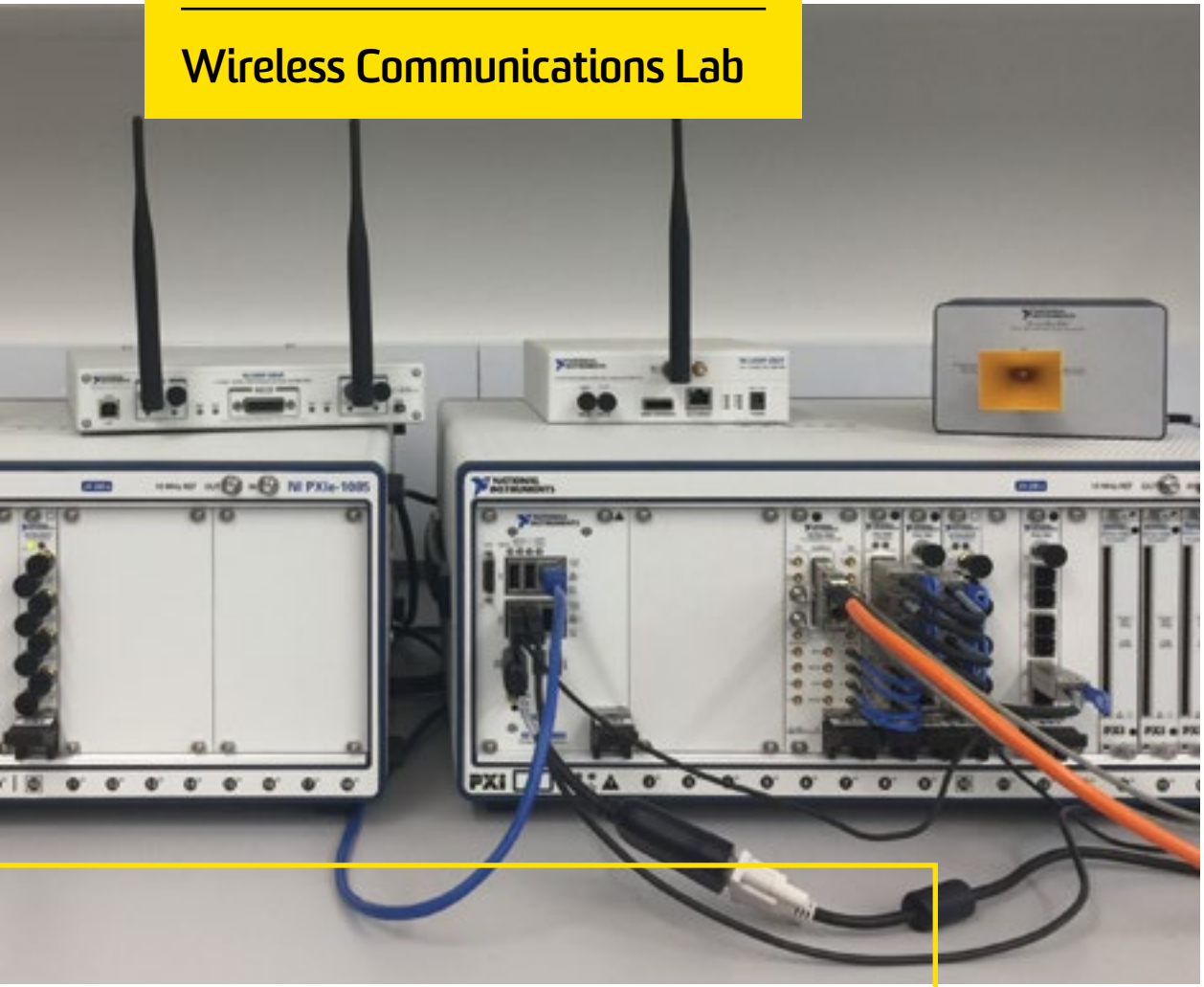
Wireless Communications Lab



Wireless Communications Lab (WCL) conducts innovative and cutting-edge research in wireless communications; specialising in ultra-reliable M2M and IoT communication technologies for 5G and industrial applications.

Competitive advantage

- Extensive experience in research, design and development of ultra-reliable, dense multi-user communication systems, M2M communication transceiver technologies and communication protocols
- Extensive research collaboration experience with leading telecoms companies and organisations

Impact

- Faster and more reliable wireless communications

Successful applications

- Massive multiple-input, multiple-output technique for 5G wireless networks
- Massive connectivity and low latency machine-to-machine communications for 5G
- Enhanced decoding algorithms for 5G LDPC codes
- Efficient and sustainable wireless-powered communication networks
- Design and analysis of delayed bit interleaved coded modulation
- Efficient cross-layer coding techniques for wireless networks

Capabilities and facilities

- Wireless communication system design and test facilities—microwave chamber, spectrum analysers, vector signal generators, FPGA development platforms and software-defined radio platforms
- High performance computing clusters for ultra-reliable system error performance evaluation

More information

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Quadseal
Hardware Attack Mitigation

Quadseal is a mitigation technique to stop attackers from obtaining secret keys from block ciphers. Where a conventional encrypting device is accessible it is possible to obtain the secret key in less than 10 minutes. With Quadseal the attacker is stymied, making communications channels and other protected items far safer.

Competitive advantage

- First known countermeasure that can thwart both power and fault attacks
- Smallest power area product among all available technologies
- Embedded Systems Laboratory has over 20 years' experience in hardware–software co-design, security and design automation

Impact

- Enhanced communications security

Successful applications

- Our work in pipelined processing systems has been used extensively by Canon Inc.
- Optimised systems used within multiple other commercial environments

Capabilities and facilities

- Side channel analysis equipment for measuring power and electromagnetic radiation
- SASEBO FPGA-based boards to create circuits that can be tested
- Custom made processor boards for testing of software countermeasures

Our partners

- Canon Information Systems Research Australia
- Seeing Machines Inc.
- Defence Science and Technology (DST)

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Terahertz Radiation

Terahertz (THz) radiation has strong penetrability and high bandwidth, which makes it ideal as the key technology for the next generation of non-intrusive imaging scanners and ultra-high bandwidth wireless communications beyond 100 GHz.

Competitive advantage

- Suitable for high-resolution and non-invasive imaging
- Developing an integrated physical planar platform for ultra-high bandwidth short-range THz communications (terrestrial and space including WiFi, vehicular and health monitoring systems)
- Utilising advances in photonics to improve the overall system performance in terms of cost, size, bandwidth and coupling losses

Impact

- Offers an enormous unlicensed bandwidth for high-speed wireless communications with a wide range of applications such as:
  - Whisper radio communications over high-attenuation bands, for example, battlefield sensors and on-body health monitors
  - Long distance communications over low-attenuation bands for example cellular, vehicular radar and space communication

Successful applications

- First THz flexible and single-mode waveguide with metamaterial cladding
- Planar high bandwidth photonic crystal waveguide-based devices
- Hybrid metal-dielectric meta-devices for ultra-sensitive sensing and beam forming
- THz polarization-maintaining filters for imaging, sensing, and wireless communication
- Anti-stealth THz ultra-wideband radar

Capabilities and facilities

- THz Time Domain Spectroscopy system with imaging facilities
- Numerical modelling software such as Computer Simulation Technology (CST) microwave studio and in-house developed analytical codes
- Access to Australian National Fabrication Facility (ANFF) for fabrication of devices

Our partners

- Protemics GmbH

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Cyberspace Law and Policy

Exploring emerging challenges across a broad range of issues arising from the intersection of law and technology. The emphasis is not on technology as such, but rather on the regulation of the social space created by computing networks - 'cyberspace'

Competitive advantage

Expertise in:

- Regulation of malware and cybercrime
- Online content regulation
- Hacktivism
- Cloud computing
- Legal jurisdiction in virtual worlds
- Intellectual property in digital artefacts
- Privacy and personal information security
- Online financial transactions and investment services, e-commerce, e-government
- Authentication and encryption
- Internet governance
- Legal issues arising from threats to networked security

Impact

Understanding the legal and policy issues arising from digital transactions in online and networked environments assists in policy development in relation to cybersecurity.

Submissions to various government agencies, including

- Office of the Australian Information Commissioner on Big Data
- Office of the Australian Information Commissioner mandatory data breach notification inquiry
- Consultation on proposals for reform of Copyright Act, including the viability of Orphan Works under a 'Fair Use' exception
- Parliamentary Joint Committee metadata retention and s 313 Telecommunications Act inquiries
- Australian Law Reform Commission Serious invasions of privacy in the digital era

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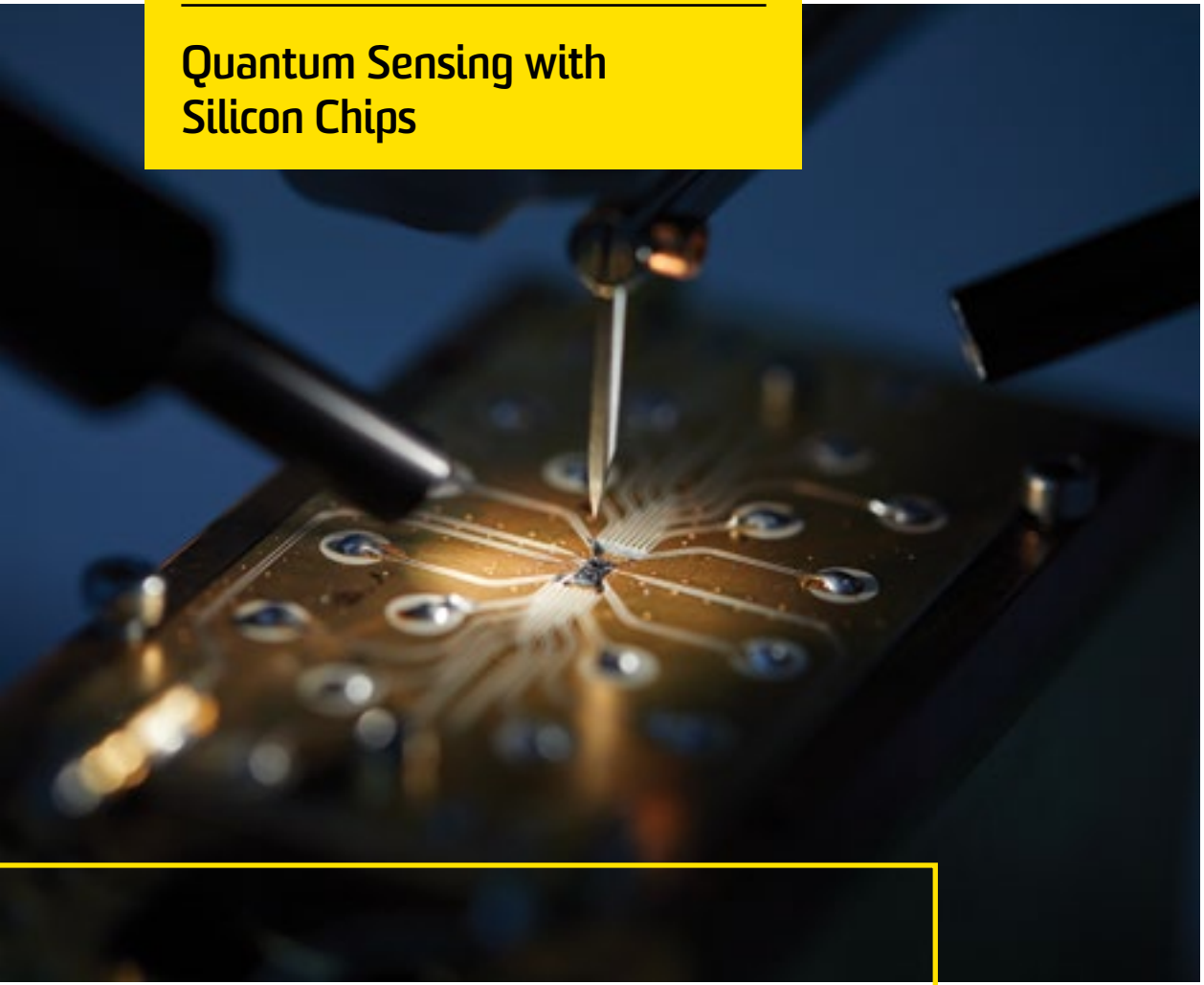
Quantum Sensing with Silicon Chips



Exploiting the inherent fragility of quantum systems to develop advanced sensors for weak electric and magnetic fields.

Competitive advantage

- First in the world to demonstrate a quantum bit in silicon, using the spin of a single atom, introduced in the chip via an industry-standard technology
- Record-holder for quantum memory time, which translates into a record sensitivity to perturbing electromagnetic fields
- International collaboration to develop novel methods for extracting the maximum information on the environment of the atom
- Extension of world-leading silicon-based quantum computer technology to demonstrate quantum sensors integrated within a silicon nanoelectronic device

Impact

- Substantial improvements in the sensitivity of sensors for defence systems
- Quantum sensors within silicon chips to facilitate integration with other functionalities

Capabilities and facilities

- Leading silicon nanofabrication facilities via the UNSW node of Australian National Fabrication Facility (ANFF) and unmatched in-house expertise
- Extensive platforms for quantum measurements in ultra-low temperature, high-frequency, low-noise environment
- International network of collaborators with access to state-of-the-art theoretical and computational facilities.

More information

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Intelligent Security

Focused on developing intelligent cybersecurity applications based Artificial Intelligence (AI), such as intrusion detection, anomaly detection, adversarial machine learning and cyber threat intelligence, to automatically detect, respond to, and prevent advanced persistent threats from causing potentially catastrophic disruption.

Competitive advantage

- Development of cyber threat intelligence and detection models including intrusion-detection privacy-preserving and digital forensics, using statistics, machine and deep learning algorithms
- Development of automated risk assessment, and penetration testing methods using AI planning and deep learning algorithms
- Design of new testbed architectures for Industry 4.0 networks including IIoT, cloud and fog systems.
- Ability to develop automated cybersecurity applications using artificial intelligence methods that have the capability to be deployed at large-scale and real-time networks.

Impact

- Analysis of how AI could develop automated cyber applications, for the CSCRC, Australian Federal Police (AFP), Australian Army, and ARDC.
- Threat intelligence and detection models for identifying and preventing cyber threats and reducing financial losses that could damage critical infrastructure

Successful applications

- Evaluating network intrusion detection-based deep learning and graph models
- A collaborative host-network anomaly detection framework for the Internet of Things
- An intelligent wargaming web service-based machine learning to understand human influences and behaviours

Capabilities and facilities

- Cyber Range Labs
- Digital Forensics Lab
- IoT Lab

Our partners

- Australian Federal Police (AFP)
- The Commonwealth Scientific and Industrial Research Organisation (CSIRO) Data61
- Cyber Security CRC
- Australian Army
- Oracle
- Australian Research Data Commons (ARDC)
- Cyber Centre for Security and Analytics at UTSA USA

More information

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Cyber Research, Education and Training

Focused on conducting research and actively contributing to the national defence strategy by educating and training front-line cyber defenders, as well as raising cyber awareness within government departments and corporations, to combat an increasing and persistent threat to global security.

Competitive advantage

- Design and development of user-centred and value-sensitive security and defence technologies
- Proactive and adversarial approaches to protecting computer systems, networks and individuals from attacks
- Experience in the evaluation and design of secure and resilient data acquisition and control systems for critical infrastructure
- Expertise in developing security and resilience for complex networks and systems
- Analysis of international and national security policy, strategy and diplomacy in response to the cyber age
- Developing novel artificial intelligence techniques for automatically discovering and preventing advanced cyber-attacks

Impact

- Enabling the next generation of defence leaders and influencing thinking in the cyber domain

Successful applications

- Enhanced defence capability in cyber security through the delivery of postgraduate and tailored courses delivered by leading industry professionals in collaboration with academic staff. Courses include: strategy, policy and management through to operational, tradecraft and digital forensics
- More research focus in successful applications

Capabilities and facilities

- Five cyber laboratories including virtualised solutions, peripheral software packages, and specialised hardware
- Supervisory Control and Data Acquisition (SCADA) table
- Digital forensics laboratory

Our key partners

- Australian Army
- Information Warfare Division
- Strategic Policy and Intelligence Group
- Capability Acquisition and Sustainment Group

More information

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Trustworthy Systems

A recognised world leader in the formal verification of systems software and developer of the first operating-system kernel with an implementation correctness proof.

Competitive advantage

- Unique capability in the design, implementation and formal verification of security-critical software systems

Impact

Truly trustworthy (unhackable) software systems with provable security properties

Successful applications

- Cyber-retrofit of Boeing autonomous helicopter (ULB) under the DARPA HACMS program
- Secure communication device (AltaCrypt) built by Australian company Penten and deployed in multiple defence forces
- German company HENSOLDT Cyber developing secure solutions based on seL4

Capabilities and facilities

Verification of real-world software systems

Our partners

- DARPA
- Boeing
- Rockwell Aerospace
- HENSOLDT Cyber

More information

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Complex Systems Security

Delivering a better understanding of the security of future networks and platforms; these networks include the Internet of Things, Industry 4.0, Industrial Control Systems that run Australia's critical infrastructure, and resilience of social networks against coercion and soft influence.

Competitive advantage

- Expertise in next-generation networks, critical infrastructure security, cyber-resilience and simulation
- World class experimentation development platforms and lab facilities
- Strong industry links to develop usable outcomes

Impact

- Development of new processes and techniques to discover vulnerabilities in large scale systems
- A holistic perspective on network development and security analysis
- Increasing resiliency of future networks against cyber threat
- Running wargames and scenario-based learning opportunities to understand future threats
- Cyber influence and security simulation platforms for decision support and situational awareness

Successful applications

- Social Media Dataset Generation, Australian Army
- An Intelligent Risk Evaluation Tool for Safeguarding IoT Smart Airports, Cyber Cooperative Research Centre (Cyber CRC)
- Cyber Supply Chain Mission Assurance, Australian Army
- Cyber Impact Analysis Towards Mission Assurance, Defence Science and Technology
- Secure Software Defined Networking for Multi-Bearer Time-Sensitive Distributed Systems, Defence Science and Technology

Capabilities and facilities

- UNSW Canberra Cyber Range
- Future-facing Internet-of-Things (IoT) Security Laboratory, incorporating realistic Supervisory Control and Data Acquisition (SCADA) and Industrial Control System (ICS) platforms

Our partners

- Information Warfare Division
- Defence Science and Technology Group
- The Netherlands Organisation (TNO)
- Domos

More information

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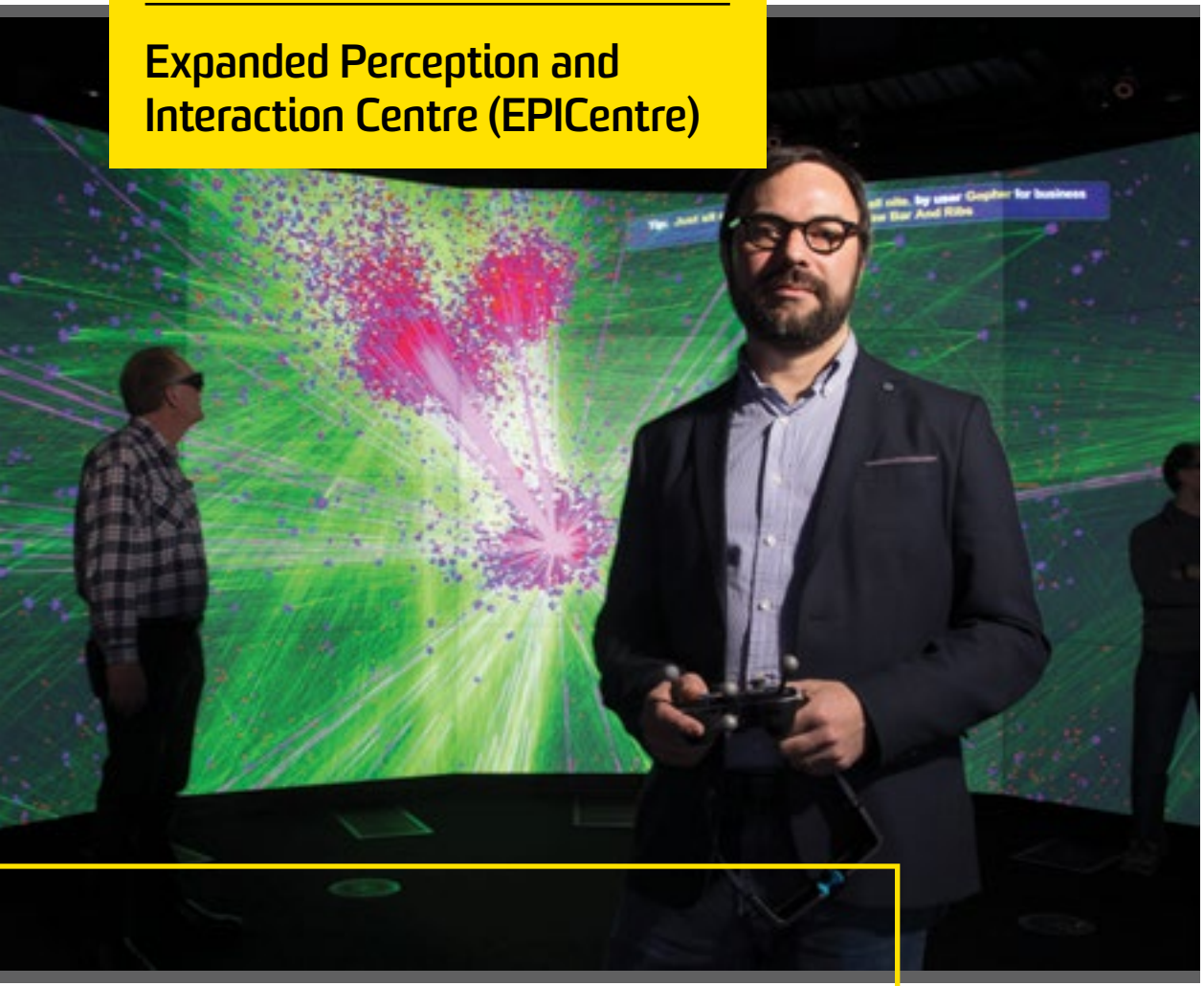
Expanded Perception and Interaction Centre (EPICentre)



Pioneering high-performance visualisation facility forging new ground in integrated artistic, design-led and scientific thinking, facilitating understanding of complex datasets through ultra-scale imagery, hybrid analytics.

Competitive advantage

- High-End Visualisation System (HEVS) removes barriers of entry for deploying visualisation applications to any platform
- The most influential computer graphics and high-performance visualisation lab in Australia
- Hosts the highest resolution Virtual Reality (VR) system in the world with integrated computational platforms

Impact

Promotes cross connection of visualisation with applied computational simulations, artificial intelligence (AI), and creativity in arts, science, design, engineering, medicine and education.

Successful applications

- *Massive Networks and AI:* visualisation and analytics of very large-scale graphs in immersive environments
- *Better Simulation Models and Visualisation for the Joint Domain:* visual dashboards of multi-agent simulations for informed warfighting decision making
- *Simulation and Visualisation Using Data Farming for Joint Operating Concept Analysis:* visualisation grammar and storytelling for improved decision making, AI for JFoRCE end-run simulations analysis

Capabilities and resources

- EPICylinder: 340-degree cylindrical screen, ~120 million pixels in 3D
- DomeLab: 6.4m Hemispherical Full-Dome 4K
- XR-Lab and CG-Lab: wide range of VR/AR/XR systems, motion tracking system
- Interactive 3x3 MultiTaction iWall
- AI-driven Visual Analytics, with creative and design-led approach, Digital Twins

Our partners

- Defence Science and Technology
- Commonwealth Scientific and Industrial Research Organisation (Data61, CSIRO Astronomy and Space Science)
- Children's Cancer Institute
- National Measurement Institute
- National Institute of Standards and Technology
- Association for Computing Machinery (SIGGRAPH)
- Khronos Group

More information

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Director EPICentre
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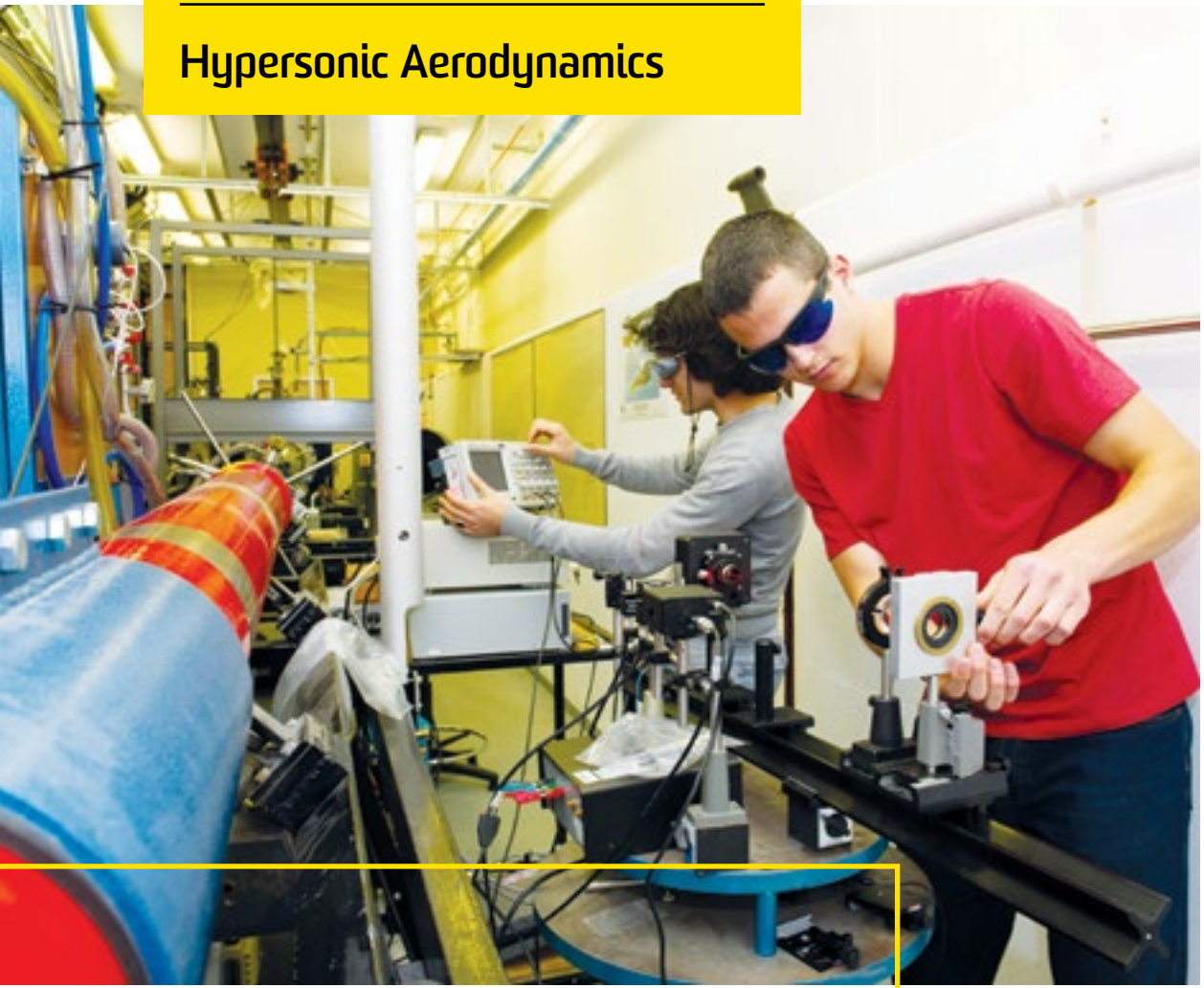
HYPERSONICS

Hypersonic Aerodynamics



Reducing the risk of high-speed flight testing and development through the application of scaled, dynamic free-flight testing in wind tunnels.

Competitive advantage

- Pioneering the use of highly-instrumented, low-inertia, dynamically-scaled, rapidly-prototyped, models with on-board instrumentation for free-flight testing in hypersonic conditions in ground-based test facilities
- Measurement of the aerodynamic derivatives of a design across a range of attitudes in a single experimental run using a unique combination of on-board instrumentation, including miniature inertial measurement units, in tandem with high-speed video tracking. This technique offers the unique ability to quickly validate numerically-derived aerodynamic databases using a small number of wind tunnel experiments
- Ability to investigate high-speed separations including multi-stage separation and stores release and to quantify the associated multi-body aerodynamics

Impact

- Tunnel-based, free-flight testing helps to reduce the requirement and risks associated with expensive flight testing of high-speed vehicle designs and configurations. Tunnel-based free-flight testing allows for assessing the accuracy of numerical designs and identifying unforeseen issues using ground-based test facilities. Changes to geometric design, mass distribution and separation approach can be rapidly assessed

Successful applications

- Free-flight technology has been successfully applied to a number of hypersonic vehicles and test flight programs to validate aerodynamic databases and to investigate separation dynamics, including the Defence Science and Technology (DST)/AFRL HIFiRE program and ESA's HEXAFLY-International program. Initial vehicle designs have also been tested for Reaction Engines Limited (Skylon) and UQ (SPARTAN)

Capabilities and facilities

- Ability to design models and experiments
- Fabricate bespoke on-board electronics
- High-speed wind tunnels including T-ADFA

Our partners

- TUSQ at USQ
- HDT at the University of Oxford

More information

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Hypersonic Control

Testing and analysing the performance of control methods and algorithms in flow conditions that are representative of hypersonic flight.

Competitive advantage

- Technologies developed are used to test robust control algorithms on representative configurations in hypersonic flows
- Test technologies cover both “algorithm-in-the-loop” testing in wind tunnels as well as “software-in-the-loop” testing via numerical simulation
- Technologies can be applied to evaluate novel actuation methods such as fluidic control and fluidic thrust vectoring

Impact

- Test methodologies enable a steady progression through Technology Readiness Levels of both control algorithms and control actuation approaches by testing them dynamically in flow conditions representative of hypersonic flight

Successful applications

- Development of technologies to test both control methodologies and control actuation approaches; supported by the U.S. Air Force Office of Scientific Research and BAE Systems

Capabilities and facilities

- High-speed wind tunnels including T-ADFA and the Supersonic Nozzle Test Facility
- Partner facilities at USQ and HDT at the University of Oxford
- Commercial and in-house numerical codes are utilised to predict the transient performance of control approaches and to optimise their design

More information

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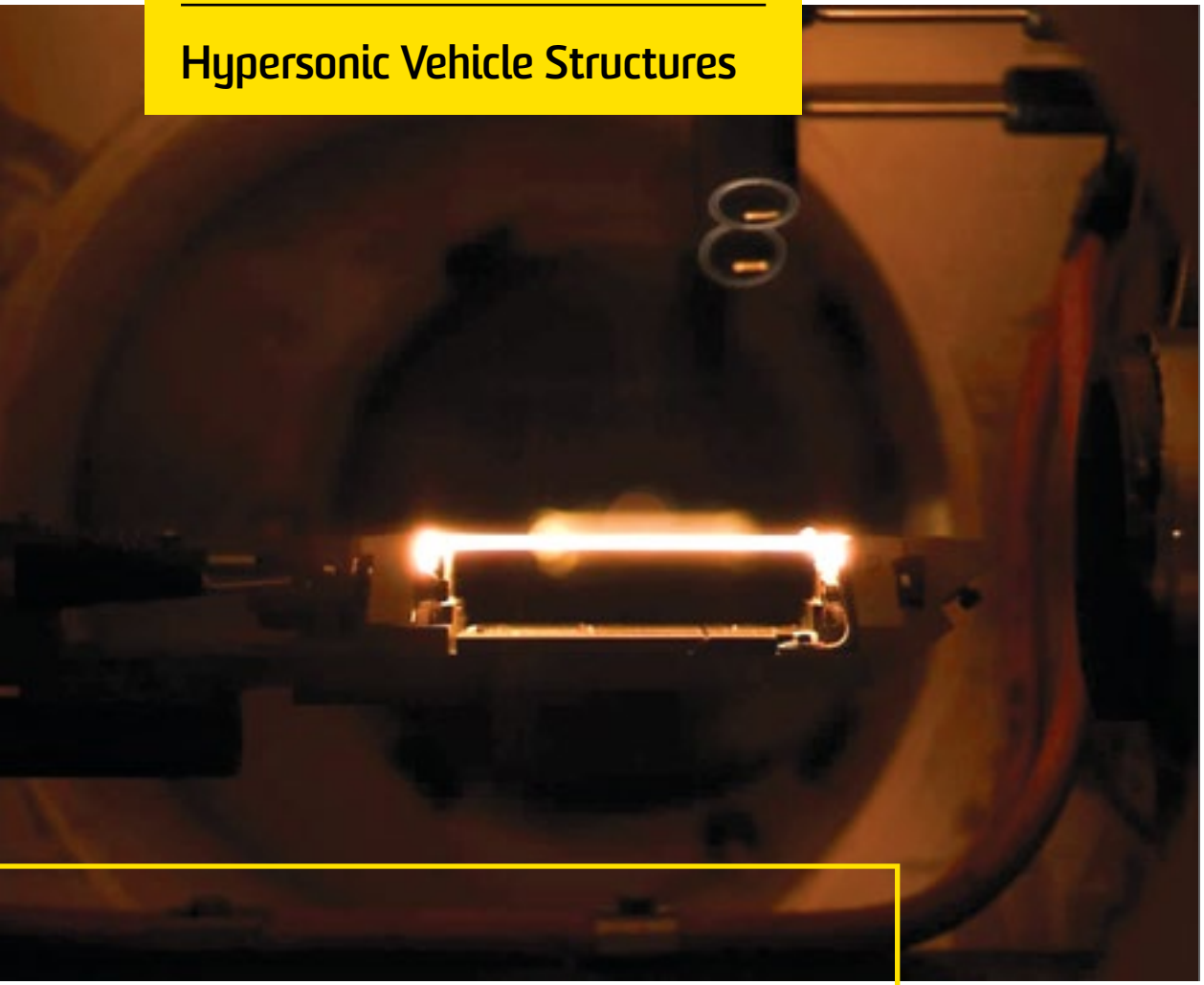
Hypersonic Vehicle Structures



Developing, validating and testing structural designs, components and materials to operate in the extremes of hypersonic flight.

Competitive advantage

- Unique in-house expertise in the design and testing of aerostructures to withstand the extreme conditions experienced by a vehicle during hypersonic flight
- Expertise extends to both the development of numerical tools as well as the experimental methods to predict and measure the performance of structures, sub-components and materials exposed to hypersonic flight conditions
- Measurement and test technologies cover both ground-based measurements and in-flight measurements

Impact

- Test and prediction technologies enable the increase in TRL of structural designs, sub-components and high temperature materials by exposing them dynamically to the thermal-structural conditions representative of hypersonic flight. This leads to the optimisation of vehicle designs and reduction in the requirement for expensive flight testing

Successful applications

- Expertise and technology has been successfully applied to the design and evaluation of aerostructures and subcomponents for the HyCAUSE (DARPA/AFRL/Defence Science and Technology (DST)), SCRAMSPACE (UQ-led consortium) vehicles and the onboard measurement of thermal-structural performance in-flight under the HIFiRE (DST/AFRL) and HEXAFLY-INT (ESA-led consortium) hypersonic test flight programs

Capabilities and facilities

- Experimental facilities and diagnostics to test the structural performance of materials and components under flight-representative temperatures and thermal gradients
- The ability to combine thermal loads with representative aerodynamic loads in supersonic and hypersonic wind tunnels
- Deployment of diagnostic technologies onboard hypersonic flight-test vehicles for real-time measurements

More information

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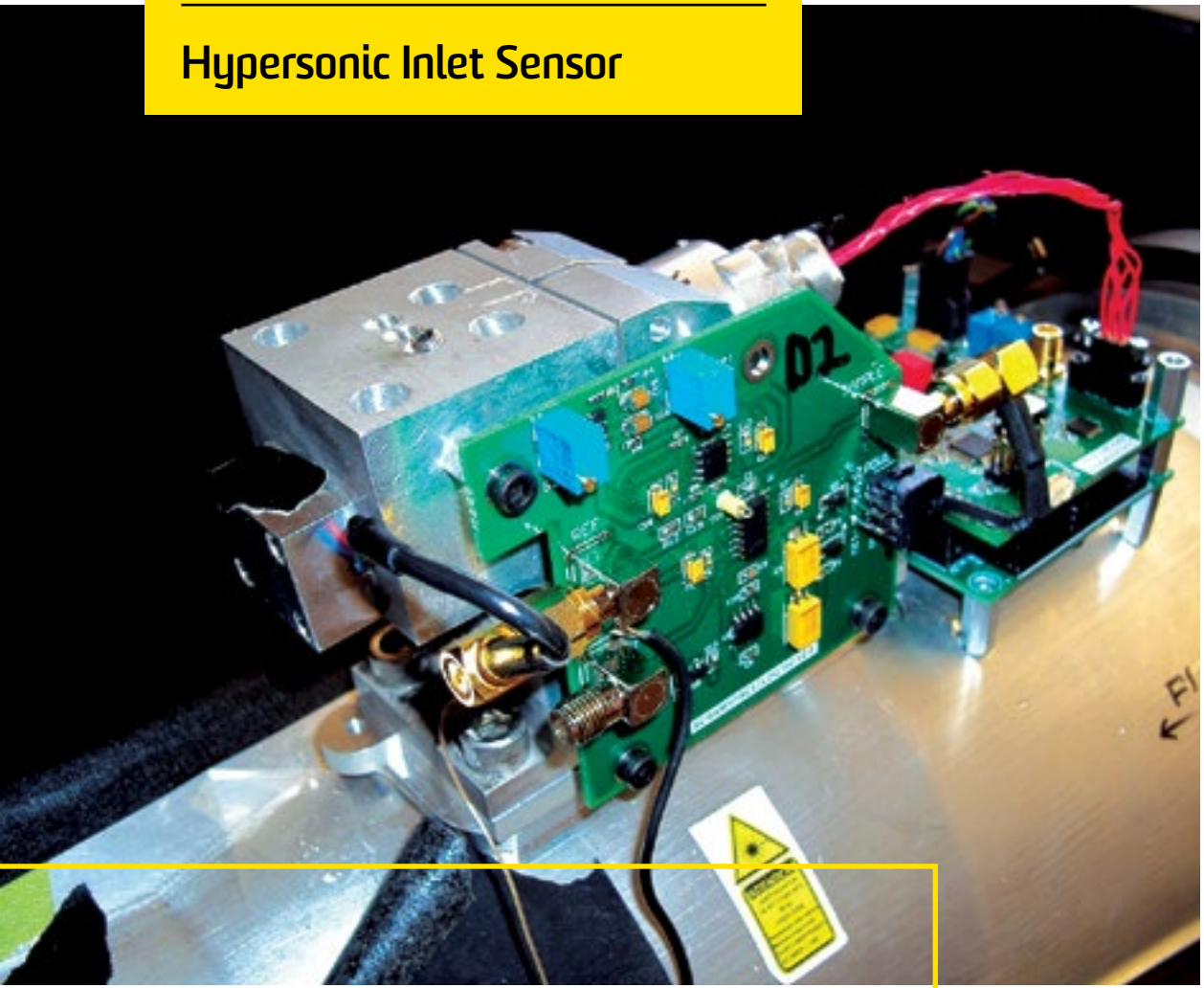
Hypersonic Inlet Sensor



High-speed Mach number and angle of attack sensor for hypersonic vehicles.

Competitive advantage

- Specifically designed for sensing applications in hypersonic flight
- The device is capable of measuring temperature, Mach number, speed and angle of attack for hypersonic vehicles
- Spin-off technology has been patented as an air-speed sensor for subsonic vehicles
- More stealthy and faster response rate than pitot tubes, and able to be used from subsonic to hypersonic flight domains
- Not as susceptible to icing as standard pitot tubes

Impact

- Enhanced control of hypersonic vehicles
- Replacement for pitot tubes in subsonic aircraft and large UAVs

Successful applications

Flight test associated with the Australian Space Research Program "Scramspace"

- Measured under 20 g acceleration conditions in flight
- Subject to obtaining an export licence, a proposed flight test with the Korean Aerospace Research Organisation KAIST
- Funding from the US Air Force

Capabilities and facilities

- In-house development of all optics, electronics and communications technologies

More information

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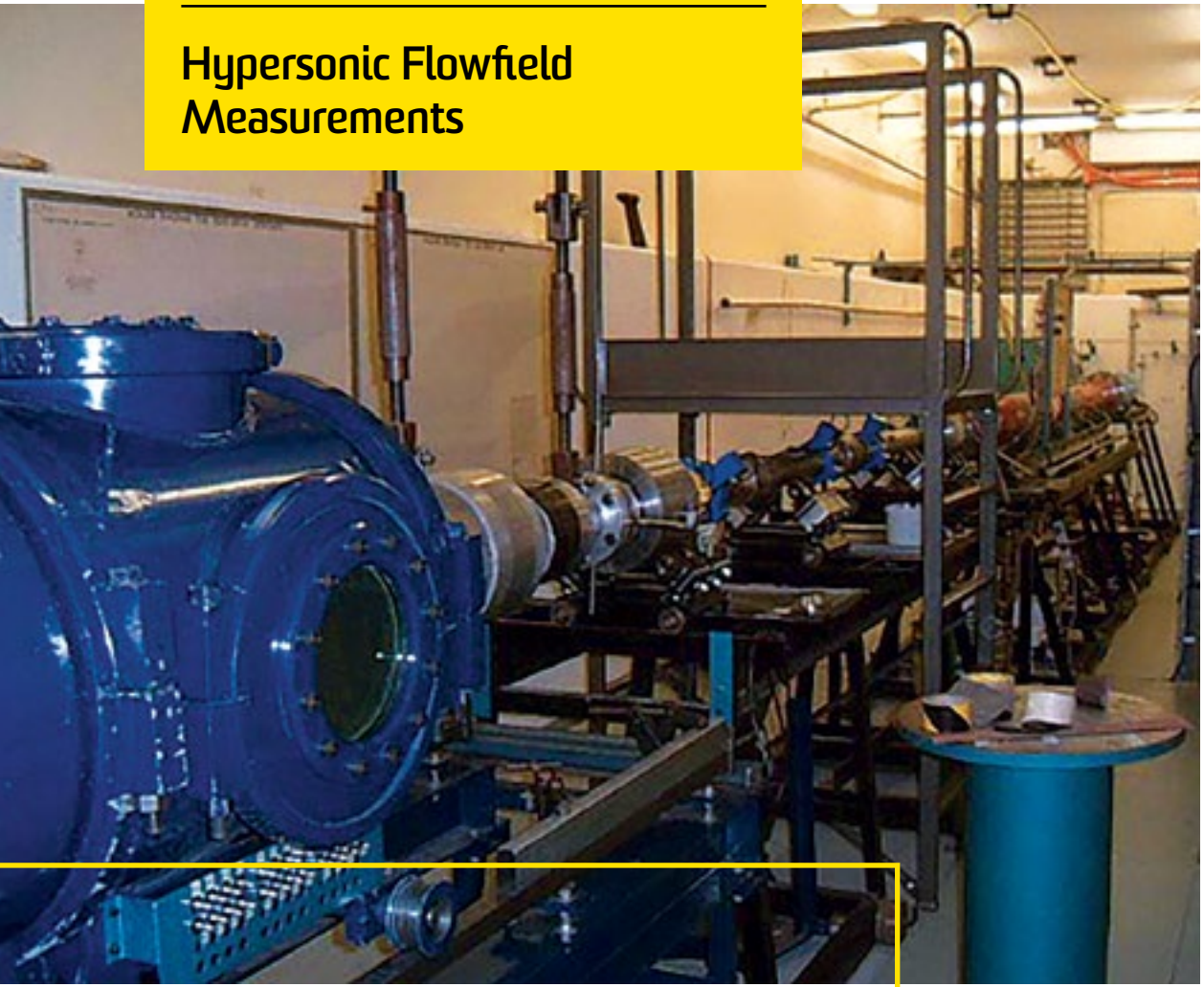
Hypersonic Flowfield Measurements



World leading laser flow diagnostics.

Competitive advantage

- Unique combination of state-of-the-art shock tunnel for generating hypersonic flows and laser-based diagnostics for making precision measurements in those flows
- Wide range of laser-based measurement technologies, including laser-induced fluorescence diode laser absorption spectroscopy and resonantly-enhanced shearing interferometry

Impact

- Design of more efficient hypersonic vehicles
- Improved understanding of aerothermodynamic heating and drag characteristics of hypersonic vehicles
- Testing validity of computational models

Successful applications

- Produced the world's first two-dimensional velocity maps in hypersonic separated flows
- Density measurements 100 times more sensitive than existing technologies
- Fastest scanning temperature measurement technology currently in existence (1.6 million temperature measurements per second)
- International collaboration in comparison of state-of-the-art computational methods
- Multiple funding streams including US Air Force programs

Capabilities and facilities

- T-ADFA free-piston shock tunnel
- YAG-pumped dye laser system
- Diode laser absorption spectroscopy system

More information

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HUMAN PERFORMANCE, PROTECTION AND BEHAVIOURS

Biodefence Collaboration

The UNSW Medicine Biodefence Collaboration is between the Kirby Institute and the UNSW School of Public Health and Community Medicine; bringing together chief investigators in Epidemic Response and complementary capabilities in public health interventions and acute response to biological threats.

Competitive advantage

- Joint capabilities from three of the world's leading universities; UNSW, Arizona State University and King College London
- Cross-disciplinary approaches to threat detection

Impact

- Enhanced biodefence

Successful applications

- NHMRC Centre for Research Excellence, Integrated Systems for Epidemic Response (ISER)
- Identifying risk factors of a human-to-human transmissible form of highly pathogenic avian influenza H5N1, UNSW PluS Alliance
- AIAA pandemic risk assessment
- Defence Science and Technology, Chimera evolution

Capabilities and facilities

- NHMRC CRE ISER
- UNSW School of Public Health and Community Medicine
- the Kirby Institute
- Global Security PLuS partners

Our partners

- Emergent Biosolutions
- 3M
- Bavarian Nordic
- Siga Technologies
- Leidos
- Sanofi
- Seqirus

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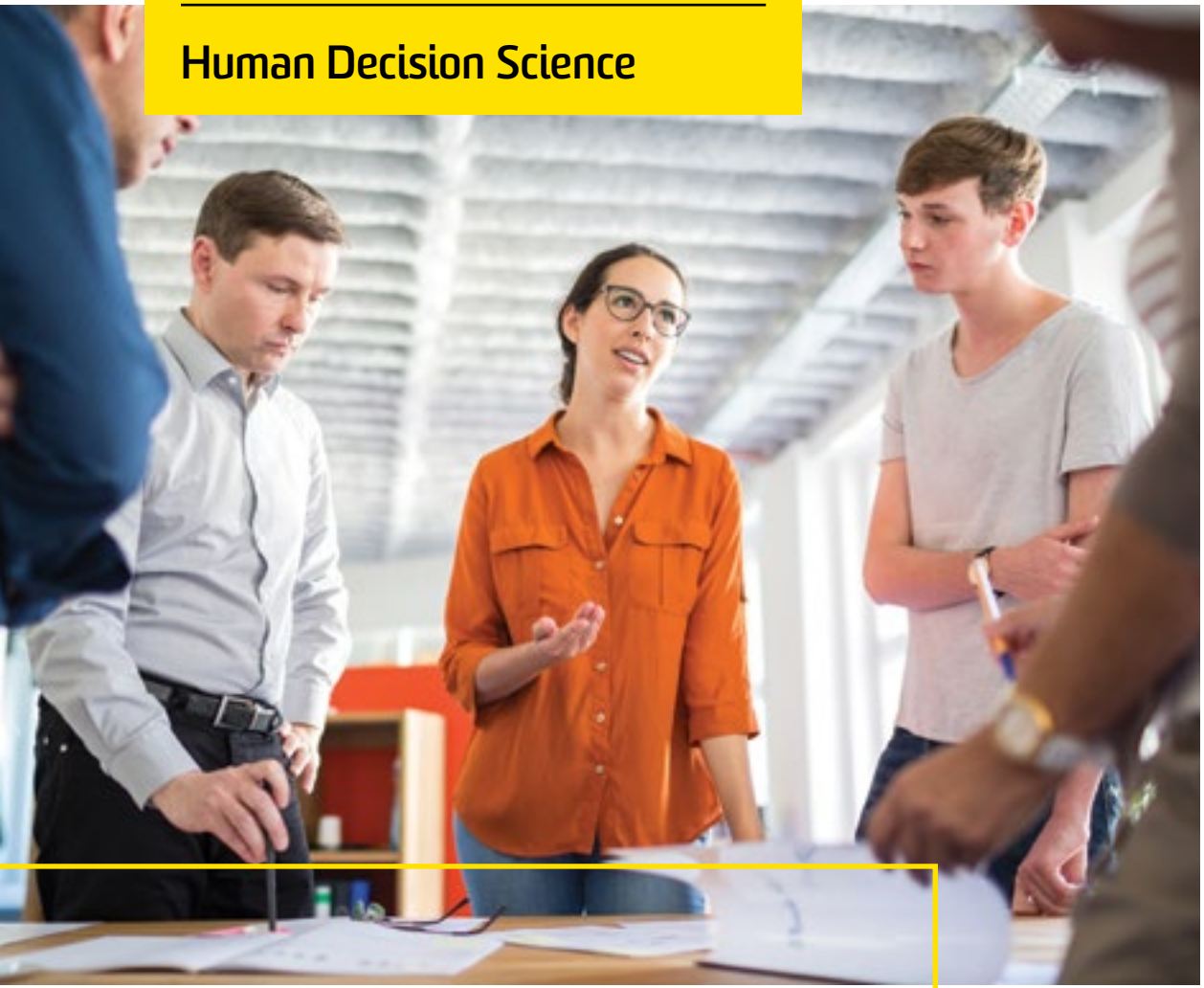
Human Decision Science



Understanding human systems is essential to achieving defence goals.

Competitive advantage

UNSW is the top ranked psychology school in Australia, with proven experience in human decision processes, computational modelling and the empirical study of human learning, emotion and cognition.

Expertise in understanding human decision making, including:

- Learning what information a human operator needs and when it is needed
- Study of memory, navigation and functioning in high stress environments
- Understanding how decision makers rely on multiple information sources
- Understanding how bias or decision failures arise in human decisions
- Developing computational models to predict human operator performance
- Developing psychologically principled 'wisdom of crowds' models to aggregate expert decisions, and
- Understanding how human decision makers manage the trade-off between speed and accuracy
- Expertise in collecting and analysing large, complex behavioural data sets
- Bayesian statistical models for human learning and decision making, compatible with probabilistic approaches to machine learning

Impact

- Better decision making

Successful applications

- Learning and choosing in a complex world; developing computational models of how people make choices in dynamic environment
- Unifying decisions from experience and description; identifying the difference between decision making from real experience and decision making from descriptions
- Novel statistical tools for analysing behavioural data

Capabilities and facilities

- State-of-the-art eye tracking, EEG, and other physiological measurement facilities
- Behavioural research using immersive VR

More information

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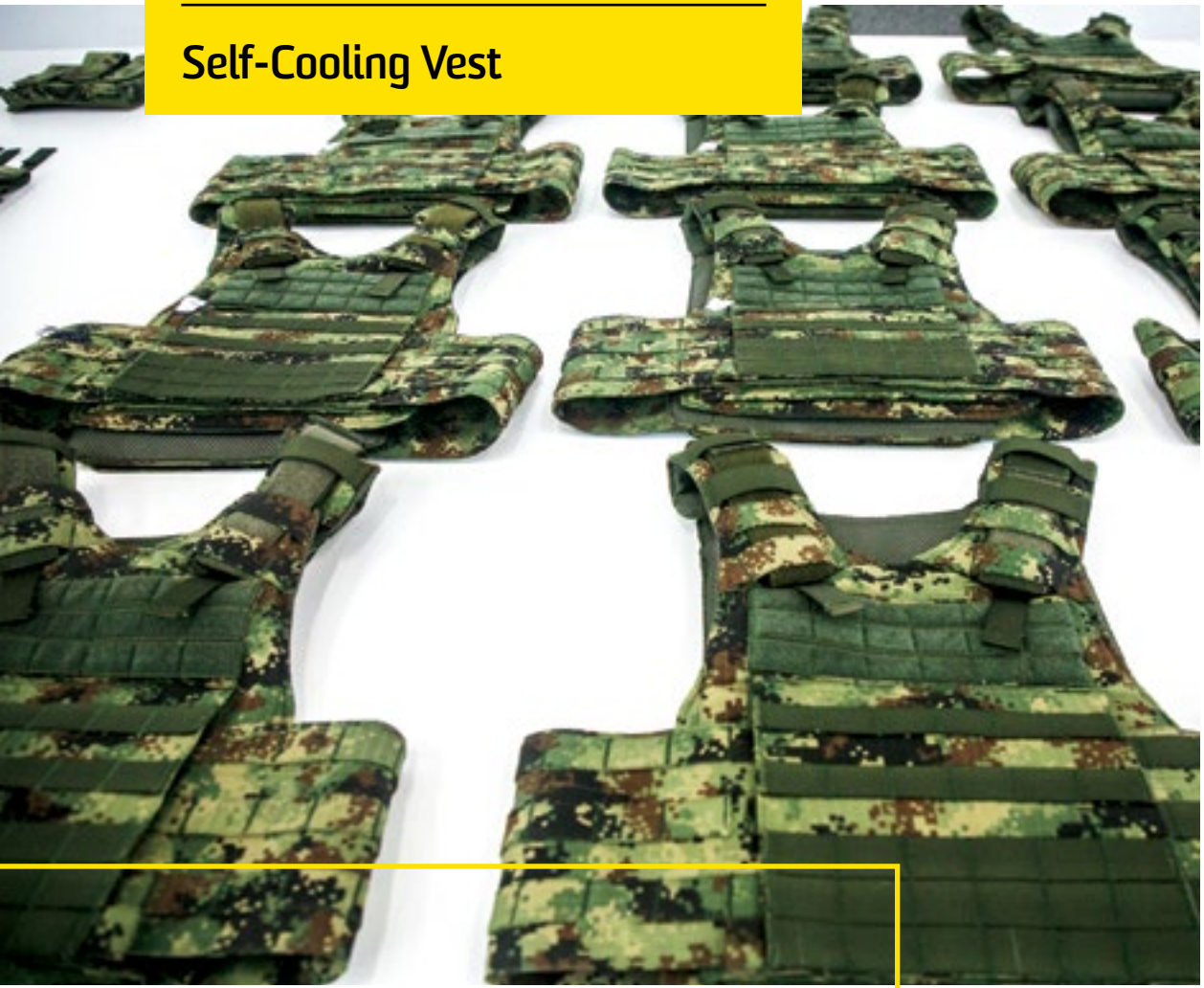
Self-Cooling Vest



A lightweight, self-cooling vest for operation in hot environments. It does not require external power and can operate indefinitely.

Competitive advantage

- Current self-cooling vests are heavy, expensive and either require a substantial power source or must be refrozen, limiting their useful operating time
- Our system is lightweight and cost-effective. It uses no power source and can operate indefinitely
- The system is based on a thermosiphon process. It uses a low boiling point phase change material (LBPCM) with a refrigeration cycle and circulation of helium

Impact

- Reduced heat stress in military personnel

More information

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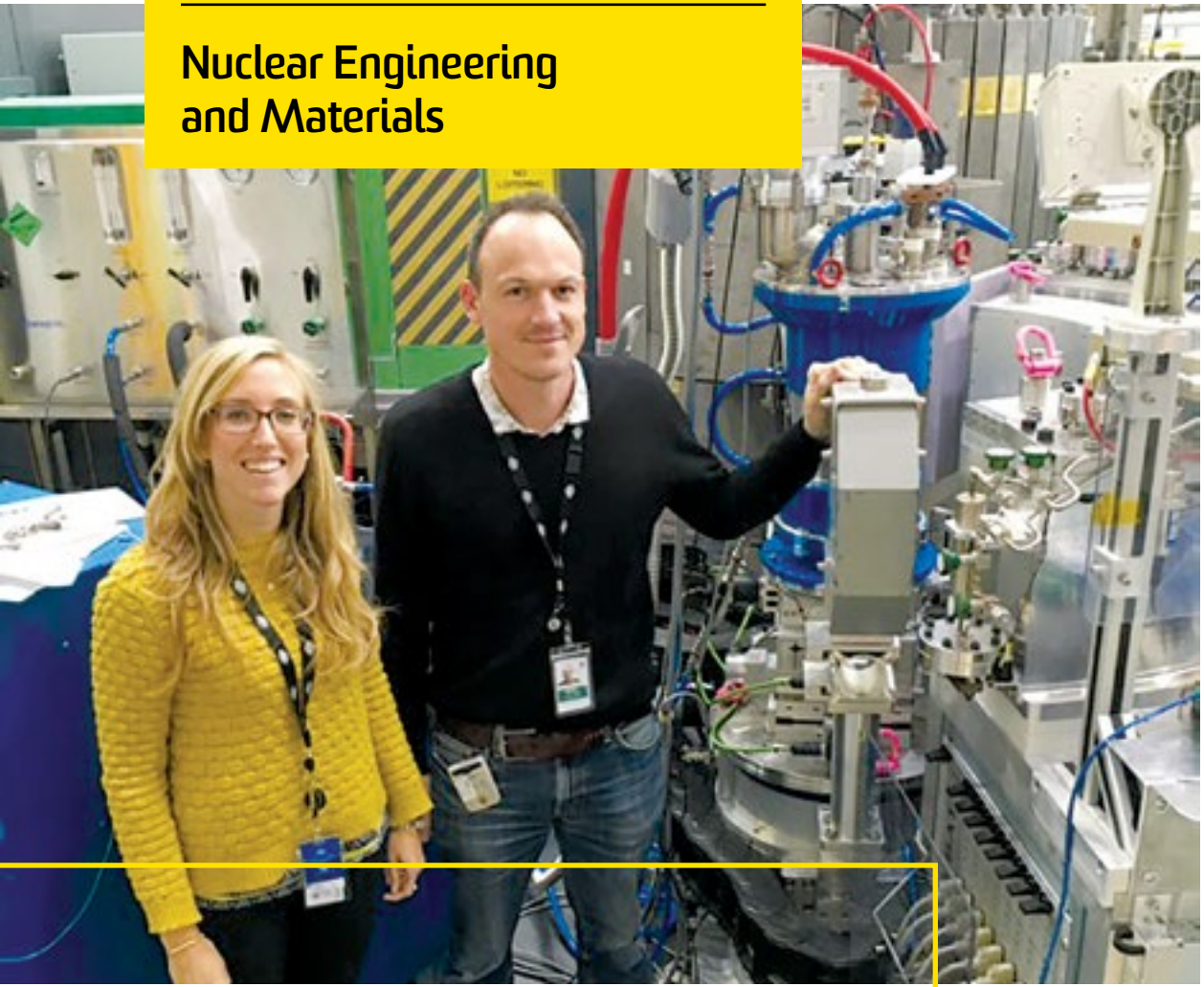
Nuclear Engineering and Materials



Specialists in nuclear engineering and nuclear materials and their application to protection against nuclear and radiological threats.

Competitive advantage

As Australia's leading research group in nuclear engineering, we offer vital expertise to government and industry sectors, including:

- Radiation-hard materials
- Radiation safety response
- Radiation impact modelling
- Uranium metallurgy and uranium chemistry
- Virtual reality, human-machine interfaces and remote handling

Impact

- Safer materials and systems for protection against radiation threats

Successful applications

- The highest possible melting-point refractory high-entropy alloy (CrMoVW), containing chromium for oxidation protection
- Tungsten-vanadium carbide alloys for hard facing, Broco/Rankin Vanotung™
- Nuclear engineering of components and systems in the OPAL reactor

Capabilities and facilities

- UNSW radioactive material research facilities
- Discretionary access to Australian nuclear infrastructure
- Experience in accessing international facilities, with demonstrated outcomes

Our partners

- Westinghouse Electric
- ANSTO
- Broco/Rankin

More information

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Special Operations Employment in Current and Emerging Conflict Environments

The School of Humanities and Social Sciences at UNSW Canberra provides expertise in policy, strategic and operational outlook for the employment of special operations forces in the current and emerging conflict environment.

Competitive advantage

Expertise in:

- The policy environment and challenges for the employment of special operations forces in operations less than war
- The ethics and leadership of special operations
- Emerging technologies and their impact on special operations
- Counter-network operations

Impact

- Improved policy, strategy and operational deployment of special operations forces

Successful applications

- Panellist to the International Panel on the Regulation of Autonomous Weapons
- Consultants to the Australian Army Special Operations Training and Education Centre
- Research input to the Official History of Australian Operations in East Timor, Iraq and Afghanistan

More information

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Military and Security Ethics

The School of Humanities and Social Sciences at UNSW Canberra can provide philosophically rigorous research on the ethical dimensions of conflict, operations and security policy.

Competitive advantage

- Education and research in military ethics with operational and strategic applications
- The ethical dimensions of international security policy, cooperation and governance
- The law and ethics of armed conflict across multiple platforms, conflict types and operational contexts
- The ethics of new military technologies, irregular warfare and specialised combatants such as special forces, private contractors and more, and
- Moral philosophy and ethics—the just war tradition in contemporary times

Impact

- Better ethical decision making

Successful applications

Deane-Peter Baker created the first massive online open course in military ethics and is a member of the International Panel on the Regulation of Autonomous Weapons.

More information

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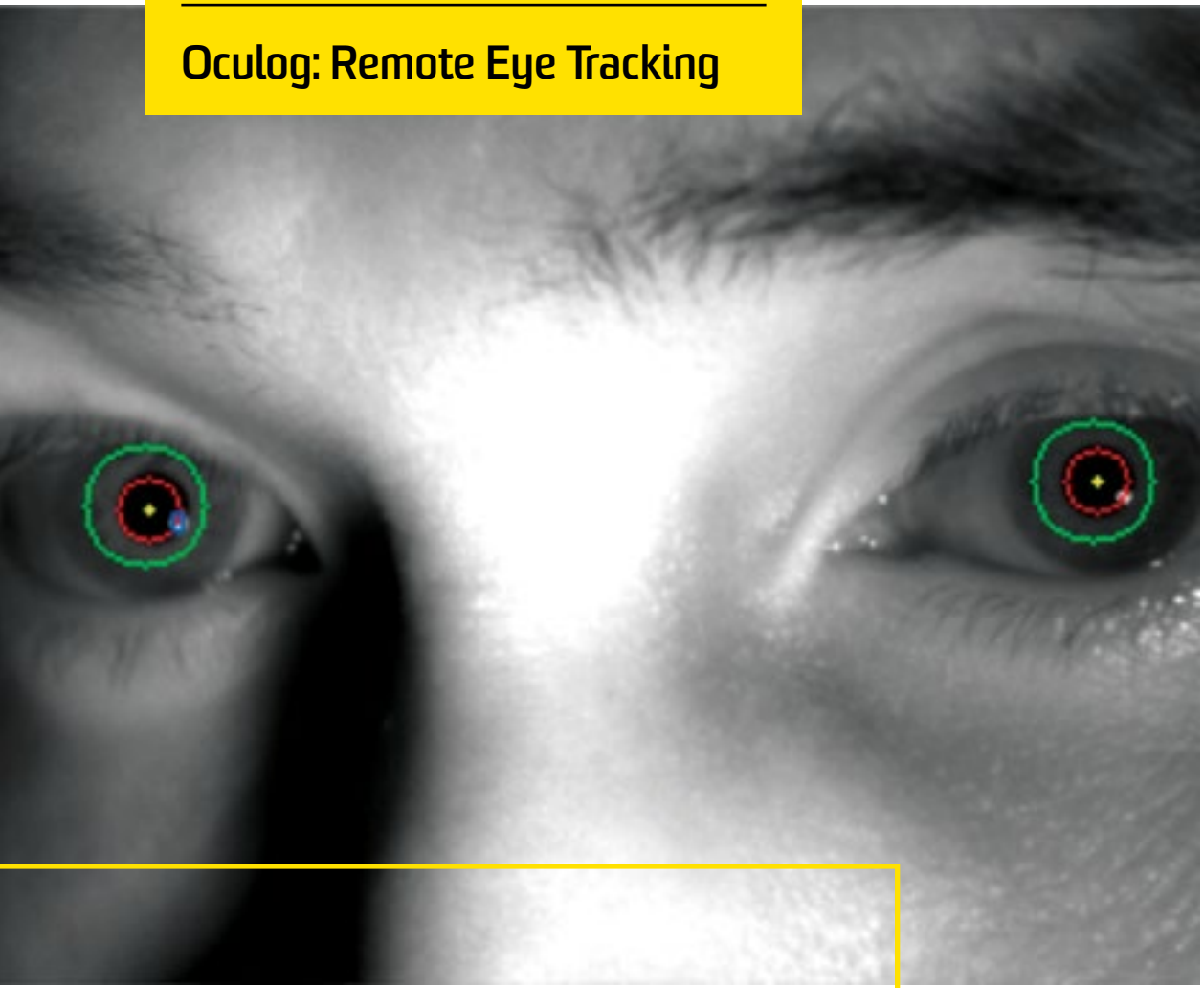
Oculog: Remote Eye Tracking



Oculog is an innovative new remote eye tracking tool that tracks pupil and corneal reflection in a controlled lighting environment to estimate gaze position relative to a stationary or mobile camera. It can potentially be used to track eye movements of many people across a variety of real-world environments. Data can then be auto-aggregated to yield population gaze metrics.

Competitive advantage

- Can track eye movements in real-time from potentially multiple people
- Estimates each individual's gaze pattern relative to either stationary or mobile visual targets
- No point-of-regard calibration required per observer
- No need to wear head-gear that will interfere with observer performance
- Cost-effective solution for a variety of eye-tracking applications

Impact

- Improved biologically-based interfaces for a range of defence applications
- Enhanced security

Successful applications

- Patents with Canon Information Systems Research Australia
- Multiple competitive research grants

Capabilities and facilities

- Eye-tracking hardware and custom software
- 3D animation and modelling for real-time rendering and simulation
- Virtual reality hardware and customisable software for rapid deployment in a variety of research and development scenarios
- Psychophysical resource suites for acquiring perceptual data to assess human perceptual performance in tailored applications
- Computational modelling methods to predict perception/performance

More information

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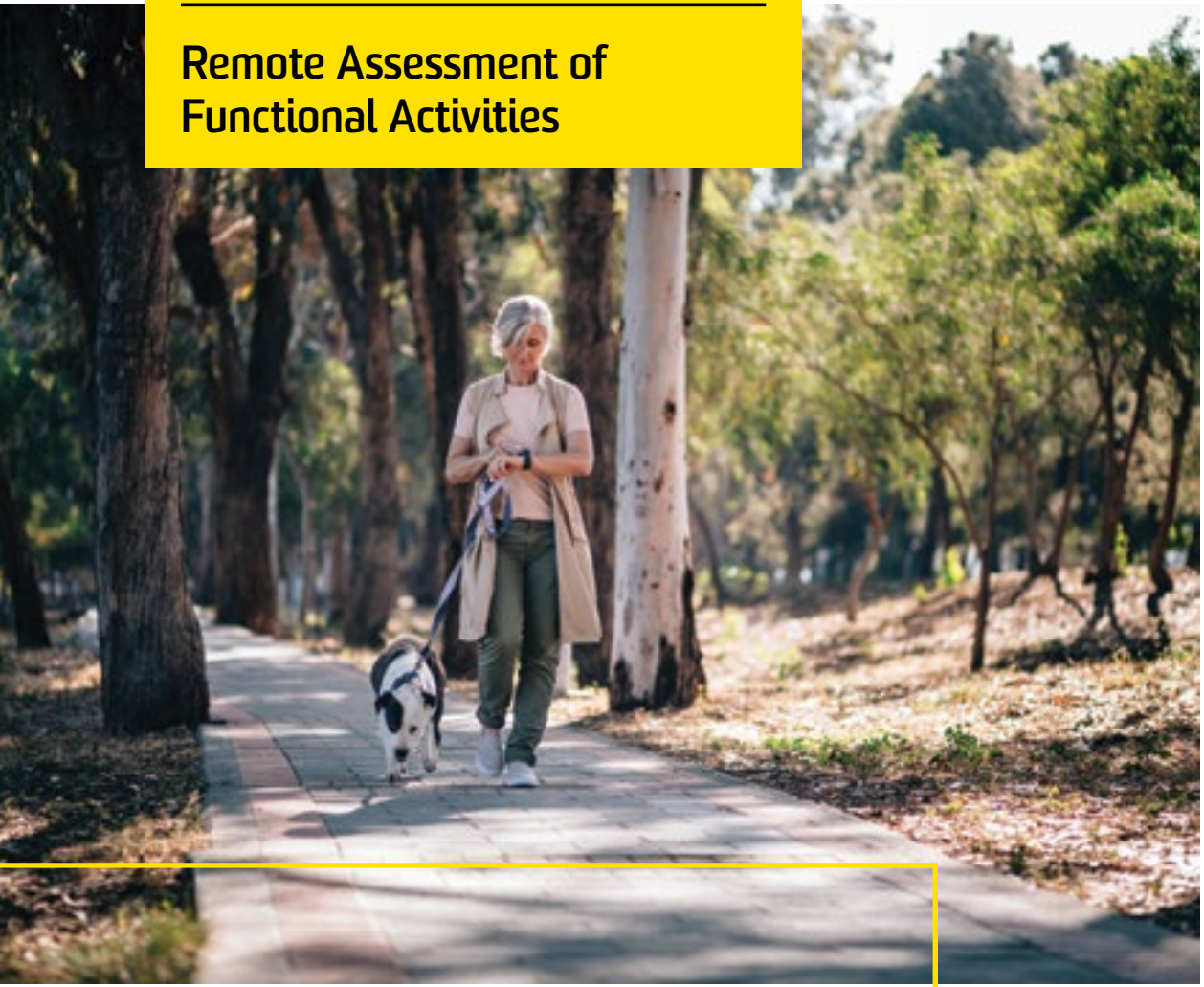
Remote Assessment of Functional Activities



Using sensors, data analysis and extensive clinical expertise, human performance can be remotely monitored in real-life stressful environments and interventions suggested to improve performance outcomes.

Competitive advantage

- Access to a team of clinical experts and engineers
- Ability to interpret sensor data in the context of improving human performance
- Clinical-based interventions
- Remote or rural clinical assessment and support

Impact

- Enhanced human performance through assessment and intervention

Successful applications

Through the Rehabilitation Glove Project at The Quadriplegic Hand Research Unit, Royal North Shore Hospital a wearable device known as Exoflex was developed to provide applied finger joint movement to 15 joints of the hand.

- The device provides therapeutic movement, hand assessment and light functional pinch for people recovering from trauma, surgery or burns, and people with permanent paralysis such as those with spinal cord injury.
- Technology is secured by international patents and licensed to BES Rehab, UK
- Successfully commercialised and used internationally
- Multi-award winning

Capabilities and facilities

- Movement control and evaluation especially as the result of intervention
- VR and 3-D analysis
- Detection and interpretation of biomechanical and bioelectric signals
- Rehabilitation Medicine Specialist
- Paediatric Medicine Specialist

Our partners

- Sydney Children's Hospital, Rehab2Kids
- Royal North Shore Hospital, Hand and Peripheral Nerve Surgery Department

More information

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Genomics Research and Analytics

The Ramaciotti Centre for Genomics is the largest genomics facility at any Australian University. It is comprehensively equipped with the latest next-generation sequencing (NGS) technology, with single-cell genomics platforms and with high throughput microarray systems. It is funded by the Australian Government as infrastructure of national significance.

Competitive advantage

- Genomics facility with 20 years' operational experience in virtually all areas of genomics
- Highly experienced technical staff and facilities capable of annually processing more than 50,000 samples by NGS and other technologies

Successful applications

- Human genome sequencing, exome sequencing and genotyping
- Rapid genome sequencing and assembly of viral, microbial and fungal pathogens
- Microbiome analysis of samples from humans, soil and water by 16S rRNA or metagenomics
- Short-read and long-read sequencing
- Analysis of gene expression by next-generation sequencing or microarray
- Potential to analyse bioterrorism or biosecurity agents

Capabilities and facilities

- Capacity for end to end projects, including bioinformatics
- Custom-built labs in a new $180M biosciences building

Our partners

- CSIRO
- NSW Department of Primary Industries (DPI)
- The Australian Wine Research Institute (AWRI)
- Garvan Institute of Medical Research

More information

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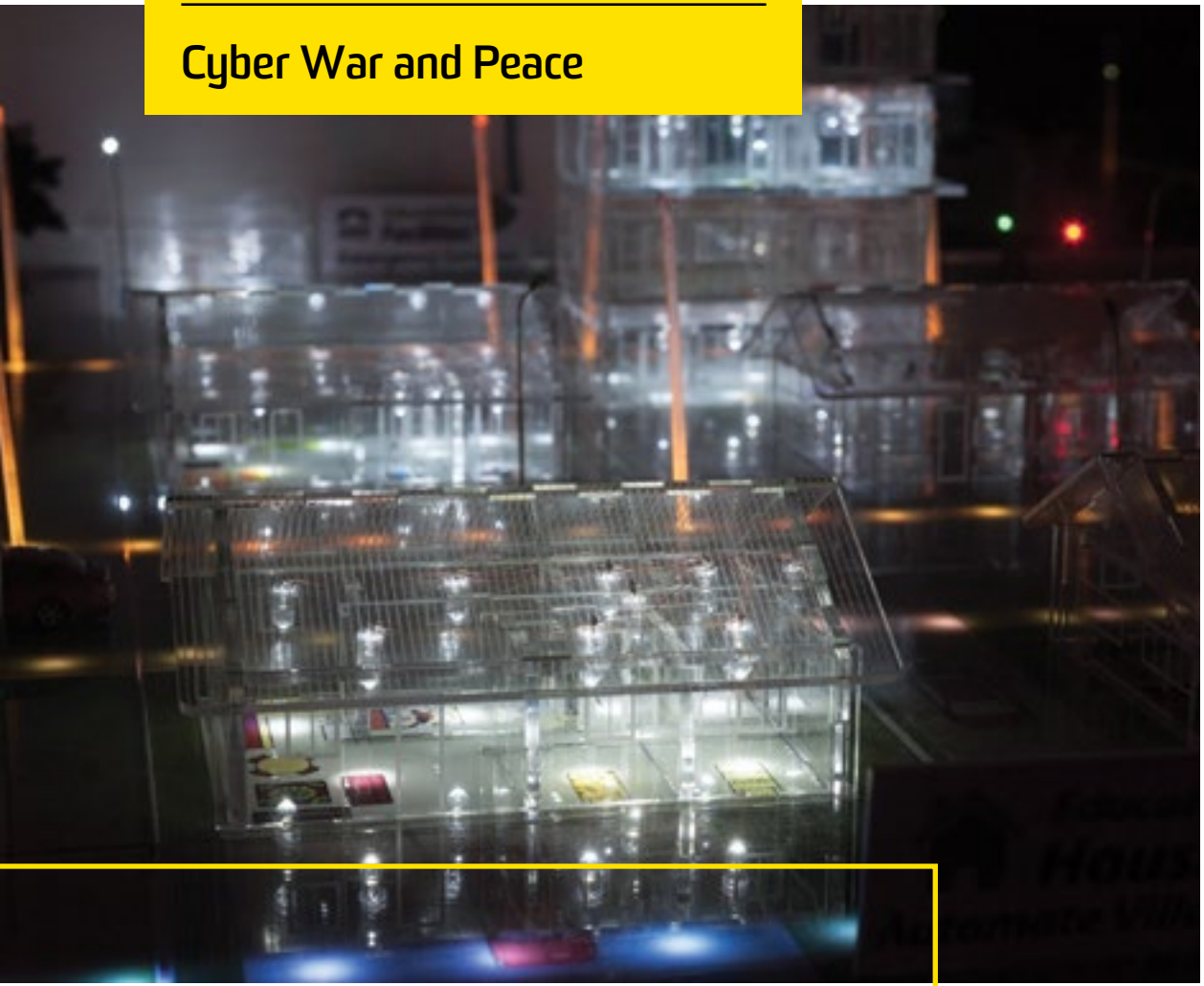
Cyber War and Peace



Combining perspectives from strategic studies and social science research to bring expertise to the military, diplomatic and national security policies for cyber space.

Competitive advantage

- Unique offerings on national security policy and cyberspace strategy
- Ground-breaking research and education on China cyber, military cyber strategies, complex cyber emergencies, and human capital for security in cyberspace
- High-value international networks in leading research centres outside Australia
- Expertise recognised by high-profile military and civilian leaders

Impact

- Contributing to defence policy at a time when Australia is moving rapidly to set up new cyber forces and wide-ranging civil-sector security measures
- Participation in policy development work with governments and the private sector

Successful applications

- Participation in national and international consultations led by government
- Innovative research projects that influence policy deliberations
- International research workshops in partnership with government
- Knowledge transfer through professional education

Capabilities and facilities

- Advanced research capability in military cyber policy, international security and diplomatic aspects of cyberspace, international cyber law of armed conflict, policy for critical infrastructure protection, education policy and workforce issues for cyber security, social media impacts on international security, technologies of decision-making for defence, human rights and cyberspace
- Professional education and postgraduate education in these fields

Our partners (past and present)

- Department of Prime Minister and Cabinet
- Australian Defence Force
- Defence Science and Technology Group
- U.S. Army Cyber Institute
- NATO Cooperative Cyber Defence Centre of Excellence
- Royal Military College Canada

More information

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Nerve Repair and Re-innervation via BaDGE® Naked DNA Therapeutics

Bionic array Directed Gene Electrotransfer (BaDGE®) is a platform technology for targeted delivery of naked DNA. The first clinical application uses DNA encoding neurotrophins to drive regrowth of the auditory nerve.

Competitive advantage

- First-in-class DNA electro-transfer technology for targeted DNA payload delivery to a broad range of tissue targets. It is:
  - Safe (naked DNA)
  - Regulatory permissive (non-viral)
  - Not limited by gene size packaging constraints
  - The highest level of control of the delivery of genes to target tissues
  - High efficiency gene augmentation therapeutics
- Multi-disciplinary team working at the interface of biology, engineering and clinical translation
- A patent portfolio covering all aspects of the BaDGE® platform

Impact

- BaDGE® is broadly transferrable to nerve/ brain injury and muscle re-innervation.
- Validated for nerve repair and directed nerve regrowth, CNS neuromodulation, control of muscle contraction
- Broad application potential based on this novel gene electrotransfer technology for discrete targeting of DNA therapeutics in tissues; brain injury, DNA vaccines, oncology, cardiovascular disease, hearing loss, vision

Successful applications

- BaDGE® cochlear implant neurotrophin gene therapy clinical trial to regenerate the auditory nerve
- Licensing agreements with industry partners reflect due diligence on BaDGE® capabilities

Capabilities and facilities

- DNA therapeutics—models, including cell, tissue and behavioural models, focusing on translational neuroscience applications, including nerve injury, brain injury, hearing and vision, pain, stroke, and traumatic brain injury
- Biomedical Engineering Faculty allows application-specific modelling, design and DNA delivery probe production

Our partners

- National and International Medical Device
- DNA Therapeutics Licensees

More information

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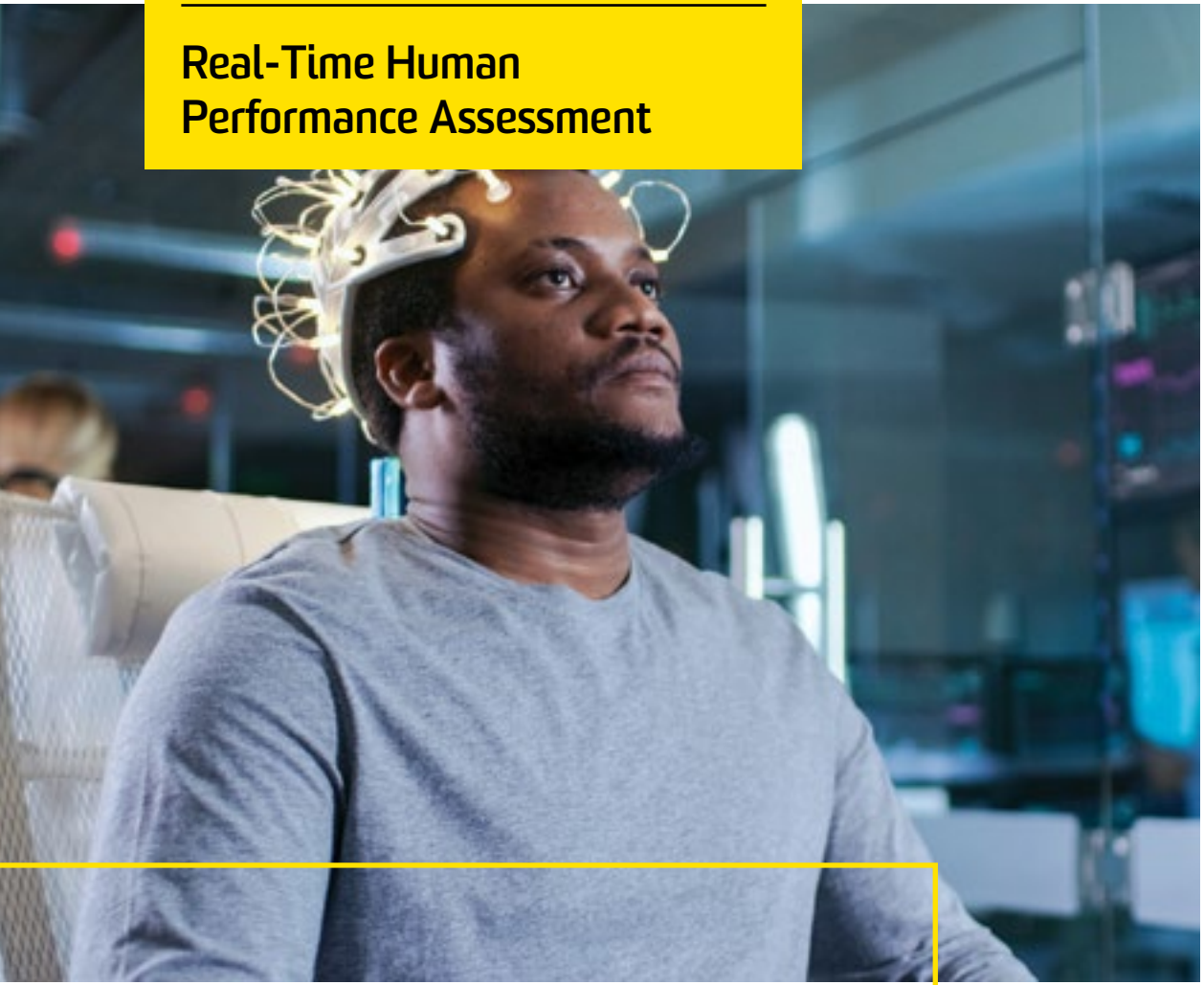
Real-Time Human Performance Assessment



Working with technologies that enable real-time cognitive human performance assessment of attention, emotion, motivation, situation awareness, task assessment, and cognitive workload indicators.

Competitive advantage

- Decades of accumulated knowledge and algorithms for real-time human performance
- Software that allows the system to operate with any commercial off-the-shelf system
- Expertise to transform lab-based psychology into in situ real-time metrics
- A technology that works with different data sources and is robust against loss of a data source. A technology that assesses human mental states on a second-by-second basis and integrates them to adapt AI and automation to the human.

Impact

- Real-time improved understanding of human performance and behaviour in organisations
- Improved decision making through real-time cognitive augmentation
- Trusted human-machine environments

Successful applications

- eLearning commercialisation, Smart Sparrow
- Real-time assessment of human performance in air traffic control systems
- Trusted human-autonomy teaming in teleoperation
- User-task co-adaptation for effective interactive simulation environments, offering a generic bi-directional human-machine communication system that allows users to adapt their cognitive load to a task and adapting the task to the user

Capabilities and facilities

- An integrated 12-seat laboratory—using a variety of sensors including EEG, Kinect, Eye Tracker, and physiological sensors—for cognitive and behavioural human performance measurement
- High-fidelity simulation environments including air-traffic management and uninhabited all-domains vehicles (UxVs) modelling
- State-of-the-art defence simulation environments including Virtual Battlespace System
- The technology uses multiple data sources including electroencephalography (EEG), facial expressions, language, speech, keyboard, and vibrations

Our partners

- Defence Science and Technology (DST)

More information

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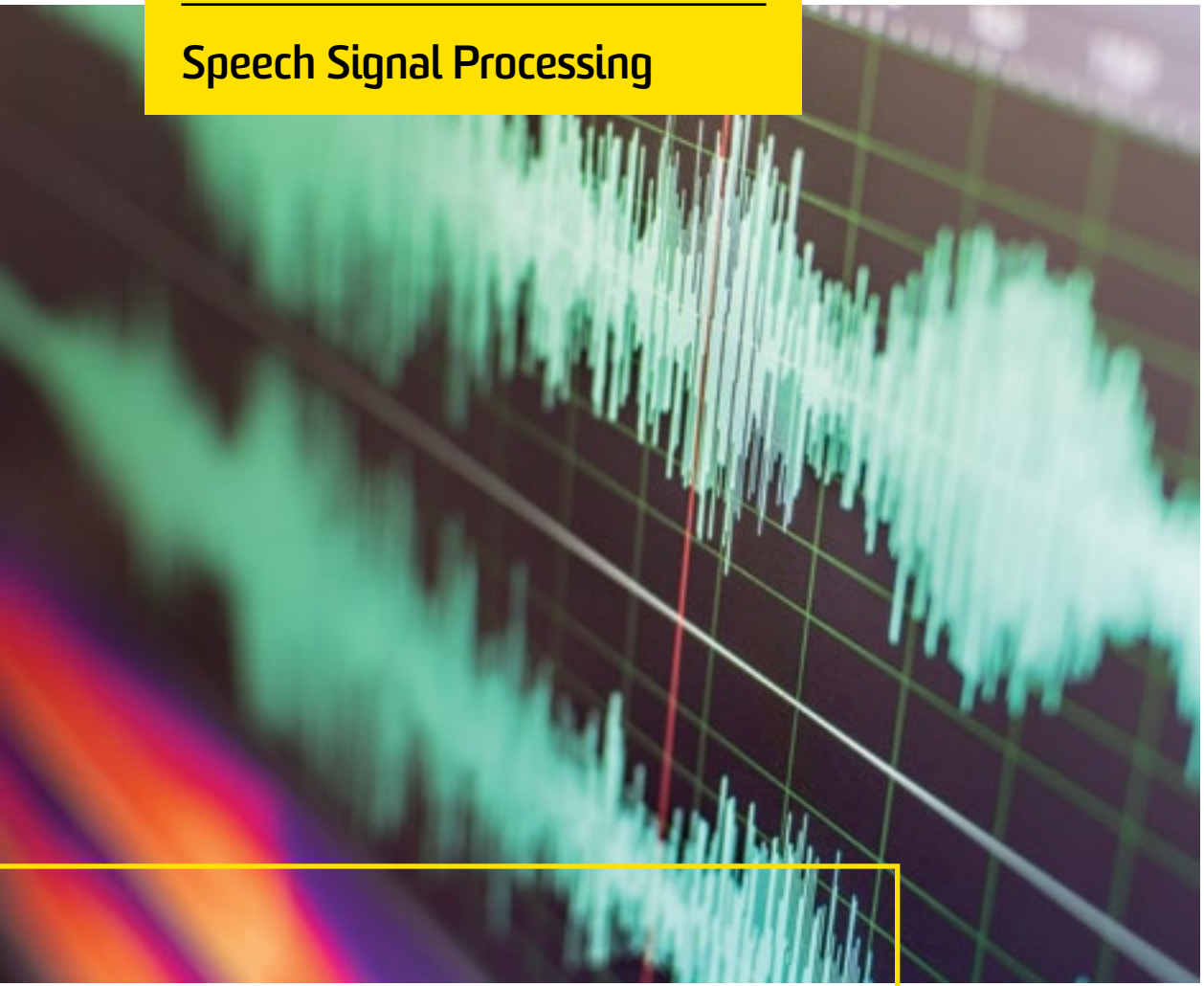
Speech Signal Processing



Inferring emotional and mental state from speech and behavioural signals—by automatically detecting speaker, language and pronunciation—to enhance security via speech analysis.

Competitive advantage

Expertise in automatic inference of emotion, distress and mental state from speech and other biometrics, as well as:

- Voice biometrics and anti-spoofing countermeasures
- Automatic identification of language and detection of pronunciation
- Behavioural and biomedical signal processing

Impact

- More efficient and effective security and surveillance
- Understanding and maximising human performance in high-stress environments
- This research has been translated into smartphone apps that can monitor mental states, smart health monitoring and interventions, automated speech therapy and second language learning, and live analysis of web-based remote video consultations

Successful applications

- Joint modelling and recognition of linguistic and paralinguistic speech information
- Affective sensing technology for the detection and monitoring of depression and melancholia
- Automatic task analysis for wearable computing
- Investigating Bayesian frameworks for paralinguistic classification
- Automatic speech-based assessment of mental state via mobile device

Capabilities and facilities

- High performance computing capabilities, including a large library of code, scripts and databases of speech and other signals
- Soundproofed, light-controlled studio facility for recording speech and behavioural signals

Our partners

- US Army
- ITC-Pacific Pty Ltd

More information

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Flexible Surgical Robots and Wearable Devices

Expertise in designing teleoperation systems, flexible surgical robots, magnetic capsule endoscopy and soft wearable devices to improve the human quality of life.

Competitive advantage

- World-leading technologies on soft robotics, wearable devices, and flexible surgical systems with multifunctionalities that can be widely applied in various applications
- Expertise in mechanical design, electronics, system modelling, functional materials, and nonlinear control
- Experienced in international patent protections
- Strong collaboration networks in USA, Singapore and Australia

Impact

Improved the human quality of life with cutting-edge technologies for haptics, entertainment, and healthcare

Successful applications

- World's first flexible endoscopic robot for gastrointestinal cancer treatment
- Soft magnetic capsule robot for weight management
- World's first multifunctional soft electromagnetic actuators, soft planar textile muscles, and microtubule sensors for haptics and robotic applications

Capabilities and facilities

- Full-scale experimental equipment for real-time control and characterisation of robotics and mechanical systems

Our partners

- Prince of Wales Hospital

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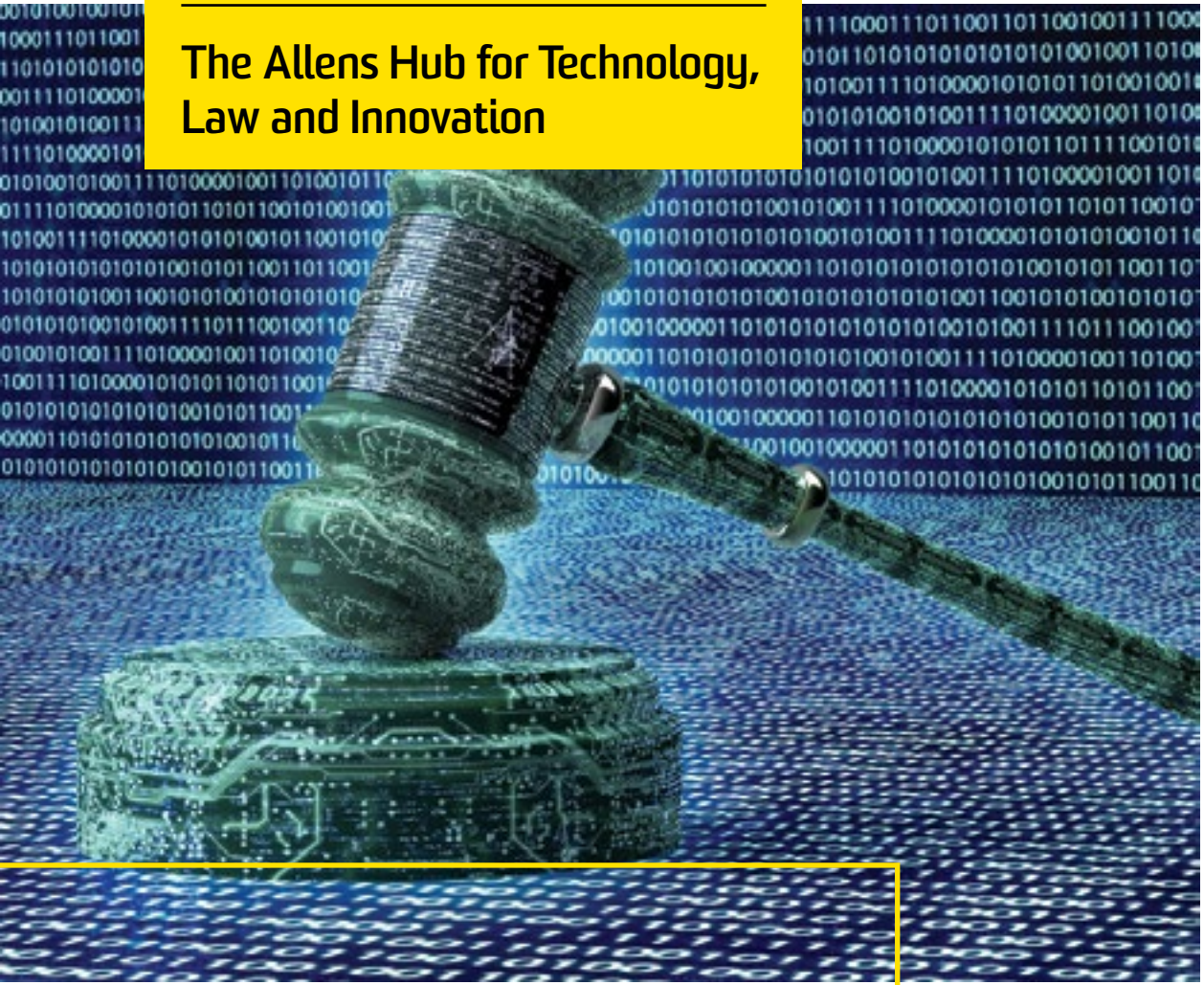
The Allens Hub for Technology, Law and Innovation



An independent community of scholars adding breadth and depth to research on the diverse interactions among technological change, law, and legal practice, enriching academic and policy debates. Driving considered reform of law through engagement with the legal profession, the judiciary, industry, government and the broader community, it incorporates a wide variety of more specific research streams including Data Justice, Data Protection and Surveillance, and Technologies and the Rule of Law.

Competitive advantage

Expertise in:

- The interaction between law and new technologies
- Legal and ethical issues related to the use of Artificial Intelligence techniques including machine learning
- Legal issues around the collection, storage and use of data, including in the context of defence and national security
- Cyber security law and policy
- Qualitative empirical research, including experience working with government agencies

Impact

- Improved legal and policy framework for appropriate use of data and data analytics as well as for cyber security and cyber resilience
- Submissions to Human Rights Commission, UN Special Rapporteur on the Right to Privacy and the Intelligence Review, leading to participation in related events and influence over policy development nationally and internationally

Successful applications

- Led projects in the Law and Policy Program of the Data to Decisions Cooperative Research Centre
- Led research on the use of Open Source data by government agencies (including Defence Science Technology), exploring issues in copyright, privacy law, and contract law

Our partners

The Allens Hub for Technology, Law and Innovation is a partnership between Allens Linklaters and UNSW Law.

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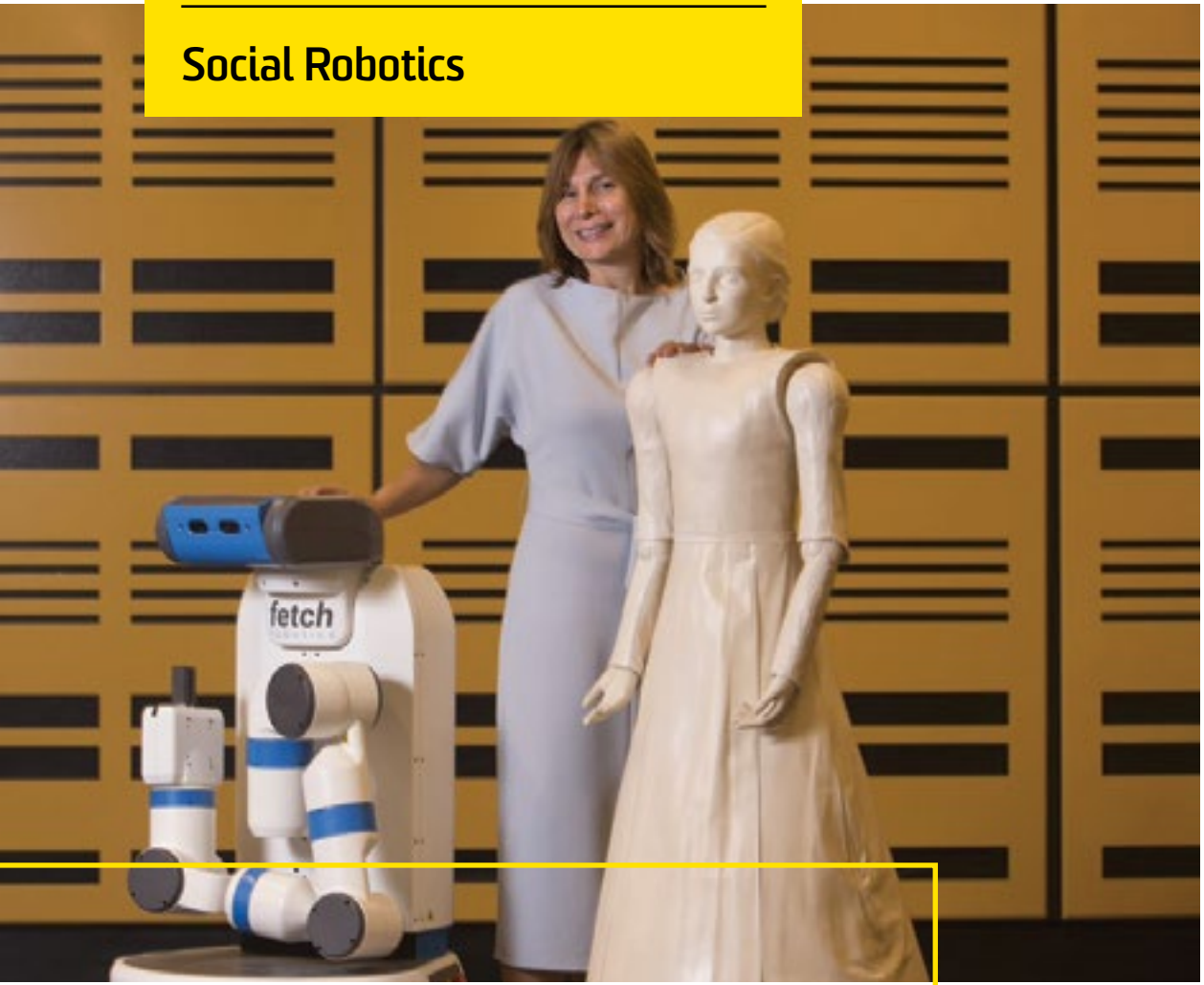
Social Robotics



A cross-disciplinary research environment dedicated to understanding how humans can interact with three-dimensional robotic agents and responsive structures within the context of creative and social robotics. The laboratory aims to provide a structured environment which facilitates the creation of experimental interfaces that promote interactivity in physical spaces.

Competitive advantage

- Pioneered the field of social robotics and one of the few centres in the world—the only one in Australia—which co-developed the terminology of social robotics
- The Creative Robotics Lab is one of the first teams in the world to take an informed multi-disciplinary approach to human-computer and human-robot interface
- Human centric approach—task taking, providing experience and respecting the human interactant regardless of age and abilities

Impact

- Changing the way assistive devices technology can resolve situations with social stigma
- Increasing safety to allow people to stay at home longer

Successful applications

- In relation to robotics, one of the few groups in the world that has done cross cultural studies across socio economic groups and countries
- Teaching interaction with humans, eye contact, focus, not being distracted in interactions; how to interact with people you don't know; acceptable social interaction; social touching

Capabilities and resources

- National Facility for Human Robot Interaction Research
- Social Robotics Lab
- Largest data collection in the world on how humans interact with robotic technology
- Experts in technology, people, culture, autism and robot morphologies

Our partners

- US Airforce
- Fuji Xerox innovation Japan
- Necta (Data61) Defence
- St Vincents

More information

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3D Visualisation Aesthetics Lab (3DVAL)

Exploring the challenges of visual narratives and developing novel ways to navigate complexity using creative methodologies from the video game, 3D computer animation and Virtual Reality (VR) creative content industries.

Competitive advantage

- Award-winning cross-disciplinary research hub that explores arts-led approaches for visualising complex scientific and biomedical scan data
- Proven ability to deploy design-led modes to the visualisation of complex scientific and biomedical data using 3D computer arts approaches, most recently VR Head Mounted Displays (HMD)

Impact

Award-winning visualisations with real-world applications, including disease comprehension and rehabilitation.

Successful applications

- VR Pain Management System provides effective distraction to hospital patients experiencing acute pain via a gamified exploration of virtual worlds. A collaboration with St Vincent's Hospital and Samsung
- 'Journey to the Centre of the Cell' project, which recreates a breast cancer cell, was nominated in the Best VizSim Project category for visualisations that have real-world applications, and for the overall Golden Cube award as part of the International 2016 Unity awards in Los Angeles, USA
- 'A fantastic voyage–travel inside your brain and visualise your own stroke' was awarded the 2016 St Vincent's Hospital Innovation & Excellence Award for clinical health engagement, allowing patients to explore personalised vascular scans

Capabilities and Resources

- Wide range of VR/AR systems
- State-of-the-art 3D visualisation creative content studio
- 3D computer workstations
- Render farm systems

Our partners

- St Vincent's Hospital
- Garvan Institute for Medical Research
- ARC Centre of Excellence in Convergent Bio-Nano Science & Technology (CBNS)

More information

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Enhancing Generalisation in Human Learning and Judgment

Studying the factors that influence how people generalise what they have learned to new contexts and situations. Basic research in this field provides guidelines on best to optimise generalisation of learned skills and knowledge.

Competitive advantage

- Extensive body of basic research on generalisation provides the scientific basis for improved training methods to optimise generalisation
- State-of-the-art mathematical modelling techniques to gain insight into the processes that drive human learning and generalisation

Impact

- Increased training efficiency—by developing programs that maximise generalisation without increasing length of training
- Increased insights into trainees' sensitivity to biased evidence and improved ability to adjust/correct for these biases

Successful applications

- Generalisation training strategies successfully utilised to improve children's learning of scientific concepts (Hayes et al., 2003)
- Generalisation strategies incorporated into a program for improved understanding of climate science (Kary, Newell, & Hayes, 2018)
- Recent work examined how people generalise from a sample of evidence when this evidence is biased.

Capabilities and facilities

- Access to specialist software for mathematical modelling of human learning and generalisation performance

More information

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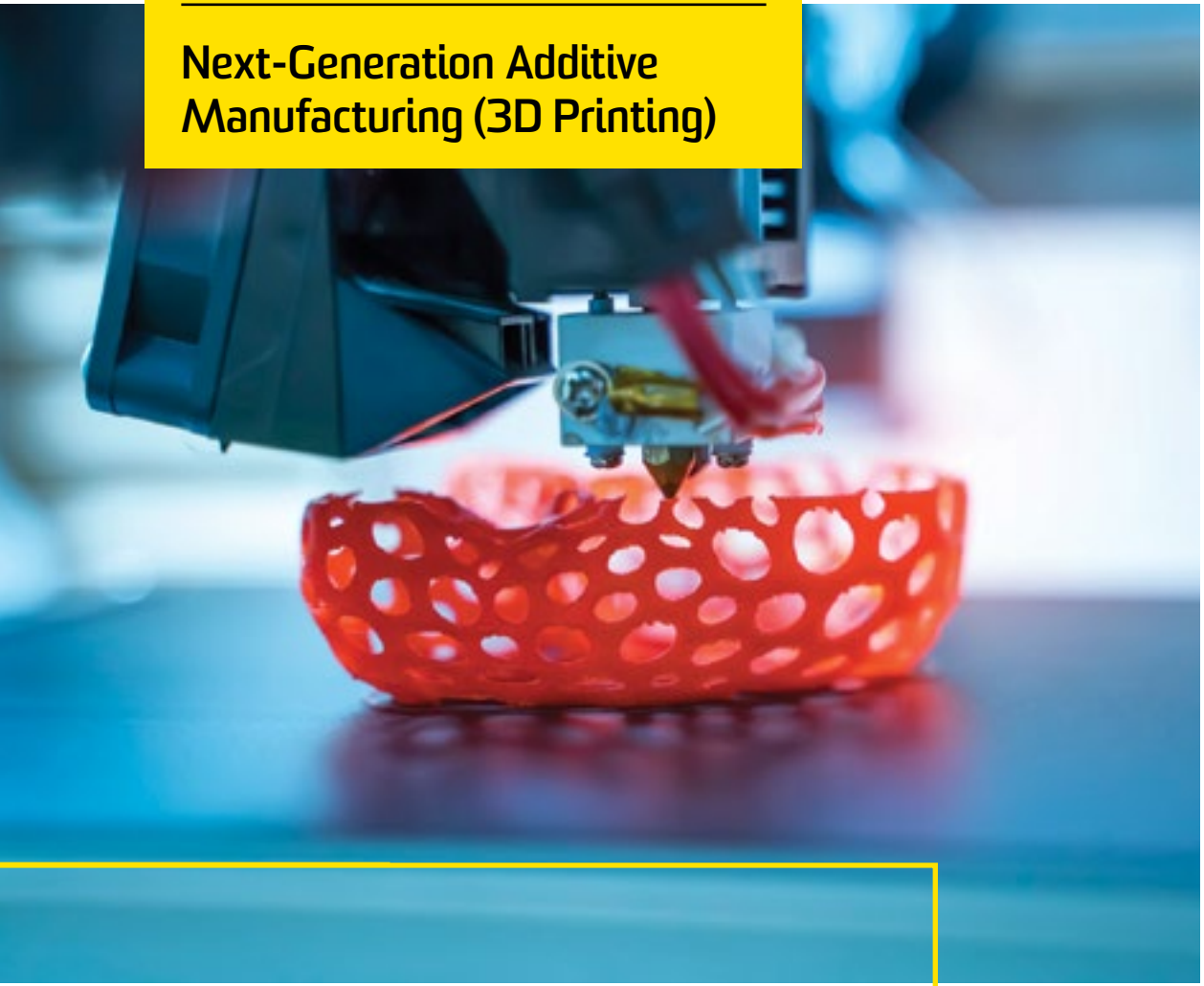
MATERIALS & MANUFACTURING

Next-Generation Additive Manufacturing (3D Printing)



Enabling the creation of innovative products for a diverse range of industries through the development of new materials that enable additive manufacturing (3D Printing) at low cost.

Competitive advantage

- Expertise in additive manufacturing of advanced materials, including Al, Ti, steels, Cu, CoCr, Ta, NiTi, metallic glasses, and high entropy alloys and metal matrix composites, including a machine-learning based design process that enables timely development of new metallic materials
- Finite element modelling, to deliver robust performance, multi-functionality and low-cost solutions
- Novel structures—functionally gradient, porous or solid—with tailorable stress state and microstructure for unparalleled properties
- Low-cost and effective post-treatment strategies for additive manufactured metal components
- The additive manufacturing process of newly-designed materials can be optimised to minimise defects, allowing the creation of innovative products for a diverse range of industries

Impact

- Advanced structures with excellent and predictable dynamic mechanical performance (e.g. fatigue) through additive manufacturing
- New products and lower-cost manufacturing

Successful applications

- Additive manufacturing of high strength and high ductility metal matrix composites and structures for aerospace and automotive applications
- Additive manufacturing of antimicrobial and antibacterial stainless steel and Ti porous structures for biomedical applications

Capabilities and facilities

- Metal 3D Printers: Concept Laser Mlab cusing 200 R and ProX DMP 300
- Mechanical properties testing facilities, including in situ testing, controlled temperatures and environments, micro-mechanical testing, fatigue and wear testing
- High resolution microscopy and tomography, including Scanning electron microscope, Transmission electron microscope, Electron backscatter diffraction and Micro X-ray computed tomography

More information

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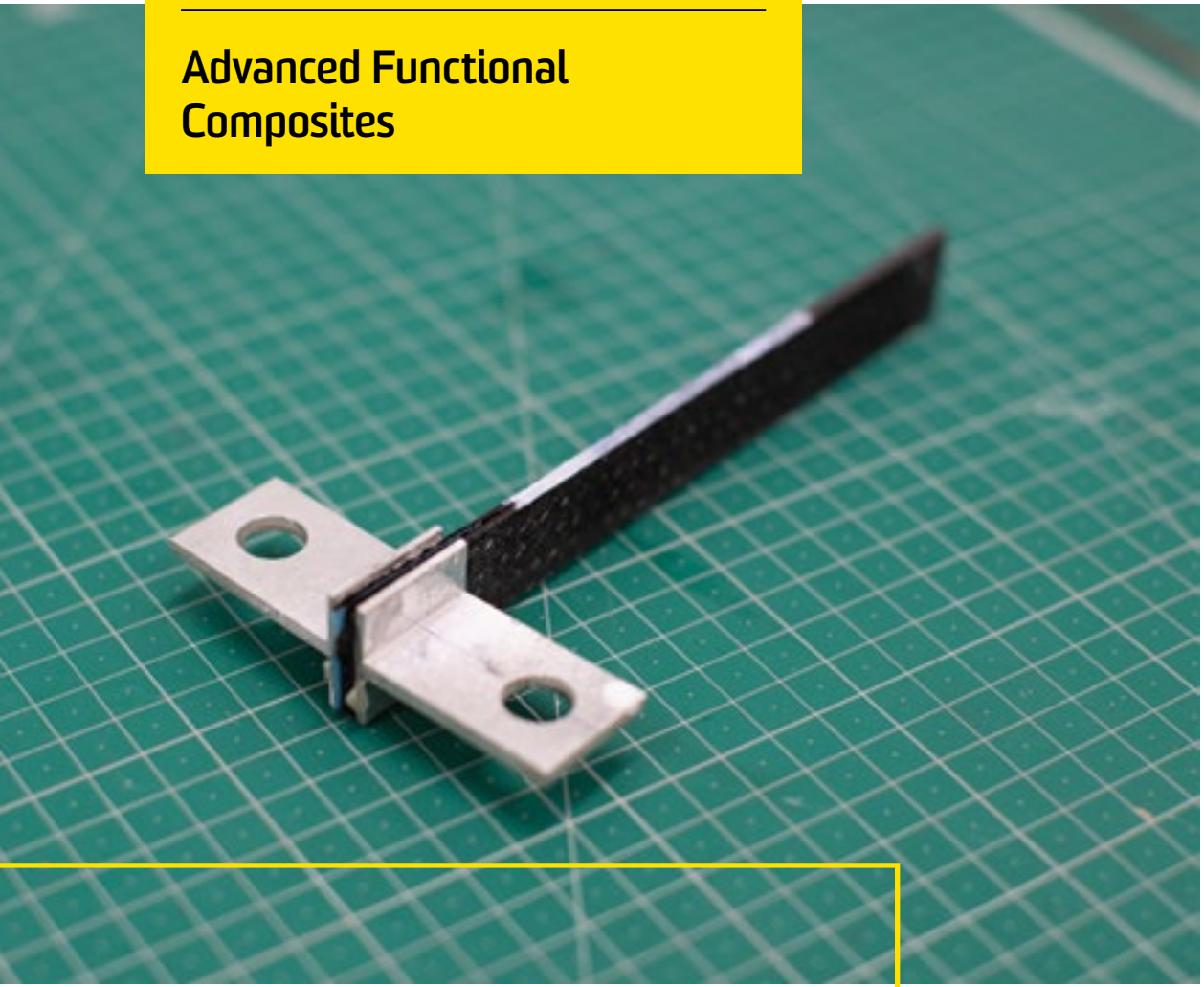
Advanced Functional Composites



Advanced expertise in the design, modelling, optimisation, manufacturing and testing of lightweight fibre-reinforced composites enabling new materials and structures.

Competitive advantage

- Advanced expertise in lightweight fibre-reinforced composites and polymer materials
- Expertise in design analysis, including computational modelling and optimisation
- Advanced manufacturing techniques, including autoclave, thermal oven, resin infusion, compression moulding, solution casting, and 3D printing
- Advanced testing facilities for static and fatigue loading, wear, impact, environmental (temperature) degradation, non-destructive evaluation, mechanical properties, durability

Impact

- Lighter, stronger materials for improved performance

Successful applications

- Flame-retarding composites
- 3D non-crimp fibre preforms for polymer composites
- Carbon fibre wheel to drive clean technology
- Structural health monitoring
- Aligning and chaining carbon nanofillers in fibre composites to improve damage tolerance and diagnosis
- Structural batteries
- Electrically conductive polymer coating
- Nanocomposites for cryogenic hydrogen storage, Lockheed Martin, USA
- Stretchable sensors

Capabilities and facilities

Comprehensive facilities for prototyping and testing including:

- Automated composite manufacturing robots
- Vacuum infusion devices
- Industrial-scale autoclave
- Extensive range of 3d printers
- Ultrasonic system, laser vibrometer, shaker, piezoactuators, wet-chemical, and three roll mill

Our partners

- GE Aerospace
- CSIRO
- Lockheed Martin
- Innovative Manufacturing CRC
- Australian Advanced Aerospace Technologies
- ARC Training Centre for Fire Retardant Materials.

More information

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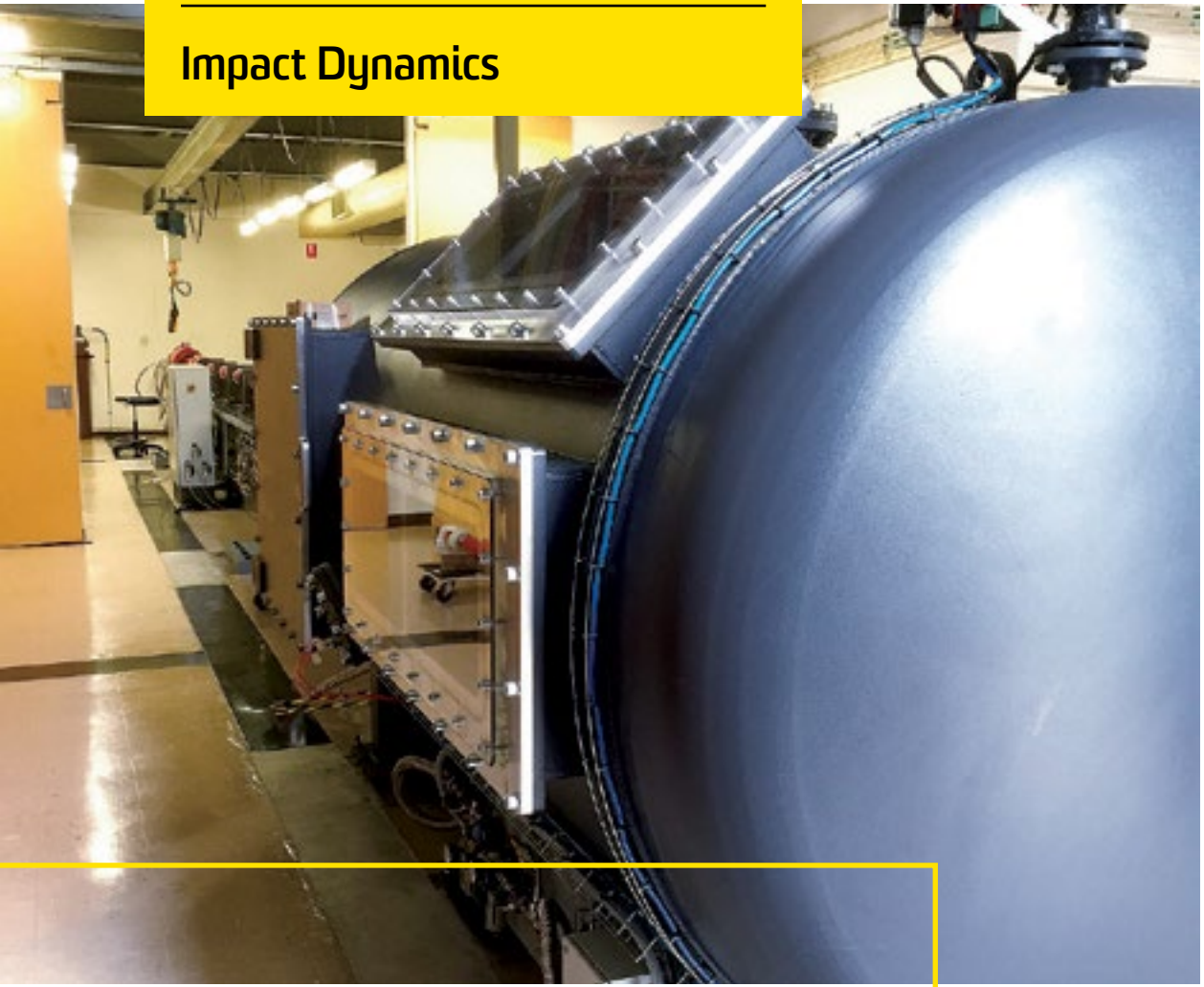
Impact Dynamics



Testing the performance and functionality of materials by subjecting them to a range of extreme loading conditions, including shock loading, ballistic loading, dynamic tension, compression and shear. Diagnostic techniques are used to understand the precise impact of extreme dynamic stress.

Competitive advantage

A unique gas-gun capability that can:

- Fire projectiles to velocities of 4500 m/s
- Conduct flyer-plate tests to 'shock' materials
- Launch any projectile shape

Impact

- Maximise survivability by developing new protective structures for Defence
- Minimise the weight burden on the soldier by developing lightweight durable structures
- Reduce injury by developing a better understanding of the behaviour of the human body to dynamic loading

Successful applications

- Probing the ballistic performance of a bunker design
- Developing models for armour materials
- Understanding the role of a bullet's jacket during the penetration of hard targets

Capabilities and facilities

- Split Hopkinson Pressure Bar (compression and tension)
- Instrumented drop-tower for low velocity impact studies
- High-speed photography equipment and laser-based diagnostics
- Flash x-ray
- Computational codes for simulating dynamic events

Our partners

- Defence Science and Technology
- Australia's Nuclear Science and Technology Organisation (ANSTO)
- DefendTex

More information

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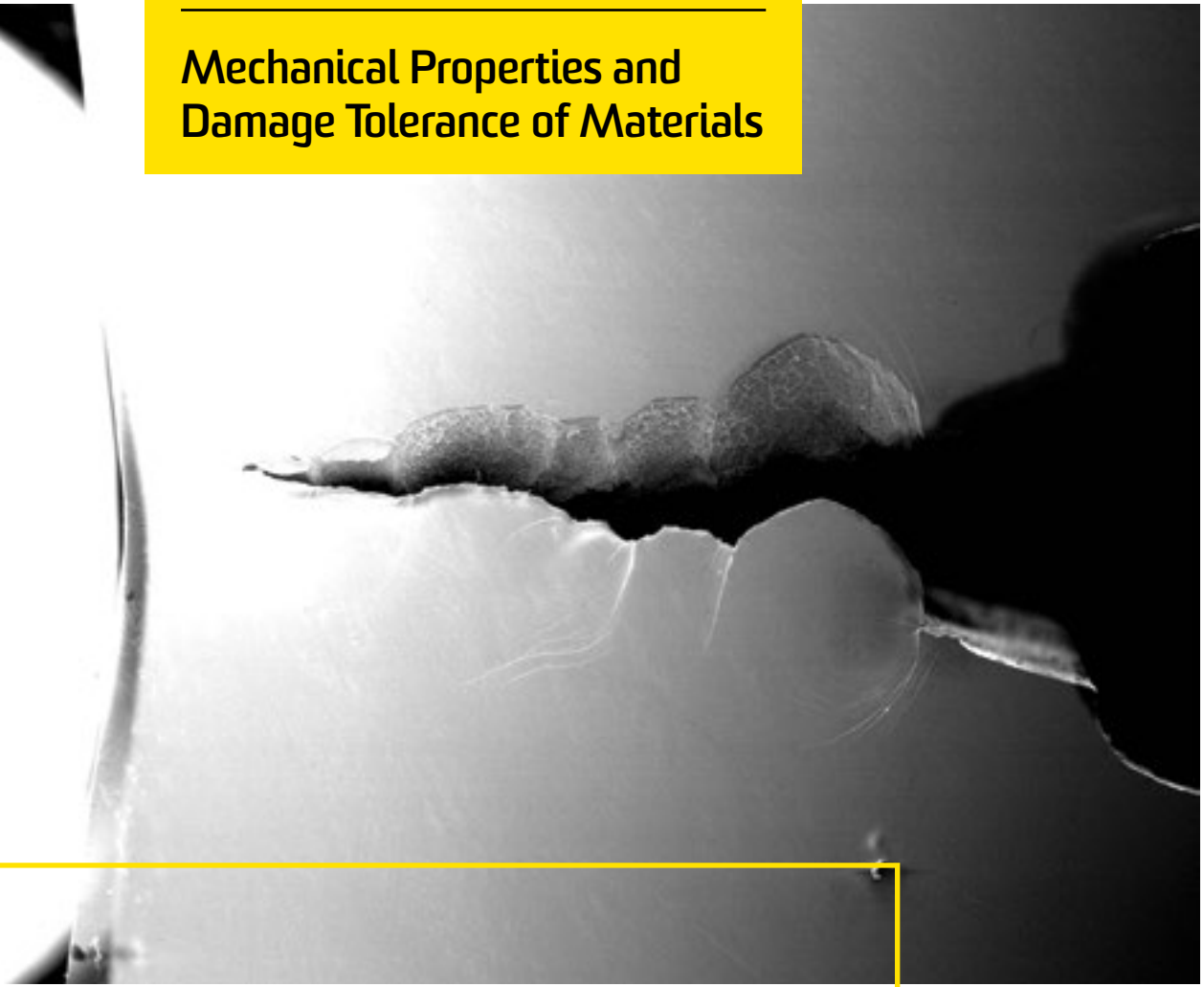
Mechanical Properties and Damage Tolerance of Materials



Delivering a better understanding of materials through characterisation, testing, failure analysis and lifetime prediction across a range of harsh and challenging environments. Thereby contributing to the development of new and novel materials such as high entropy alloys, bulk metallic glasses and bioinspired composites.

Competitive advantage

- Material performance in extreme environments
  - » Nano- and Micro-scale testing up to 600°C
  - » Macro-scale testing from cryogenic to 1500°C
  - » Corrosive and oxidizing environments, vacuum, inert gas, aqueous & biological conditions
- Modelling and simulation:
  - » Novel crack propagation model development (overloads, spectrum loading, creep-fatigue)
  - » Discrete damage model development
- Conventional alloys and novel materials (high-entropy alloys, ceramics, metallic glasses, intermetallics, bio-inspired materials, etc.)

Impact

- Novel materials development for challenging environments
- Improved lifetime predictions

Capabilities and facilities

- Alemnis *in situ* nanoindenter with intrinsic displacement control
- Deben micro-test for ex situ and in situ deformation and property measurements
- Instron multi-axial testing frames
- Crack propagation modelling with overloads, spectrum loading
- Discrete modelling of deformation, damage, failure

Our partners

- US Department of Energy – Superalloys
- Hereaus Group – Additive Manufactured Metals
- Intel Corporation – Solders
- SPEE3D – Additive Manufactured Metals
- PCC Structurals – Superalloy Castings
- ESCO Corporation – Steel Welds
- Plansee SE Corporation – Refractory Metals
- Glassimetal Inc. – Metallic Glasses
- Liquidmetal Technologies– Metallic Glasses
- PLATIT AG – PVD Coatings

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Nanometals for Contaminated Land Remediation

New nano-iron formulations, including sulfidised nano-iron and bimetallic nanoparticles to overcome the limitations associated with traditional zero-valent iron for contaminated land remediation. The conditions generated by nano-iron are favourable for follow-on in situ bioremediation.

Competitive advantage

Expertise in optimisation of sulfidised nano-iron formulations for improved reactivity, contaminant selectivity and reaction longevity, resulting in formulations that are:

- Able to degrade a wide range of chlorinated compounds, including ethlyene dichloride and potentially many PFAS
- Reactive in situ over extended periods (in excess of one year).
- Electrochemically activated sorbents for pfas defluorination
- Next generation nano-iron formulation to degrade PFAS

Impact

- More effective remediation of contaminated land

Successful applications

- Electrokinetic enhanced transport of nano-iron, persulfate and lactate for emplacement of these amendments in chlorinated solvent contaminated clay in Ontario, Canada. Continued monitoring demonstrating considerable contaminant degradation
- Sulfidised nanoiron applied at site impacted by chlorinated solvent in Ontario, Canada, with significant decreases in chlorinated solvent concentrations including ethlyene dichloride
- Additional field trials in collaboration with Canada's Department of National Defense, Dow Chemical, CH2M and Geosyntec

Capabilities and facilities

The water research laboratory has extensive facilities, including:

- Numerous wave flumes, a spillway flume and a wave basin
- A fully equipped chemistry lab and a soils lab for sample preparation, separation and analysis
- Groundwater field and survey equipment
- A centrifuge permeameter
- UAV/drone surveying equipment

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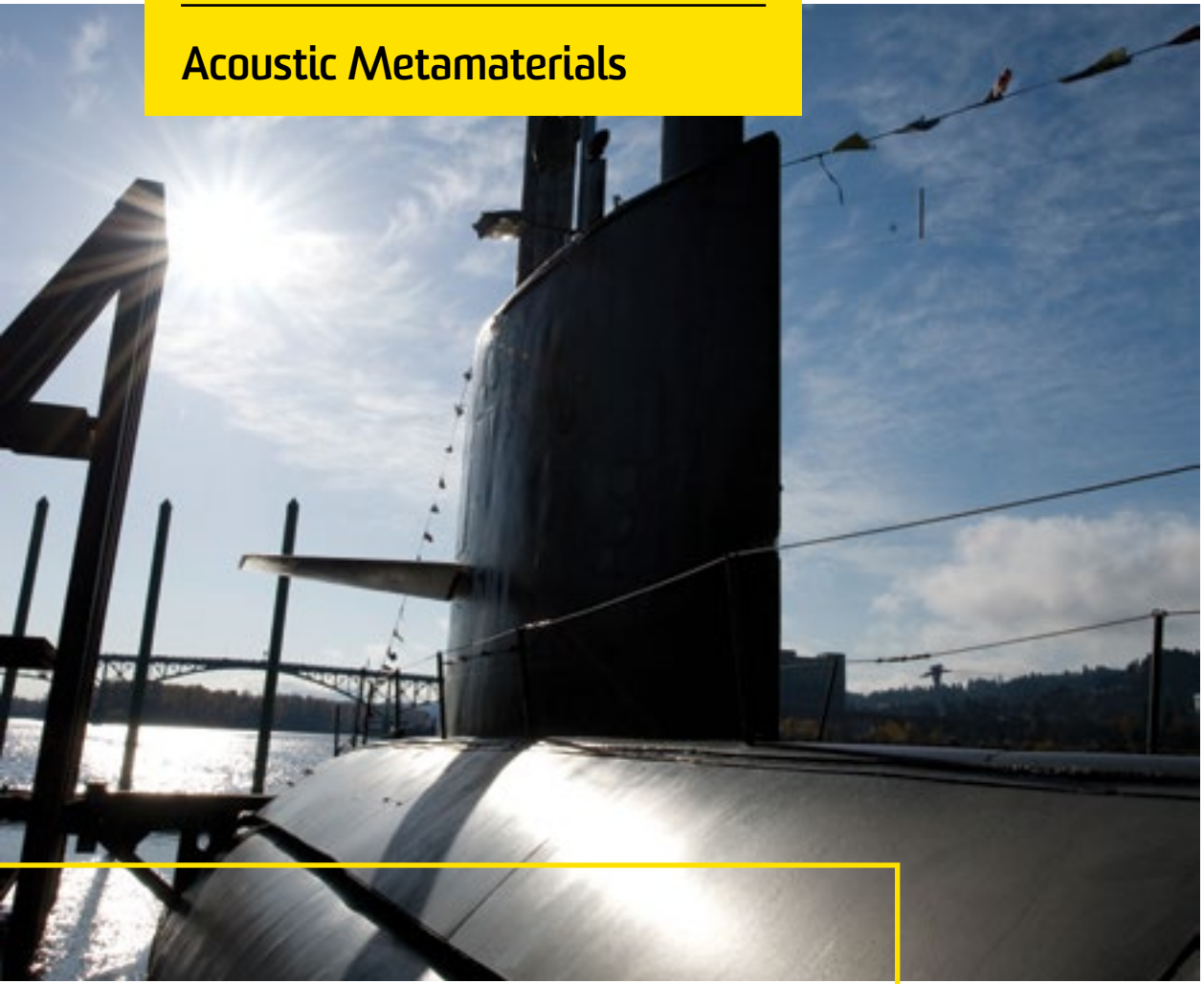
Acoustic Metamaterials



Acoustic metamaterials, effective medium approximation and development of novel materials for maritime applications.

Competitive advantage

- Development of sound-absorbing materials for use as hull coatings
- Design of composite materials with sub-wavelength acoustic capabilities.
- Novel materials including locally resonant photonic crystals
- Understanding acoustic performance by incorporating physical phenomena associated with size, shape and location of inclusions

Impact

- Advances in design of hull coatings and the characterisation of novel materials to be applied in submarines and surface shipbuilding for the Royal Australian Navy
- Minimising underwater noise pollution, contributing to the health of the natural marine environment
- Maximising stealth capability through reduction of sonar detection

Capabilities and facilities

- Expertise in multi-disciplinary numerical modelling on vibro-acoustics and flow induced noise

Our partners

- Defence Science & Technology (DST)
- Naval Group

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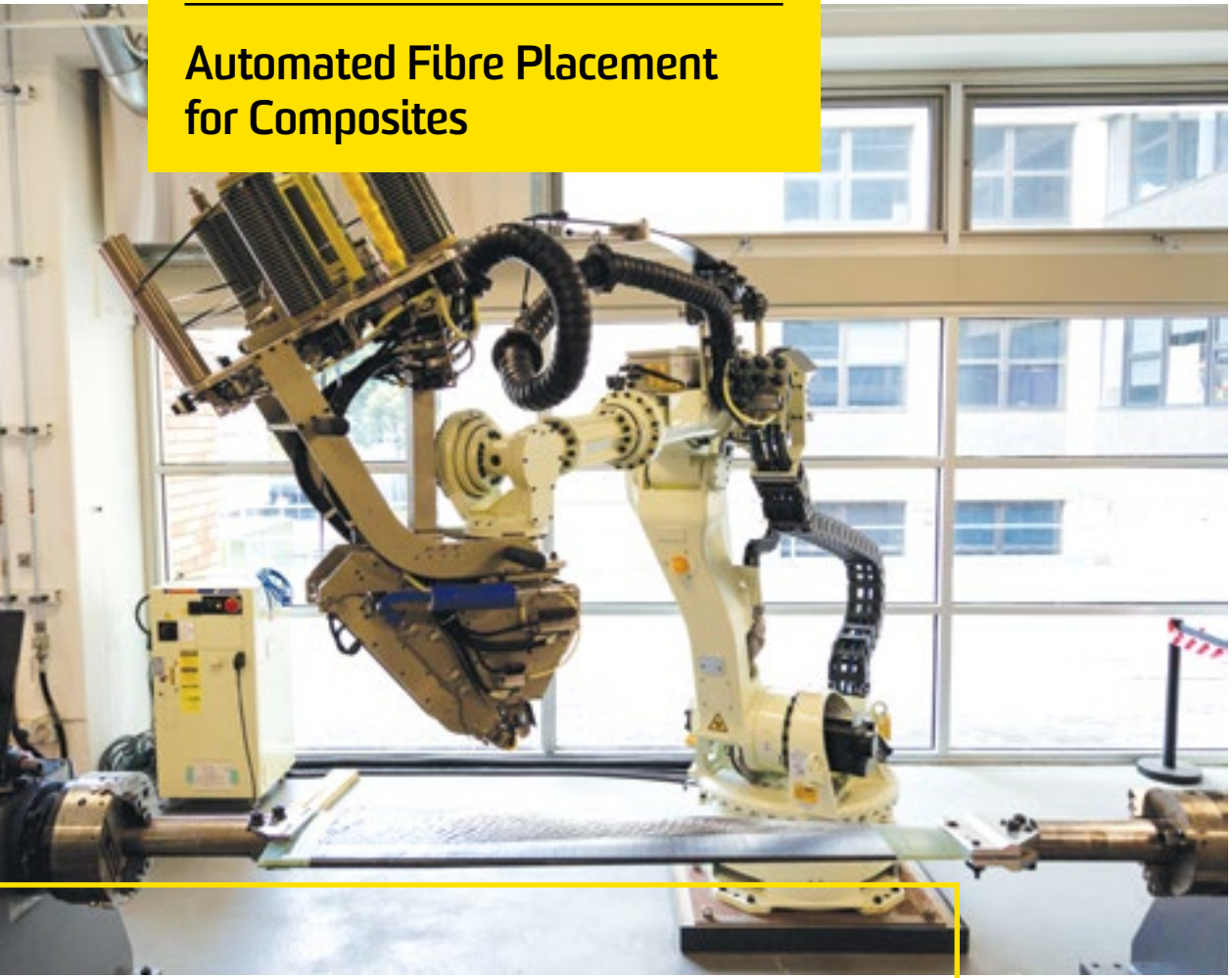
Automated Fibre Placement for Composites



Providing maximum control over fibre trajectories and part geometry; this facility includes a head for laying parallel thermoset prepreg composite tows as well as a specialist thermoplastic composite head for in-situ melding for one-shot part fabrication of bespoke high-performance composites.

Competitive advantage

- AMAC's state of the art manufacturing, testing and analytical facilities provides a comprehensive research and development capability
- The only Automated Fibre Placement facility in the Southern Hemisphere
- In-situ and ex-situ sensing expertise using distributed fibre-optics sensors, fibre Bragg gratings for temperature, strain and acoustic emission
- Testing capabilities from coupon level to large structures at various loading and temperature conditions

Impact

- Ability to undertake complex shape manufacture using AFP techniques
- Manufacturing of metal-composite hybrids
- Impact and damage assessments of composites using smart materials and sensors to inform and enhance future designs

Successful applications

- Shape-adaptive composite hydrofoil, Defence Science and Technology (DST)
- Retrofittable composite solutions for helicopter crashworthiness, DST
- Robust design of composite cylinders for space applications

Capabilities and facilities

- State-of-the-art impact testing
- Robotic fabrication facilities

More information

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Supramolecular host–guest systems

Cucurbituril, a supramolecular system unit developed at UNSW, is a robust host molecule that can be used in various applications, including drug delivery, asymmetric synthesis, molecular switching, and dye tuning.

Competitive advantage

- Strong background in supramolecular synthesis and international expertise in molecular host-guest systems of cucurbituril for chemical property manipulation
- Expertise in energetic materials including analysis, detection and controlled degradation
- Suite of intellectual property protection

Successful applications

- Supramolecular manipulation for improved IR countermeasure flares, Defence Science and Technology (DST)
- Safe degradation methods to cyclic peroxide base explosives, DST
- A sensor-reporter approach to explosive detection in aqueous environments via luminescence manipulation within molecular cages
- Environmental treatment of waste water from nitrotriazole (NTO) manufacture, DST

Our partners

- Defence Science and Technology (DST)

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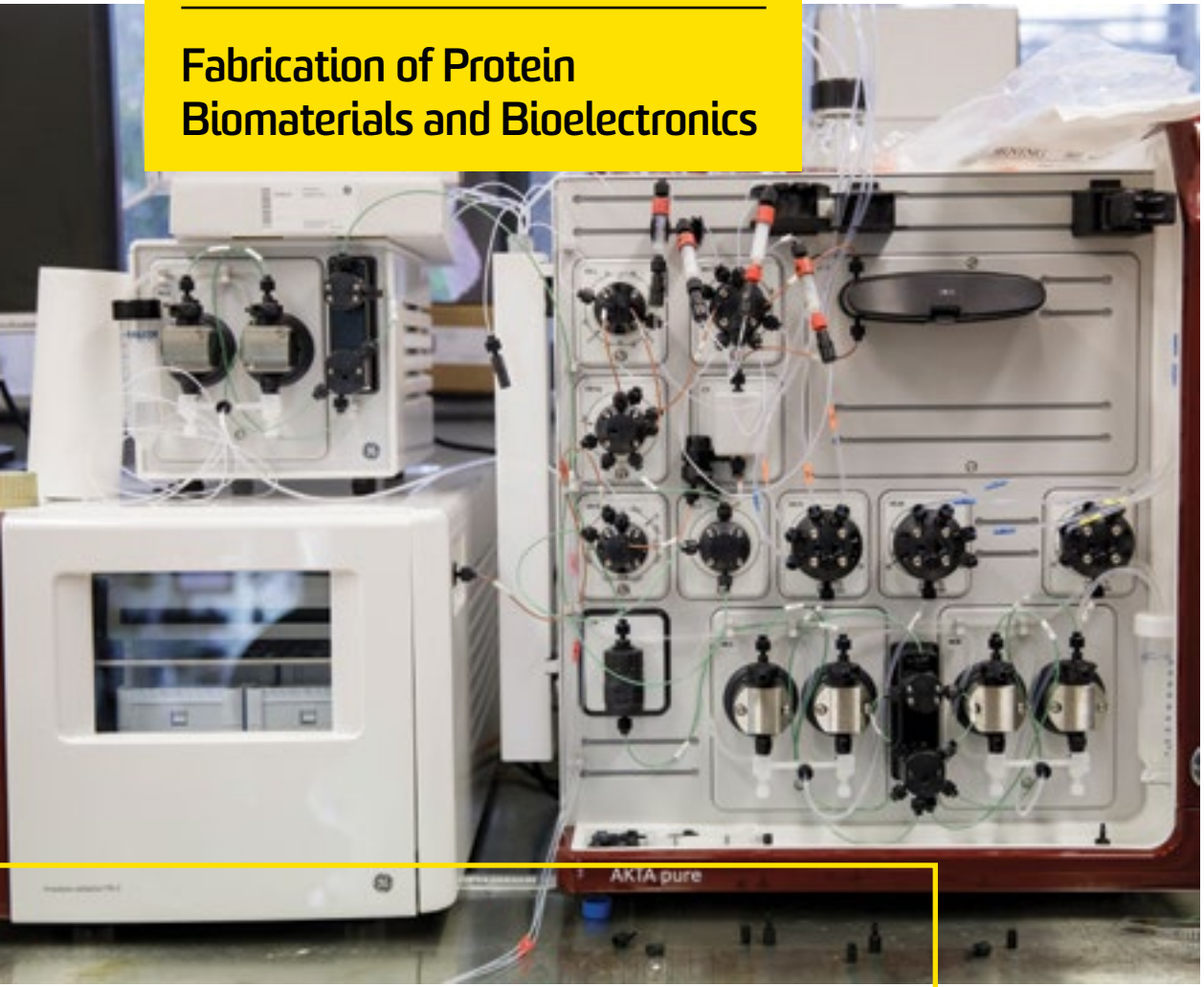
Fabrication of Protein Biomaterials and Bioelectronics



Protein scaffolds are promising templates for nanomaterials because of their inherent molecular recognition and self-assembly capabilities. Transfer of electrons through protein complexes is also central to cellular respiration. Exploiting this mechanism of charge transport in a controlled fashion has the potential to revolutionise the integration of biological and electronic systems.

Competitive advantage

- Expertise in fabrication and assembly of ultra-stable proteins into geometrically-defined templates of controllable size and symmetry
- Production of highly conductive metallic and semi-conductive nanowires on protein templates of specific dimensions
- Assembly of functional molecules into ordered arrays including multiple enzymes for substrate channelling and catalysis
- Engineering and fabrication of molecular chaperones for stabilisation and protection of biological systems in extreme environments

Impact

- New generation of bioelectronic devices

Successful applications

- Application investigation, AFOSR
- Nanowire material prototyping, AFRL

More information

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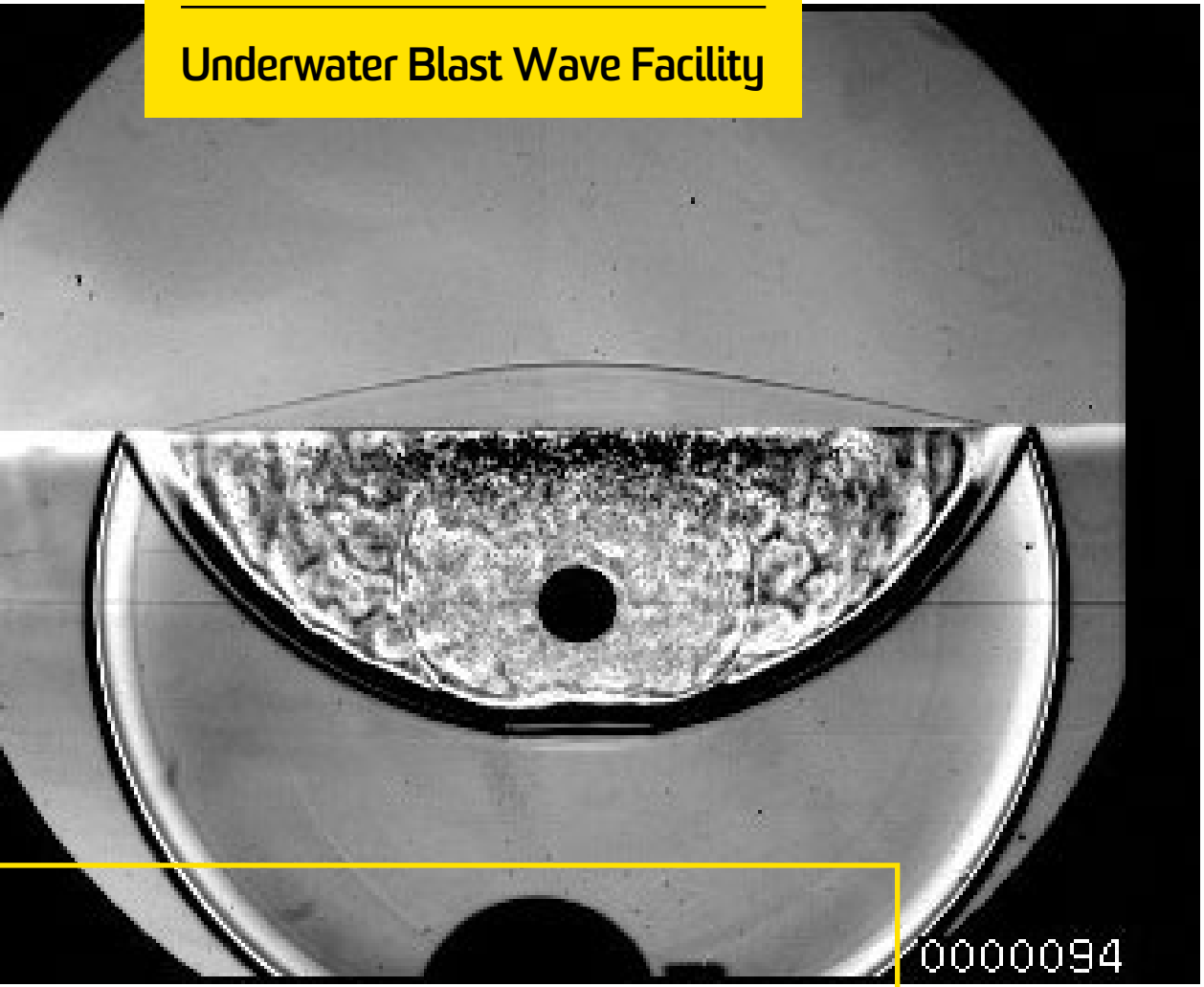
Underwater Blast Wave Facility



The study of blast behaviour in liquids at high pressures.

Competitive advantage

- The ability to study blast waves under water at very high pressures that, unlike most facilities that use explosive pellets to generate the blast wave, uses the spark generated by a high-powered pulsed laser focused into the water
- The only facility of its kind that is capable of operation at pressures of up to 50 MPa

Impact

This unique facility has a number of potential applications to personnel safety, protection of platforms and the design of future equipment, including:

- Study of the behaviour of blast waves in water at depth
- Investigation of the effects of blast on human/animal tissue

Successful applications

- Non-thermal sterilisation of meat, Australian Meat Processing Corporation

Capabilities and facilities

- High-speed visualisation and high-speed, high-pressure measurement technologies to investigate the transient processes

Our partners

- Australian Meat Processing Corporation

More information

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Laboratory for Precision and Nano Processing Technologies

More information

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The Laboratory for Precision and Nano Processing Technologies is a leading research unit equipped with state-of-the-art facilities for material testing, characterisation and manufacturing.

Competitive advantage

Expertise across a range of areas, including:

- Process innovation for manufacture and optimisation of advanced material devices and structures
- Lightweight design of components and structures, including lightweight vehicles
- Prediction/control of friction, wear and lubrication
- Durability and optimisation (fracture, fatigue, wear rate and friction prediction and residual stresses)
- Microstructural design and manufacture of materials with tailored properties and functions, and
- Nano and precision machining and thermal forming

Impact

- New materials and manufacturing technologies to solve problems across industries

Successful applications

- Residual stress determination in thin film systems (The Silanna Group, Australia).
- Control of lubrication in cold strip rolling of metals (Baoshan Iron & Steel Co Ltd, China)
- New superabrasives cutting tool technology (Ringwood Superabrasives Australia).
- Surface integrity characterisation of sapphire wafers for wireless and fibre optic semiconductor industry (Peregrine Semiconductor Australia)
- Heat conduction characterisation of buried insulation layers in silicon-on-insulator systems (ARC Linkage Project with Silanna Semiconductor Australia)
- Machining-induced damage mechanisms in KDP crystals (ARC Discovery Project)
- High speed cold rolling of tinplate steel: lubrication performance and its assessment method (Baoshan Iron & Steel Co Ltd, China)
- Automated manufacture of advanced composites (ARC Training Centre)
- Scaling microfluidics for cell manufacture (ARC Linkage Project)

Capabilities and facilities

The lab has extensive facilities for the design, manufacture, processing and testing of new materials and structures.

Advanced and Integrated Techniques for Fault Detection, Diagnosis and Prognosis

Providing maximum control over fibre trajectories and part geometry; this facility includes a head for laying parallel thermoset prepreg composite tows as well as a specialist thermoplastic composite head for in-situ melding for one-shot part fabrication of bespoke high-performance composites.

Competitive advantage

- Integrating wear and vibration analyses for machine condition monitoring and remaining life time prediction
- Estimation of gear surface roughness and remaining life using vibration, acoustic emissions and wear analysis techniques
- Expertise in vibration and wear debris analyses

Impact

- Increased safety for personnel by early detecting and predicting bearing, gearbox and engine failure
- Reduced through-life support costs through more efficient maintenance planning and practices

Successful applications

- Helicopter gearbox diagnostics, Defence Science and Technology (DST)
- Fault diagnosis and prediction of planetary gears and bearings, DST
- Model-based IC Engine diagnostics and prognostics, Siemens
- Monitoring of pump wear, Weir Minerals

Capabilities and facilities

- Two gearbox test rigs (one planetary, one parallel) and one bearing rig, all with variable speed and load capability, for diagnosis of spalls & cracks etc., and prognostics
- Extensive vibration instrumentation (including for acoustic emissions) and advanced signal processing packages developed in-house
- Tribometer, rolling-sliding and friction rigs for wear testing; wear particle analysis facilities (filtergram and ferrography)

Our partners

- Defence Science and Technology (DST)
- Siemens
- Weir Minerals
- Safran

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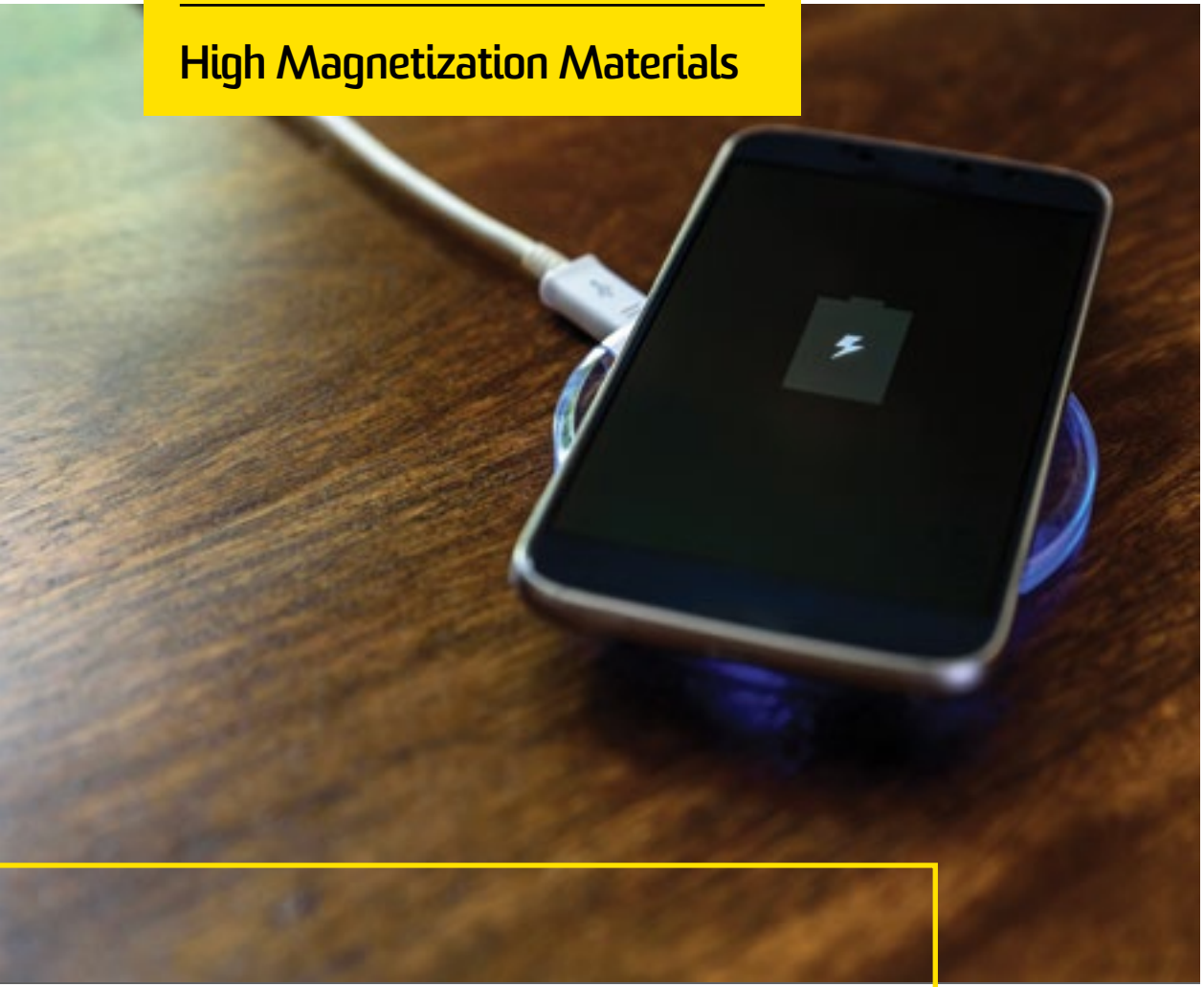
High Magnetization Materials



Exchange coupling and quantum confinement produces extremely high magnetization materials that are superior to traditional metal alloys and amorphous composite magnetic materials. Magnetic nanomaterials in a confinement environment show different properties from their bulk counterparts.

Competitive advantage

Magnetic materials have many applications, including microwave absorption, sensors, NFC for mobile devices, wireless charging, RFID readers, transformers, magnetic recording media and motors for electric cars. Higher magnetisation facilitates smaller and more efficient devices. The magnetic flux density of most current magnetic materials is limited to around 1–1.6 T. This technology uses the quantum confinement effect to greatly increase magnetisation.

By embedding nanostructured magnetic materials into a magnetic reservoir, high magnetisation materials can be achieved, with a magnetic moment of over 10 μ_B/atom at room temperature, compared to 2.2 μ_B/Fe.

Impact

- Smaller and more efficient magnetic devices

Successful applications

- Development of high sensitivity magnetic sensors
- Investigation of magnetic materials for MEMS applications, Sony
- Development of magnetic nanoparticles as agents for hyperthermia and magnetic resonance imaging
- Development of high sensitivity gas sensors

More information

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Wear and Corrosion Resistant Coatings for Tooling Applications

Medium- and high-entropy coatings enhance the toughness, wear resistance and corrosion resistance of tooling, extending its operating life and reducing costs.

Competitive advantage

Expertise in the study of microstructure-property relationships in thin film coatings, including nitrides, carbides and diamond-like carbon coatings. Delivering medium- and high-entropy coatings that exhibit both high hardness and remarkable toughness combined with excellent structural stability and wear resistance.

Impact

- Longer lasting tooling to reduce costs

Successful applications

- Tantalum nitride coatings for biomedical applications
- Analysis, characterisation and understanding of medium- and high-entropy alloy coatings for tooling applications
- Investigations into the structure and properties of zirconium nitride coating for applications in fuel cells

Capabilities and facilities

- Extensive facilities for measuring mechanical properties of thin film materials, including nanoindentation, scratch and wear testing
- Access, through UNSW Analytical Centre, to a wide range of instruments including electron microscopy, x-ray diffraction and surface chemistry instrumentation

More information

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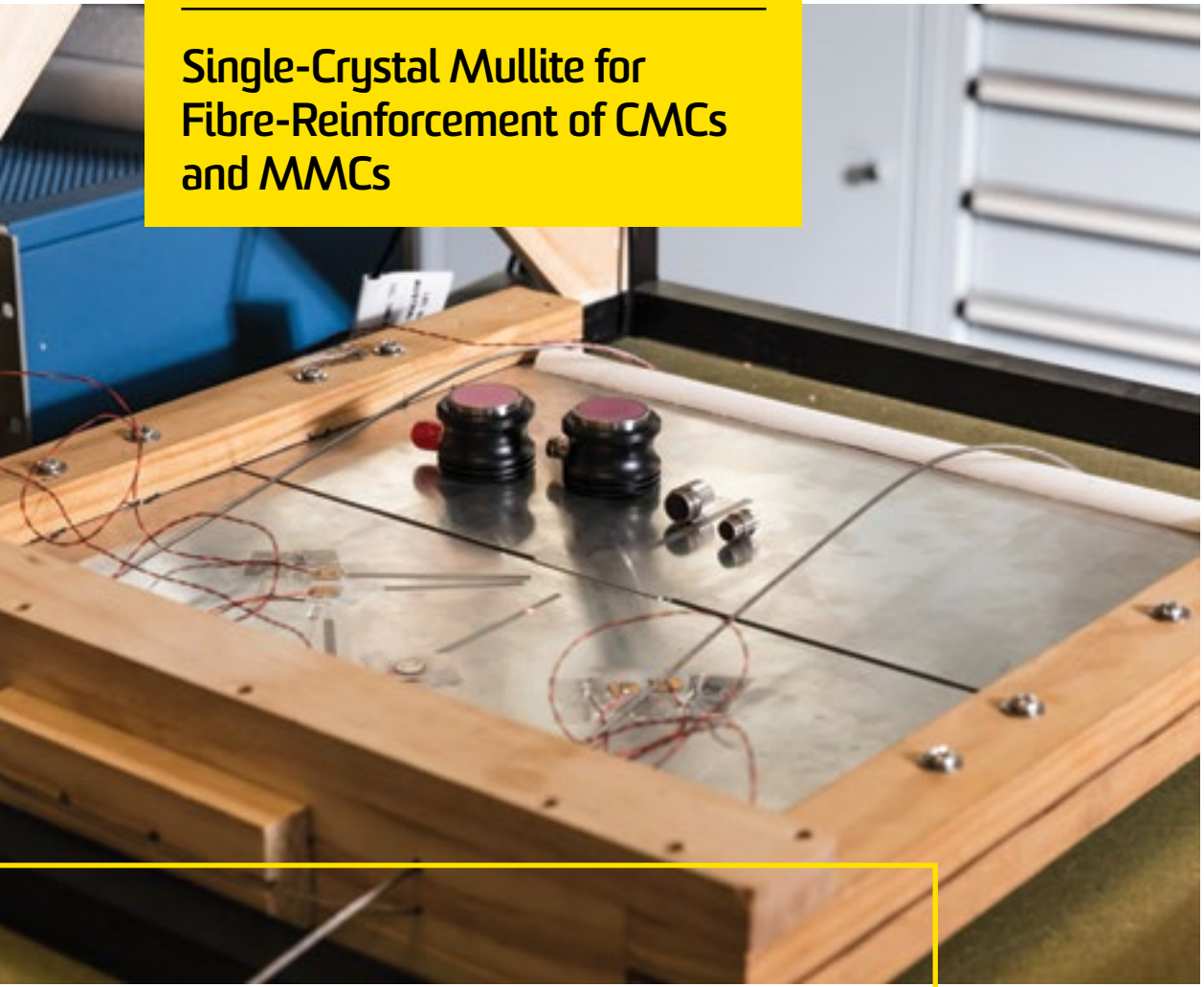
Single-Crystal Mullite for Fibre-Reinforcement of CMCs and MMCs



Single-crystal mullite is considered a prime candidate for reinforcement in ceramic matrix composites (CCMs) and metal matrix composites (MMCs) suitable for military armour. Processes suitable for world-first industrial-scale production of single-crystal mullite fibres.

Competitive advantage

Although mullite is recognised as the foremost reinforcement candidate for CMCs and MMCs, it is not currently available commercially.

Through the University's globally-patented technology, and in partnership with an Australian company that holds a mining lease covering the world's largest resource of the raw material, this resource can uniquely be used to fabricate ultra-high-purity mullite fibres.

Impact

- Stronger, lighter military armour

Successful applications

- Commercialisation of the technology in collaboration with Vecor Australia Pty Limited and TopTung Limited
- Single-crystal mullite fibre-reinforced aluminosilicates for mechanical, thermal, and chemical applications
- Separable single-crystal mullite fibres for ceramic matrix composites (CMCs) and metal matrix composites (MMCs)

Capabilities and facilities

- Ceramic processing (aligned and separable fibre production)
- Materials characterisation and analysis
- Mechanical testing at both room temperature and high temperatures

More information

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Fire Retardant Materials and Structures

Expertise in fire retardant materials and structures, including advanced fire models for coupled pyrolysis of solid materials with gas flame propagation and impact to structural integrity, development of novel fire suppression technologies, and both reduced- and full-scale flammability testing for compliance with fire safety regulatory standards.

Competitive advantage

- A consortium of local and international researchers, providing expert fire safety advice and technology
- Strong strategic partnerships and collaborations within universities, government bodies and domestic and global industries in fire safety
- Expertise in development of fire retardant materials and structures across a range of environments, including maritime platforms
- Creating new high-level fire safety Standards

Impact

- Improved fire safety for materials and structures for Defence

Successful applications

- Forensic analysis of fatal fire scenarios including Quakers Hill nursing home fire, Fire and Rescue NSW
- Risk characterisations of building claddings using big data analytics, Finance, Services & Innovation NSW

Capabilities and facilities

A range of bench-top and full-scale experimental equipment for multi-scale flammability assessments with realistic fire conditions, and detailed measurement of fire effluents including gas toxicity, smoke density and particles.

Our partners

- Fire and Rescue NSW
- Finance, Services & Innovation NSW

More information

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Improved Steels through Green QPQ Surface Modification

Thermomechanical quench-polish-quench (QPQ) surface modification—using waste, rather than the traditional cyanide-based environment—on different types of steel, to increase resistance to corrosion and abrasion.

Competitive advantage

- Surface modification can be customised and is environmentally friendly
- This new surface modification technology outperformed any other traditional nitriding or plating of steel and will increase both its corrosion and abrasion resistance
- An innovative and effective way to produce steel components with enhanced properties at low cost

Impact

This innovative and economical new approach marries industry demands for more cost-effective, durable steel products with global imperatives to address resource depletion and environmental degradation, through the recovery of resources from waste.

Successful applications

Formation of ultrahard surface on normal carbon steel increasing its compression strength by 30 percent and its hardness by 40 percent

Capabilities and facilities

- The Centre for Sustainable Materials Research and Technology ("SMaRT") is an internationally recognised pioneer in the transformation of complex waste into value-added resources, such as turning waste glass or textiles into high performance building applications, or using waste rubber tyres to produce Green Steel
- Purpose-built state-of-the-art laboratories
- Specialist furnaces
- Dedicated analytical equipment, such as an ultra-high temperature confocal microscope and an in-situ-infrared furnace

Our partners

- Moly-cop
- Dresden optic
- TES-AMM
- Nespresso

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Microstructural Engineering of Next Generation Aerospace Alloys

The demand for alloys that can withstand high mechanical loads under harsh, high-temperature environments for aerospace and defence is growing. Combining state-of-the-art experimental techniques, mechanical testing and multi-scale modelling produces materials with superior properties

Competitive advantage

- High yield strength alloys for high temperature, load applications
  - > 10 % improvement in turbine yield strength at 650°C
- Unique combination of experimental and theoretical tools
- Strong connections to international manufacturers

Impact

- Superior mechanical properties; high-temperature strength, creep resistance
- Reduced structural weight
- Improved fuel efficiency
- Increased safety
- More economical processing through targeted process re-design

Successful applications

- Microstructural engineering of turbine discs for next-generation aircraft engines
- Thermo-mechanical processing of defect-free specialty alloys
- Strong track record of applied research as evidenced by publications with industrial partners

Capabilities and facilities

- Materials processing labs; synthesis, thermal/thermo-mechanical testing and simulation
- Advanced electron microscopy and nano-scale characterisation of interfaces and small precipitates
- Mechanical & morphological testing
- Thermo-kinetic modelling

Our partners

- International and local specialty alloy manufacturers
- Voestalpine Group

More information

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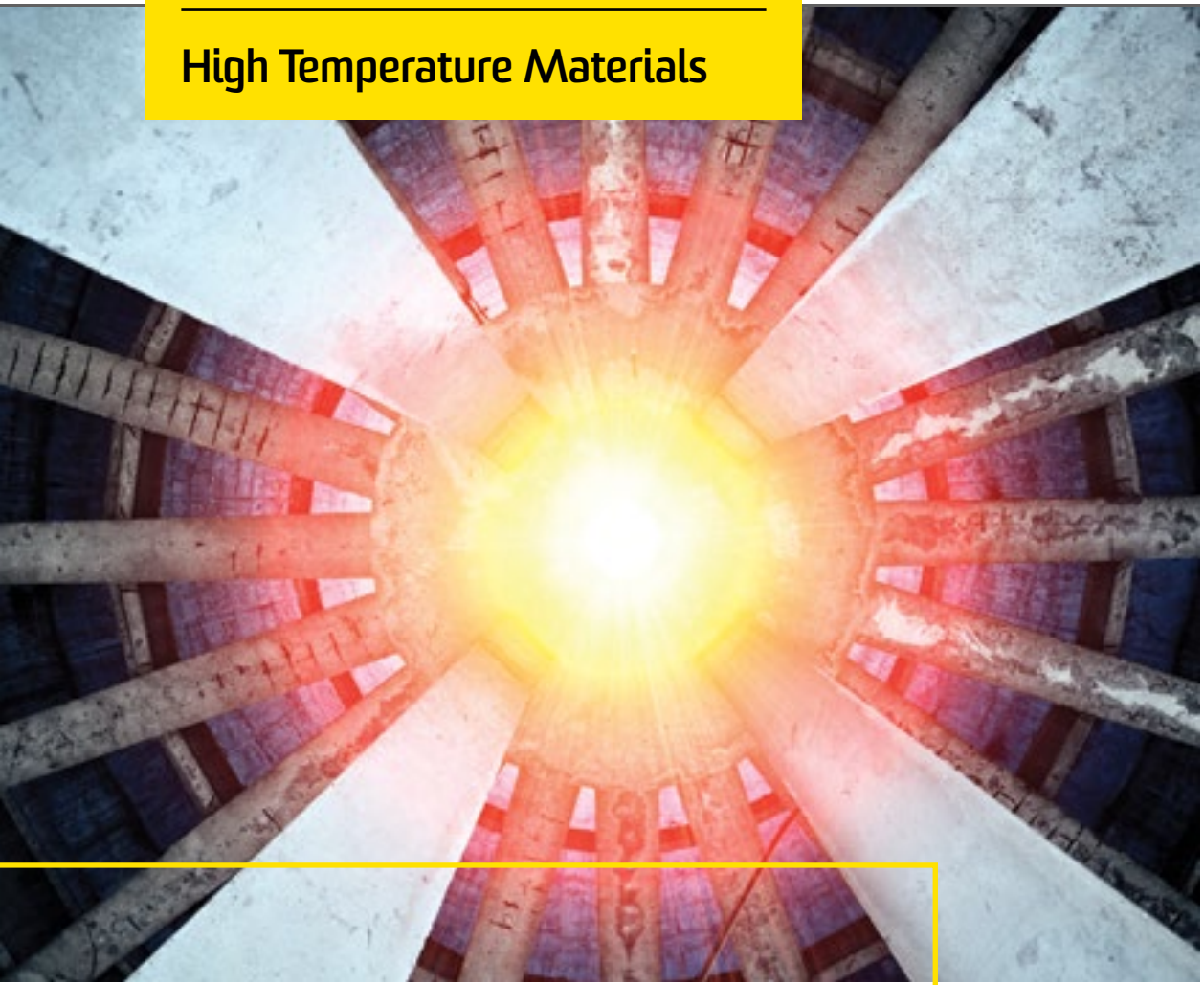
High Temperature Materials



Development of high-temperature materials resistant to high temperature corrosion; with application in gas turbine engine components, particularly high-pressure turbine blades and rotors, which are exposed to harsh environments.

Competitive advantage

- One of the world's leading research groups in the field of high temperature corrosion and high temperature materials development
- Extensive research and development experience, academically and in industry, in high temperature alloys

Impact

- Increasing the lifetime of materials in corrosive environments at high temperature
- Corrosion resistant high temperature materials are essential for many important industries, e.g. power generation (coal-fired electricity, solar thermal energy), and defence

Successful applications

- Metal dusting prevention for Haynes International (USA) and Exxon Mobil (USA)
- CO2 corrosion in gas cooled unclear reactors (AGR) for EDF (UK)
- Alloys to resist hot carburising-sulfidising gases in processing Queensland shale oil

Capabilities and facilities

- Excellent facilities, particularly in the field of corrosion by mixed gases, including:
    - Arc-melting apparatus
    - Thermogravimetric analysers
    - High temperature flow reactors with mixed gas control systems

Our partners

- Oak Ridge National Lab, USA
- CIRIMAT-ENSIACET, France
- Forschungszentrum, Juelich, Germany
- Karl-Winnacker-Institute DECHEMA, Germany

More information

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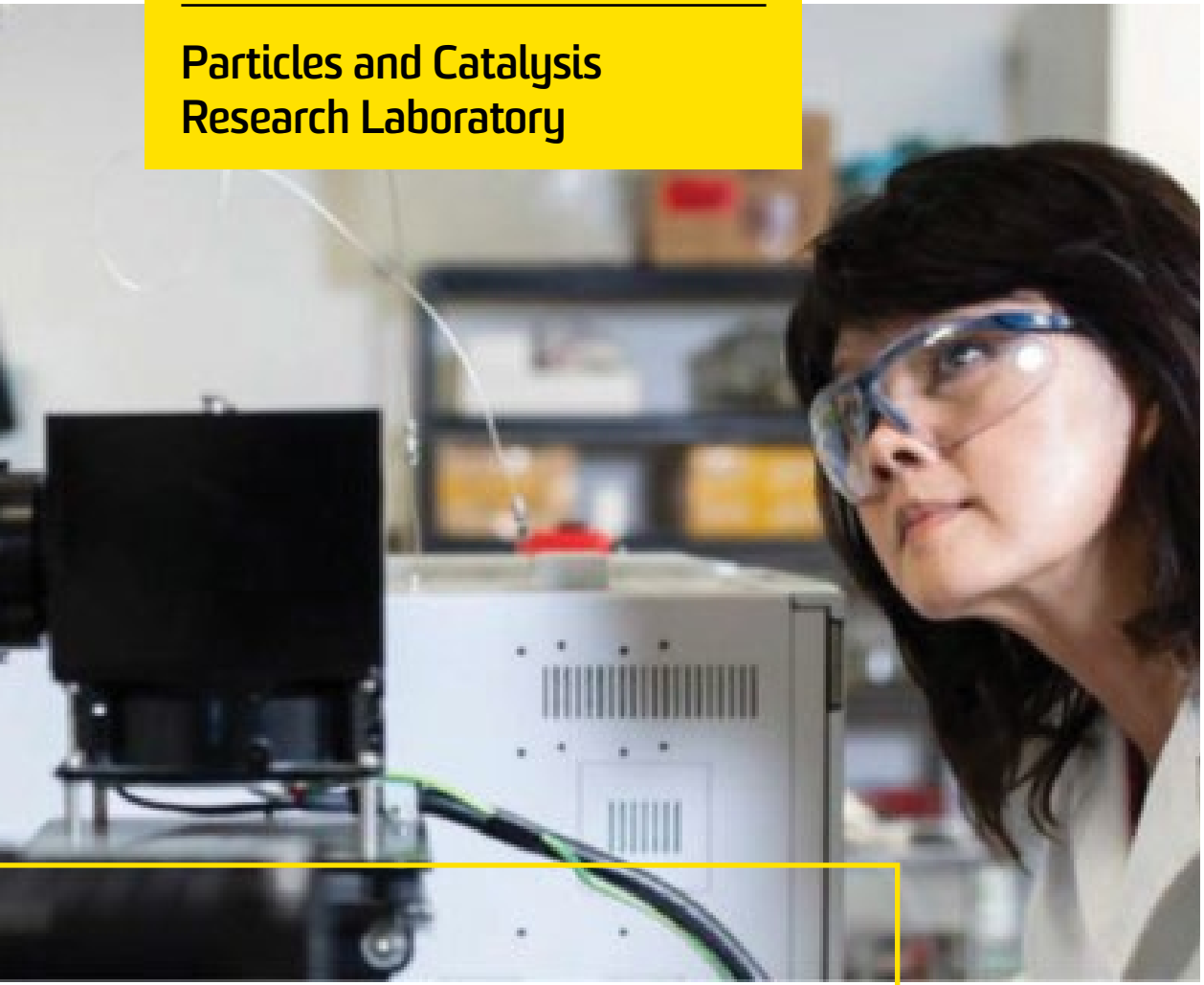
Particles and Catalysis Research Laboratory



Specialises in harnessing solar energy for sustainable fuel production through catalysis and the development of solar batteries/capacitors for the efficient capture of sunlight for storage and on-demand release.

Competitive advantage

- Over 25 years' expertise in the fields of fine particle technology, photocatalysis, and functional nanomaterials
- Vast experience in designing hetero-structured catalysts to effectively harvest solar light and translating these findings into greener manufacturing processes involving hybrid photo-electro-thermal catalysis—such as for transforming CO2 and water into valuable chemicals and energy feedstock
- State-of-the-art instruments for particle and material characterisation

Impact

- Enhanced Australian energy security by using infinite and diffusive solar energy
- Alleviate global warming by reducing the carbon footprint
- Off-grid fuel generation in remote strategic sites
- Large scale production of active and stable catalyst

Successful applications

- Australia Patent and US patent no 6558553 "Development of a stable magnetic photocatalyst" (1999) – the functionalised MNP were used for selective bio-separation, sensors, bio-imaging, water treatment processes
- Flame Spray Pyrolysis (FSP) technique to synthesis nanomaterials and highly active composite catalyst with closely controlled characteristics, and easily scalable for application in fuel cell, gas to liquid fuel production.

Capabilities and facilities

- Flame Spray Pyrolysis Process
- SSITKA – DRIFTS technique (Steady State Isotopic Transient Kinetic Analysis – Diffuse Reflectance Infrared Spectroscopy Technique)
- Photoreactor and reactor system for testing catalyst performance
- Access to Mark Wainwright Analytical Centre

Our partners

- RayGen Resources Pty Ltd
- Shenzhen Kohodo Sunshine Renewable Energy Co. Ltd
- Beijing Zhongchao Haiqi Technology Co Ltd
- CSIRO Energy
- Origin Water International Pty Ltd
- Apricus Energy Pty Ltd

More information

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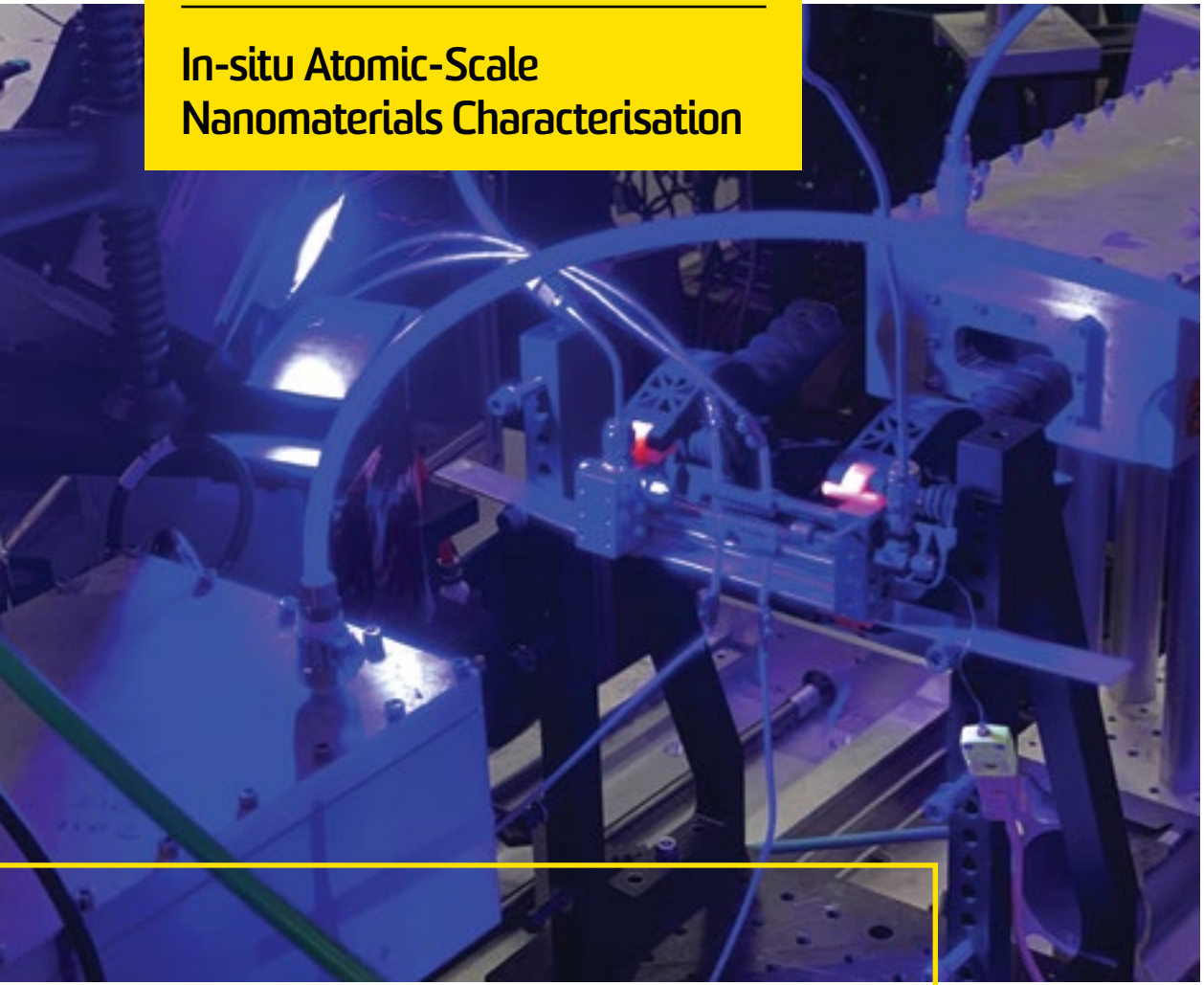
In-situ Atomic-Scale Nanomaterials Characterisation



Expertise in the characterisation of nanomaterials using synchrotron techniques, specifically developing in-situ capabilities to probe atomic-structure under real-life operating conditions

Competitive advantage

- Direct access to atomic-scale structural information that enables future design strategies for property enhancement for virtually any nanoscale material of defence interest

Impact

- Atomic-scale structural information of defence materials under real-life operational conditions
- Structural insights enable the development of new materials with emergent and enhanced properties, irrespective of defence application

Successful applications

- Atomic-scale structural transformations monitored to 900 ºC
- Observation of electrochemically induced atomic-structure under a large operational voltage range
- Structural changes during deposition techniques, such as chemical vapor deposition and atomic layer deposition
- Structural observations of materials under tensile strain

Capabilities and facilities

- Regular access to worldwide synchrotron facilities
- In-house analysis and modelling capability

Our partners

- Air Force Research Laboratory (US)
- Edgewood Chemical and Biological Center (US)
- National Renewable Energy Laboratory (US)
- The Australian Nuclear Science and Technology Organisation (ANSTO)
- Commonwealth Scientific and Industrial Research Organisation (CSIRO)

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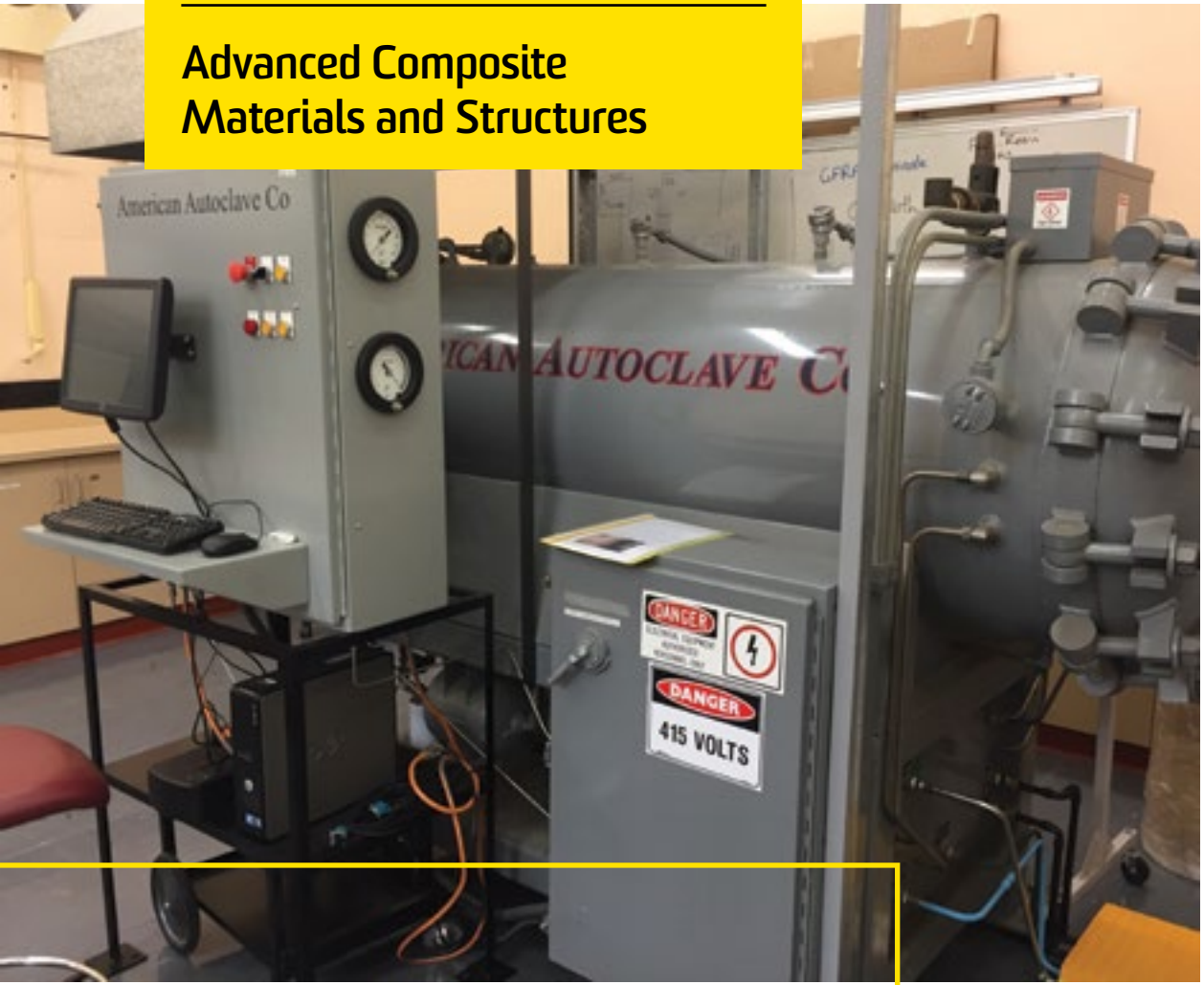
Advanced Composite Materials and Structures



Investigating various applications of advanced composite materials in the aerospace, civil infrastructure, and marine industries, including: the development of new structural design and analysis methods; experimental characterisation of new materials; and studies of structural performance and manufacturing effects.

Competitive advantage

- Advanced expertise in the mechanics of composite materials and structures
- Internationally recognised expertise in composite technology (modelling, design and analysis, material characterisation, sample and prototype manufacture and testing)
- Advanced computational mechanics (nonlinear numerical, thermal and thermal-mechanical, progressive damage, and buckling analyses)

Impact

- Higher performance of composite materials and structure

Successful applications

- Composite sandwich panels with improved structural characteristics
- Novel materials for photonics, materials for nano-antennas, and new high temperature ceramics
- Damage detection in polymer composites using vibration measurements
- Analysis and experimental assessment of adhesively bonded metal-composite joints
- Additive manufacture and characterisation of LENS 3-D printed titanium - titanium carbide functionally graded composites
- Influence of a steel strike face on the ballistic response of an UHMWPE hybrid composite
- Photopolymer resin extrusion 3-D printing

Capabilities and facilities

Composites manufacturing laboratory including:

- Autoclave
- Hot press (thermoplastic composite manufacture)
- Heat blanket vacuum bagging
- Mechanical testing facilities

Our partners

- Directorate of Aviation (Specialist) Engineering Defence Aviation Safety Authority (DASA) (DAVENG-DASA)
- Defence Science and Technology (DST)
- Commonwealth Scientific and Industrial Research Organisation (CSIRO)

More information

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Sodium-Sulphur Batteries with High Energy Storage

State-of-the-art lithium-ion batteries are hindered by their limited theoretical energy density and the natural scarcity of lithium resources. Sodium-sulphur chemistry uses abundant elements to yield high specific capacity and energy density.

Competitive advantage

- Sodium-sulphur batteries provide a low-cost option for large-scale electrical energy storage applications
- New conversion chemistry that yields an energy density three times higher than that of lithium-ion batteries
- More than ten years' experience in the design, production and integration of various energy storage technologies

Impact

- Effective, inexpensive and scalable alternativities to LIB technology for the deployed war fighter
- Sodium-sulphur technology provides a sustainable and economical choice to advance widespread vehicle electrification and grid-scale energy storage
- The two elements also are highly-abundant in nature and therefore good for the environment

Successful applications

- Developed demo coin-cell prototypes and have the capacity to develop a pouch-cell demo

Capabilities and facilities

- A platform for cell fabrication and evaluation
- Advanced characterisation facilities
- In-situ analysis techniques, including X-Ray diffraction/Raman/FTIR/XAS/EPR/UV-vis

More information

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Design and Reverse-Engineering of Soft Solids and Microstructured Fluids

Expertise in design, manufacture, and testing of hierarchically structured complex fluids with targeted mechanical response, surface coating, and chemical delivery.

Competitive advantage

- Broad experience designing complex fluid microstructures, their large-scale manufacture, and their performance on biological and synthetic targets.
- Versatile adaptation of existing technology and additives to create new-to-the-world functions like:
  - Biomimetic particle shape-change and response in passive and active modes
  - Delivery and adhesion to complex surfaces under extreme conditions
  - Rapid technology functional adaption from rare compounds to approved additives

Successful applications

- First artificial vernix for prevention of premature infant skin infections
- Responsive materials for biological tissue targeting in respiratory therapy and hair follicle fungus

Capabilities and facilities

- Microrheological measures for tiny volumes, small samples, and miniscule mechanical properties
- Microfluidic production of prototype materials and their performance testing
- High speed studies of droplet impacts and flow

More information

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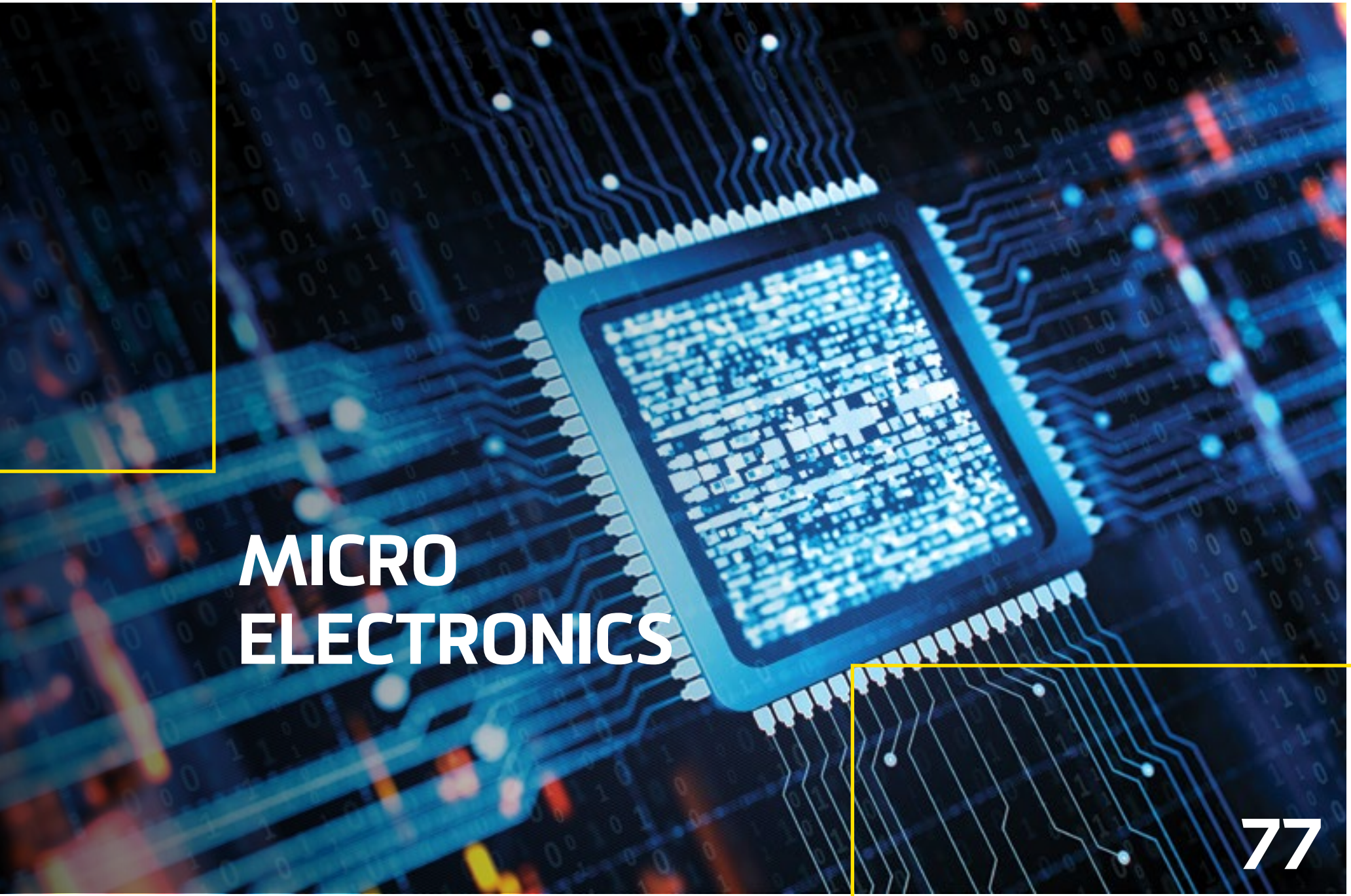

MICRO ELECTRONICS

Microwave and Millimetre Wave Research

The Microwave and Millimetre Wave (MMM) Laboratory is an international leader in radio frequency microelectromechanical systems (RF MEMS) and microwave and millimetre-wave devices for mobile and satellite communications.

Competitive advantage

- Research and development of novel devices such as reconfigurable microwave and millimetre-wave switches, switch matrices, filters, antennas and directional couplers
- Expertise across a range of technologies including microstrips, striplines, coplanar waveguides, rectangular waveguides, substrate integrated waveguides and 3D printing
- Experienced in performing cutting edge measurement, characterisation and modelling of the effects of microwave and millimetre-wave radiation on the human body

Impact

- Superior communication devices

Capabilities and facilities

- Specialised test and measurement equipment, including Agilent PNA, Anritsu VectorStar and Microprobe Cascade
- Sophisticated and powerful simulation tools, including Agilent ADS, Ansys, Coventorware, Sonnet, Comsole Multiphysics and Cadence

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Nano/Micro Optical, Electrical and Mechanical Systems on Silicon Chips and Integrated Circuits

Design, fabrication and measurement of nano- and micro-scale systems with mechanical, electrical and/or optical functionalities on a silicon substrate or CMOS integrated circuit, enabling the development of novel and advanced sensors and actuators.

Competitive advantage

A suite of novel patent-protected technologies, which include:

- High aspect ratio sharp nanotips — CMOS compatible and integration with nano-scale devices at unprecedented density, not possible with any other technology
- PZT microlens micro-actuators — record-breaking large displacement and resonance frequency and small footprint micro-lens piezoelectric actuators for micro-optics application
- Low thermal budget polysilicon films — thick and low stress silicon film with low thermal budget suitable for microelectromechanical systems (MEMS) formation on top of CMOS
- Delivering record-breaking high gauge factor piezo-resistive polysilicon films with low thermal budget

Impact

- New devices for next-generation electronics

Capabilities and facilities

- Advanced semiconductor manufacturing tools in ANFF at UNSW and other nodes around Australia
- Mark Wainwright Analytical Centre (MWAC) for process monitoring, diagnostic and film characterisation
- MEMS measurement lab equipped with Polytech MSA-500, providing the capability to measure dynamics of nano/micro structures with sub-nanometre displacement resolution
- Silicon photonics characterisation optical bench set-up with automatic nano-positioners, deterministic polarisation controller, and 7.5 GHz spectrum analyser

More information

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Reliable Electronics

Aerospace systems with high performance, real-time requirements are increasingly implemented using commercially available field programmable gate arrays (FPGAs). This requires FPGA-based systems able to operate in high radiation environments.

Competitive advantage

- Rapid, power efficient recovery from radiation-induced errors in FPGAs to achieve state-of-the-art system availability and reliability rates
- High-level synthesis of reliable subsystems to reduce design, implementation and test timeframes
- Functional verification tools to validate dynamically re-configurable FPGA designs

Impact

- Reliable FPGA-based mission critical systems designed to operate in high radiation environments
- Flexibility to rapidly adapt to changing environments and new requirements
- Reduced system lifecycle costs

Successful applications

- Dynamic partial reconfiguration demonstrator, Defence Science and Technology (DST)
- RUSH reconfigurable hardware platform for exploring new reliability techniques developed and flown on EU QB50 CubeSat and Hydra mission to the International Space Station, with further missions planned
- Rapidly generating highly reliable FPGA implementations, Thales Alenia Space and General Dynamics NZ

Our partners

- Australian Centre for Space Engineering Research
- Solinov Pty Ltd

More information

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Semiconductor Nanowire Electronics

The fabrication of nanoscale devices featuring inorganic semiconductor nanowires and organic electronic and bioelectronic materials enables novel electronic applications such as bio-compatible devices.

Competitive advantage

- Electron-beam lithography of polymer electrolytes and ionomers for electronics applications
- Deposition and nanoscale patterning of ultra-thin (< 50nm) parylene films for nanoscale device applications
- Fabrication of semiconductor nanowire devices
- Electrical characterisation of semiconductor nanowire devices

Impact

- Harnessing the advantages offered by nanoscale structures including power to size ratio and enhanced functionality and durability

Successful applications

- Development of nanowire transistors with gate-all-around structures with multiple independent gates and polymer insulators
- Nanoscale patterning of ion-conducting polymers for use as gate structures for nanowire transistors
- Nanoscale devices for ion-to-electron signal transduction
- High-performance p-GaAs MESFETs for nanowire CMOS
- Ultra-thin parylene films as patterned insulators in nanoscale devices
- Nanowire devices for bioelectronics applications

Capabilities and facilities

- Equipment for electrical measurements down to 1 Kelvin and magnetic fields up to 9 Tesla (with full-sphere rotation)
- Custom-built parylene deposition system for ultra-thin film deposition
- Electrical characterisation of devices under controlled atmosphere

Our partners

- Collaborations with numerous internationally respected teams

More information

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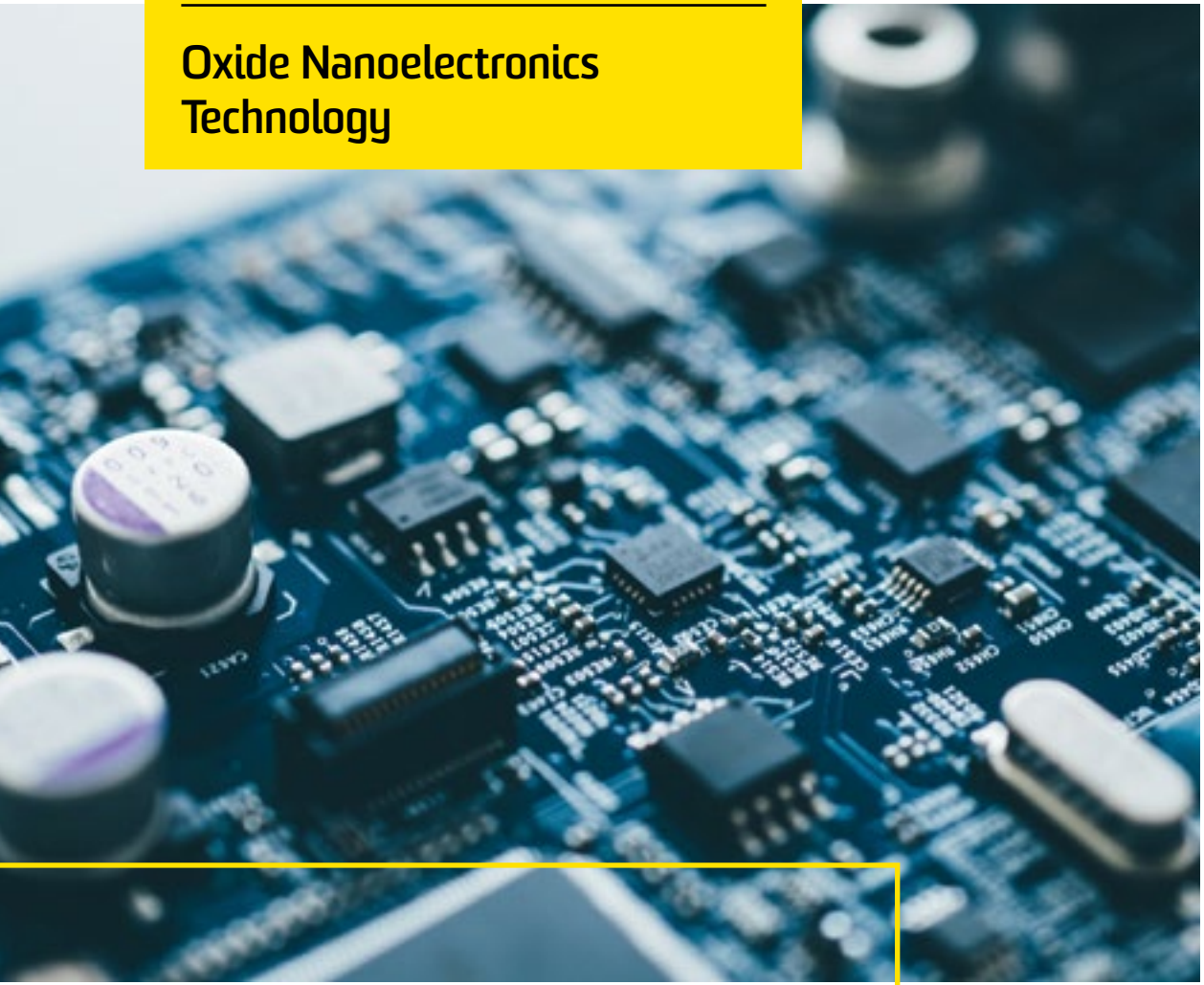
Oxide Nanoelectronics Technology



Oxide nano-electronic materials promise dramatic improvements in the performance and lifespan of electronic devices. Due to these superior properties, the materials have been implemented in radiation-hardened circuits for space applications, in an array of sensors and actuators, and within next-generation electronics such as ferroelectric memory.

Competitive advantage

- Pioneering research into conducting materials with nanoscale topological features
- Key skills in design of materials with sub-nanometer ion channels
- Advanced scanning probe microscopy including instrument development
- Demonstrated first domain wall electronics elements
- A leading publication and IP profile within this critical research field
- As a member of the Australian Research Centre (ARC) Centre of Excellence in future low-energy electronics technologies, this group has access to state-of-the-art nanoelectronics characterisation equipment.

Impact

- Potential use in reconfigurable electronics, ultralow energy technology, domain wall memory, radiation detectors, sub-nanometer ion channels, and radiation hardened electronics

Successful applications

- Domain wall memory, utilising magnetic oxides is approaching commercial implementation, team holds key IP in the field
- Characterisation of bespoke circuits for critical hardened electronics applications

Capabilities and facilities

- Specialised tools and expertise in materials synthesis using ultra-high vacuum technology and pulsed laser deposition
- State-of-the art scanning probe microscopy material characterisation techniques

Our partners

- US Office of Naval Research
- Intel Corporation
- Australian semiconductor manufacturers (Silanna, among others)

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POWER, GENERATION & CONTROL

Highly-Efficient Thin Crystalline Silicon Solar Cells and Flexible Solar Modules

UNSW's School of Photovoltaic and Renewable Energy Engineering, a global centre of excellence in photovoltaic research, is leading the development of highly-efficient thin crystalline silicon solar cells and flexible solar modules.

Competitive advantage

- Unmatched expertise from over 30 years of world record breaking silicon solar cell development
- Advanced surface and contact passivation technology allows for high-efficiency thin silicon solar cells
- Crystalline silicon technology has proven reliability and longevity, and offers the best compromise between cost and efficiency
- Thin silicon solar cells are flexible, allowing for implementation in lightweight and foldable solar modules that can be used to charge equipment in the field or incorporated into other equipment

Impact

- Cheaper, silent and more efficient in-field power generation for personnel, minimising the need for batteries
- Reduced fuel requirements for deployments

Capabilities and facilities

- Solar Energy Research Facility (SERF)—an on-campus R&D pilot line for silicon wafer solar cells
- State-of-the-art labs for cutting edge academic research in silicon wafer fabrication and characterisation

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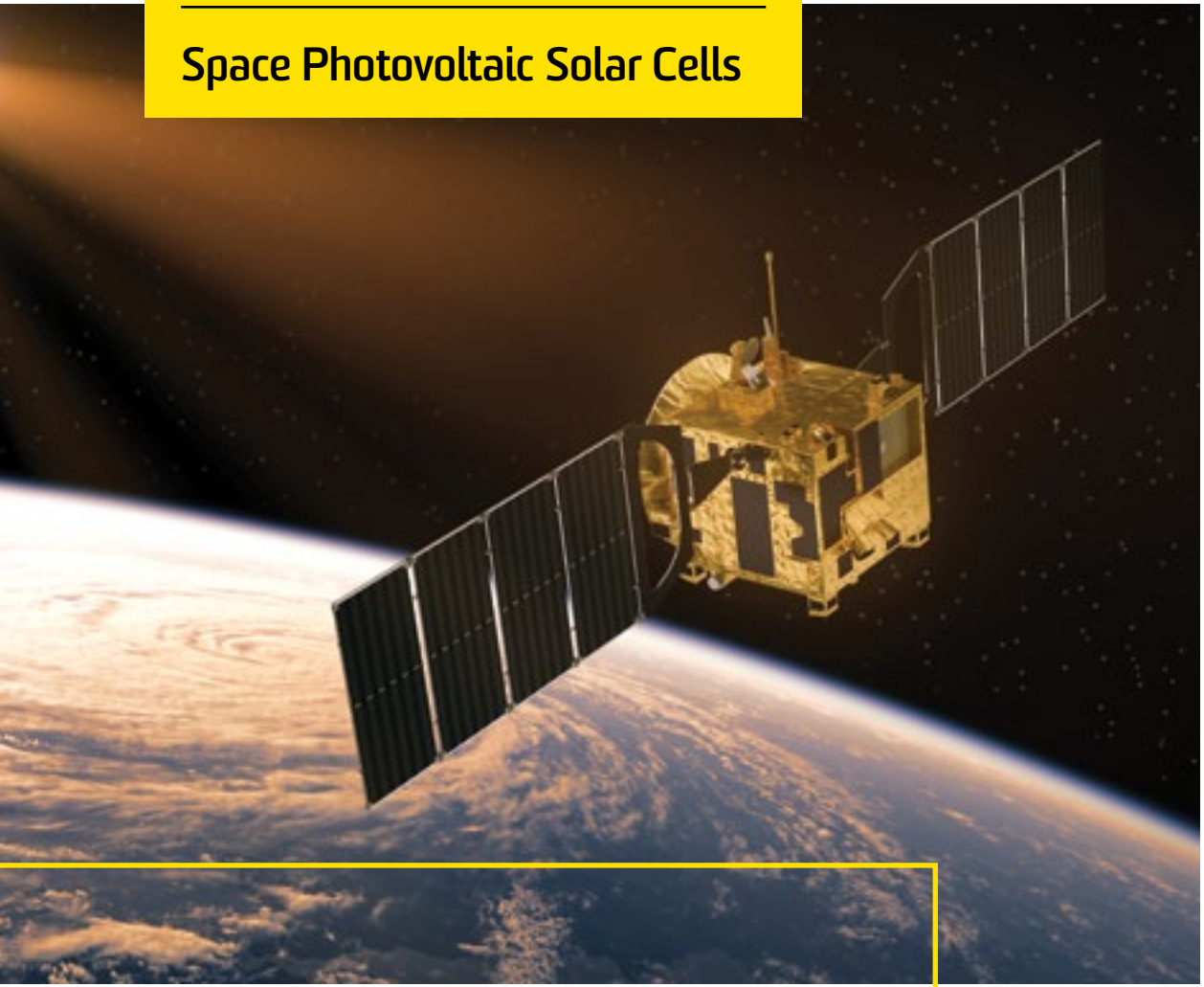
Space Photovoltaic Solar Cells



Next generation multi-junction solar cells for powering satellites and spacecraft.

Competitive advantage

- Semiconductor material and processes for solar cells with higher efficiency, lower weight and greater radiation tolerance
- Extensive knowledge of multi-junction solar cells and computer simulation capabilities, coupled with collaborations with space cell manufacturers, enables rapid prototyping of devices
- Patented technology for achieving ultra-radiation hard solar cells using interstitial light trapping

Impact

- Reduced weight and hence payload launch costs
- Radiation hardened solar cells for longer missions and/or resilience in high radiation orbits
- Enabling high altitude persistent UAVs

Successful applications

- Demonstrated the use of metal nanoparticles in space solar cells in collaboration, Azur Space GmbH
- Demonstrated the feasibility for achieving radiation hard space cells, Azur Space GmbH and European Space Agency
- Demonstrated the first triple junction solar cell using silicon–germanium–tin alloys, IQE PLC
- Developing ultra-radiation hard solar cells, US Naval Research Laboratory

Capabilities and facilities

- State-of-the-art labs for research in multijunction solar cell fabrication and characterisation
- Solar Energy Research Facility (SERF)—an on-campus R&D pilot line for silicon wafer solar cells

Our partners

- IQE PLC, UK.
- Naval Research Laboratory, USA

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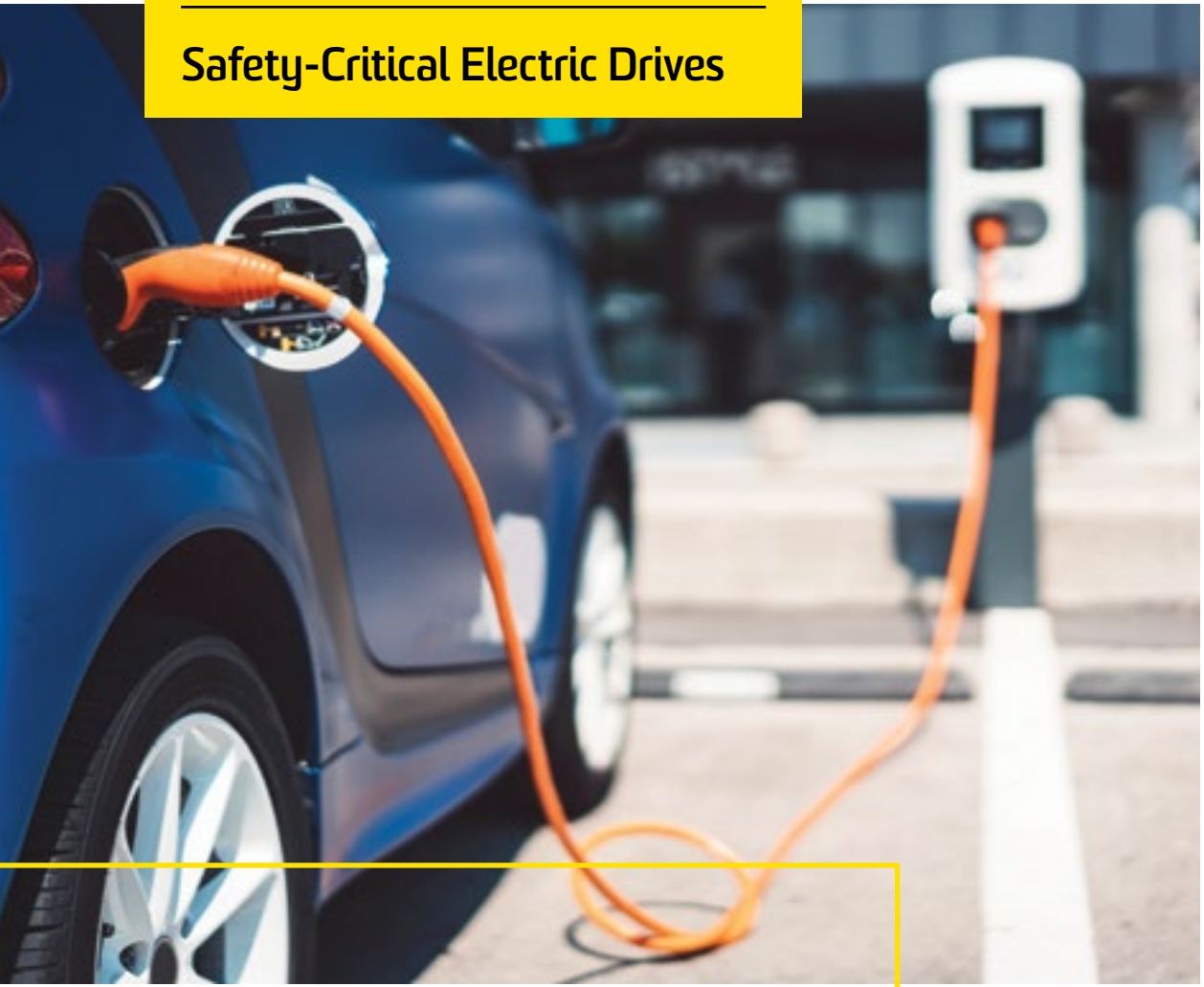
Safety-Critical Electric Drives



Expertise in design and control of novel, power-dense, multi-phase electric drives for safety-critical applications, including rail transportation, electric vehicles, marine propulsion drives and aerospace.

Competitive advantage

- Novel five-phase generator technology, using fractional-slot, concentrated-wound electric machines, provides best-in-class power density for permanent magnet machines
- Drives that also incorporate novel multi-phase designs that enhance torque production, smooth ripple-free torque, and provide tolerance to faults

Impact

- More efficient, safer transport solutions

Successful applications

- Open winding multi-phase drive system for fault tolerance

Capabilities and facilities

- Four-quadrant dynamometer
- Bidirectional grid simulators
- High-speed load machines
- Medium-voltage testing

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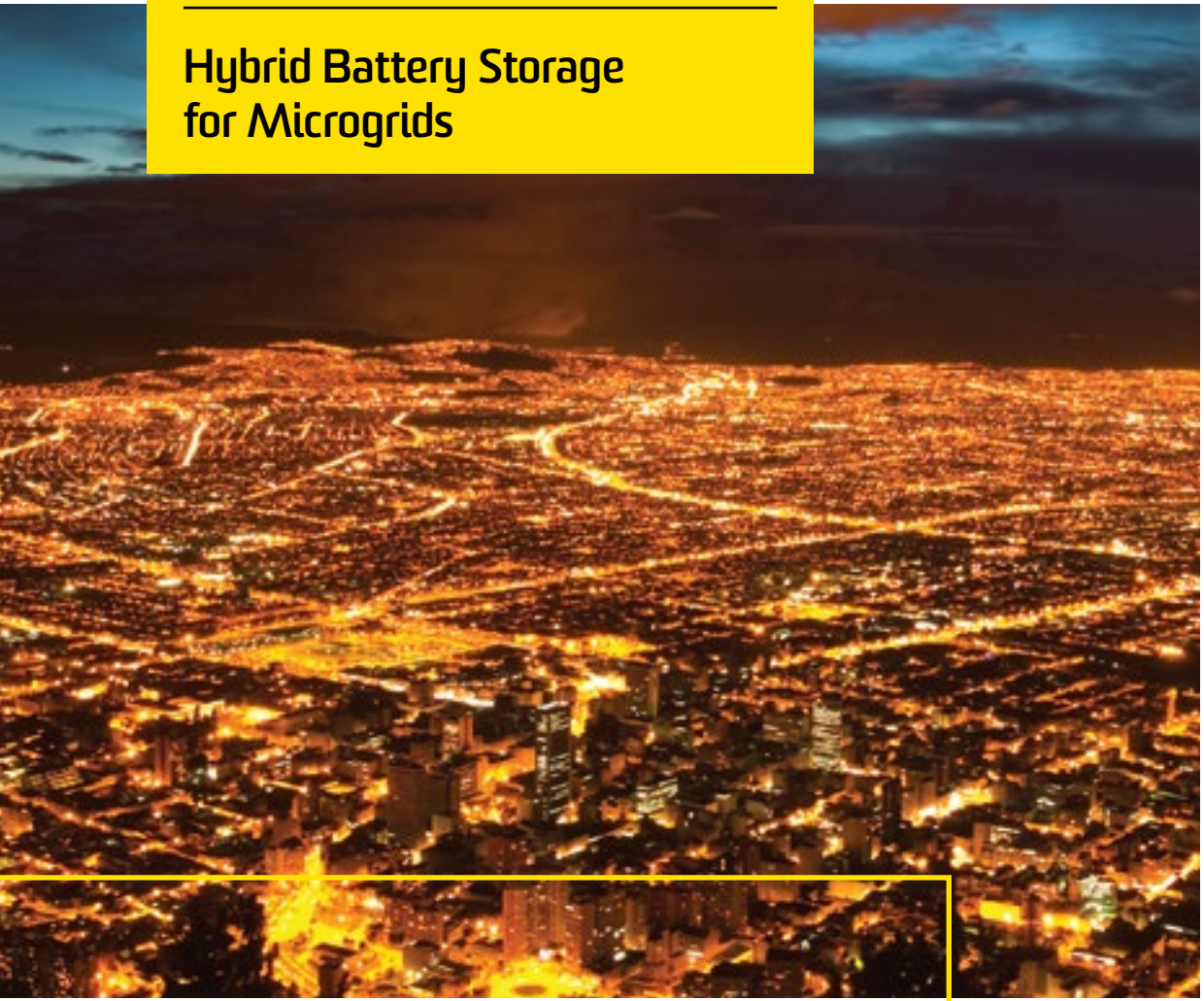
Hybrid Battery Storage for Microgrids



Battery storage plays an important role in microgrids, improving grid reliability and resilience while facilitating effective operation of critical and frequency-sensitive loads. Battery storage is critical both for daily operation of a microgrid, as well as providing for grid redundancy in extreme events.

Competitive advantage

A complete test bed and procedures for assessing battery storage performance under different grid events to:

- Improve the reliability and resilience of grid supply using coordinated microgrid battery storage
- Improve continuous supply to loads, balanced with reducing demand
- Provide reliable and economical reserve

Impact

- More reliable and efficient microgrid performance

Successful applications

- Development of a hybrid portable mobile microgrid station system
- Microgrid planning software for urban and remote area
- Hybrid portable mobile microgrid station for Australian Defence Force — a project focussed on hybrid battery storage systems for mobile and reliable power supplies for remote operation activities

Capabilities and facilities

- Energy and power research group with industrial standard software
- Hardware-in-the-loop testing bed for energy storage systems with programmable grid simulations on real time digital simulators (RTDSs)

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Tesla Turbine

The Tesla Turbine is a miniature combustion-driven power generation system that can be used as a personal, portable power supply for individuals, or as a power plant for small autonomous systems such as UAVs.

Competitive advantage

- Much higher power/mass ratio than existing battery technologies
- Unlike other turbine technologies, the Tesla Turbine performance improves as the scale decreases
- Simple to use and maintain, and field-serviceable
- Very small footprint, with the turbine and generator integrated into design

Impact

- The main use of this technology is as a portable power supply for devices used by soldiers
- The device has potential for development as a power plant for small autonomous systems, either for direct power or for electrical generation systems

Successful applications

- Successfully prototyped

Capabilities and facilities

- Computational fluid dynamic modelling of the combustor
- Laser diagnostics for optimising combustion efficiency

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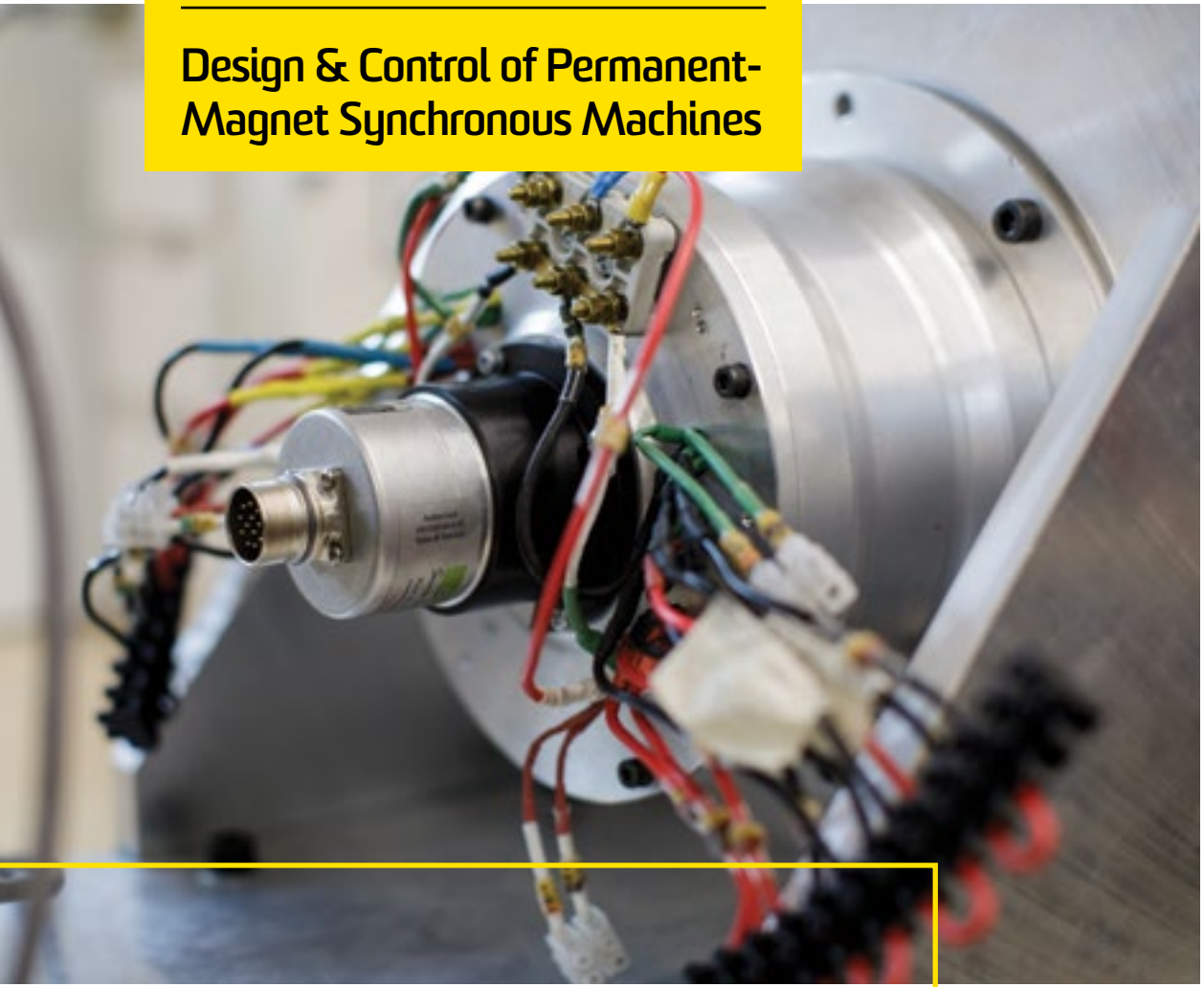
Design & Control of Permanent-Magnet Synchronous Machines



Design, optimisation and control of various permanent magnet synchronous machine (PMSM) geometries, delivering improved torque and power density, reduced cogging torque, and extended constant power operating range.

Competitive advantage

- Expertise in highly efficient, low cogging torque, wide constant power speed range permanent magnet synchronous motors, generators and their advanced drive systems
- Development of the first sensorless control and fractional-slot concentrated wound IPM machines
- Expertise in enhanced control techniques, including direct torque and flux control, mechanical sensorless control and model predictive control
- Expertise in PMSMs for application in renewable energy systems
- Expertise in the design, optimization, manufacture and testing of IPM machines with V and other shaped magnets embedded in the rotor, as well as fractional-slot concentrate wound (tooth-coil) PM machines that demonstrate very high torque and power density and deep filed weakening range

Impact

- More efficient motors and generators

Successful applications

- Development of fractional-slot IPM machines
- PWM based sensorless control
- High-speed IPM machines

Capabilities and facilities

- Finite-element packages such as Magsoft and Ansys, with optimisation tools that have been developed in-house
- Two and three-level inverters, several machine drive set-ups complete with shaft position sensors, torque sensors, highly dynamic loads
- Four-quadrant dynamometer, simulation platforms (Matlab–Simulink, PSIM), FPGA and DSP systems with high-performance signal acquisition, estimation and switch gate-drive interfaces

Our partners

- Wisconsin Electric Machines and Power Electronics Consortium (WEMPEC)
- CSIRO

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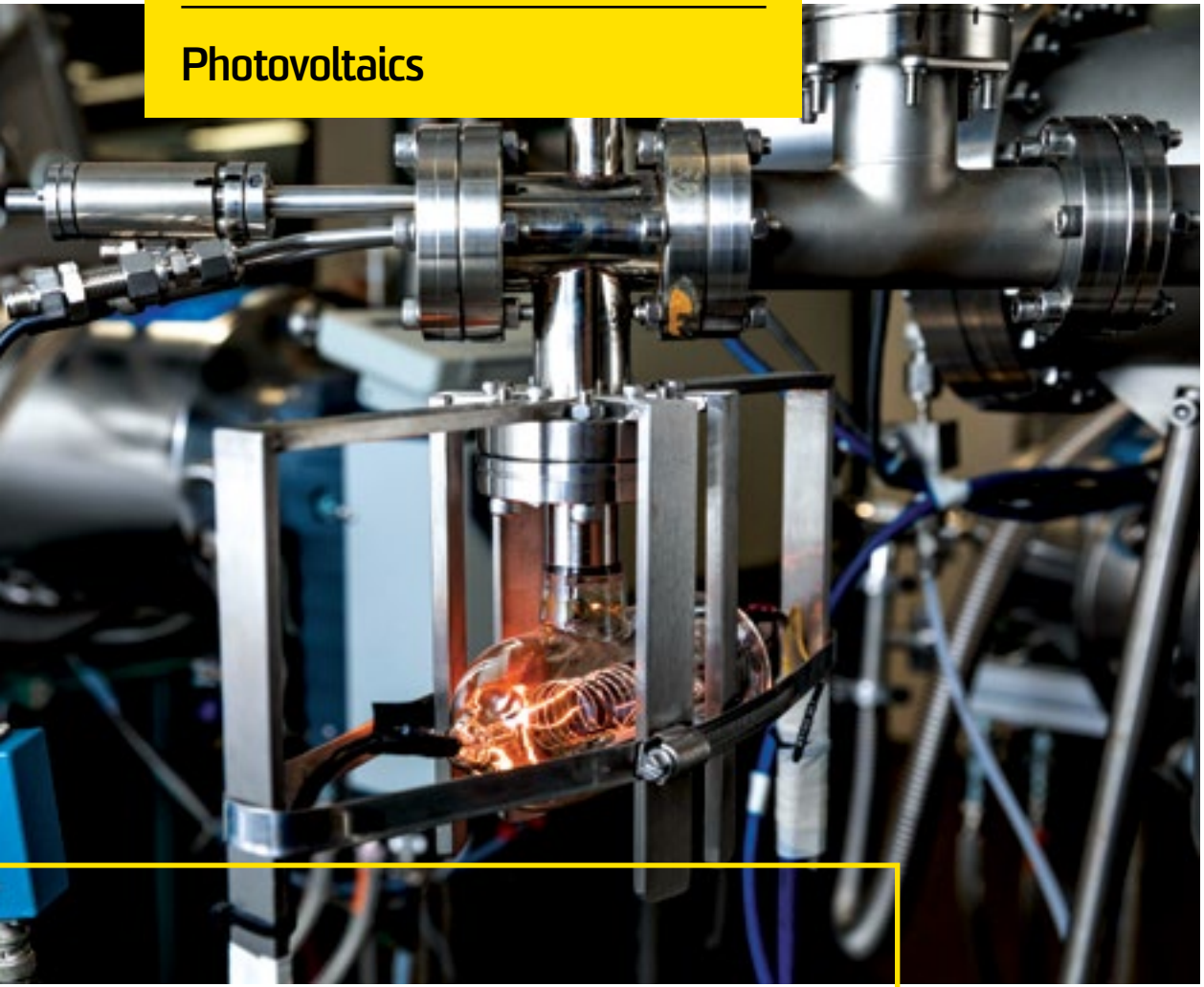
Photovoltaics



UNSW's School of Photovoltaic and Renewable Energy Engineering, a global centre of excellence in photovoltaic research, has over 40 years' experience in photovoltaic device development and metrology. Successful commercialisation of various solar cell architectures and enabling technologies for the photovoltaic industry.

Competitive advantage

- 200 experts in photovoltaic and renewable energy technology
- World-first degree in photovoltaics
- Proven track record in commercialising technologies
- Extensive alumni network, with many in senior industry leadership roles

Impact

- Solar cells across the rooftops of the world

Successful applications

- First 25.0% silicon solar cell more than a decade before others
- PERC solar cell structure developed at UNSW dominates the industry
- Current world-record holder for large area perovskite, CZTS, and one-sun system efficiency

Capabilities and facilities

- Solar Energy Research Facility (SERF)—an on-campus R&D pilot line for silicon wafer solar cells
- State-of-the-art labs for cutting edge academic research in silicon wafer, perovskite, CZTS, organic, and silicon-based tandem (including III-V) fabrication and characterisation

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Environmentally Rugged Solar-Electric Power Supply

New technology delivering the highest environmental survivability to photovoltaic (PV) power systems by reducing the impact of wind loads and heat stress.

Competitive advantage

- PV platforms provide silent sustained energy to support the power-intensive electronics of modern equipment in isolated locations
- The energy yield of tracking PV technology is 40% higher per unit area than ideally orientated fixed PV systems. Off-the-shelf concentrating-PV (c-PV) modules (using multi-junction technology) outperform the highest efficiency PV modules by 50% when facing the sun
- The environmental survivability of the rugged c-PV system is enhanced by Double-Layer Orthogonal Offset Platform (DLOOP) technology which sheds up to 30% of the wind load on platforms and thermal stress from PV modules
- Development of DLOOP platforms integrating c-PV modules promise twice the power per unit area of the best fixed single silicon modules while compatible with field deployment requirements: featuring unfolding hinged sections with elevation control from a road tractable trailer mount
- Patented DLOOP technology

Impact

- Supply chain facilitated by autonomous electric power to outposts delivered by the sun
- A rugged PV power system with maximised environmental survivability

Capabilities and facilities

- Modern prototype machine workshop managed by PEMS.
- Central warehousing and integration facility of 600m2 located in Queanbeyan, NSW

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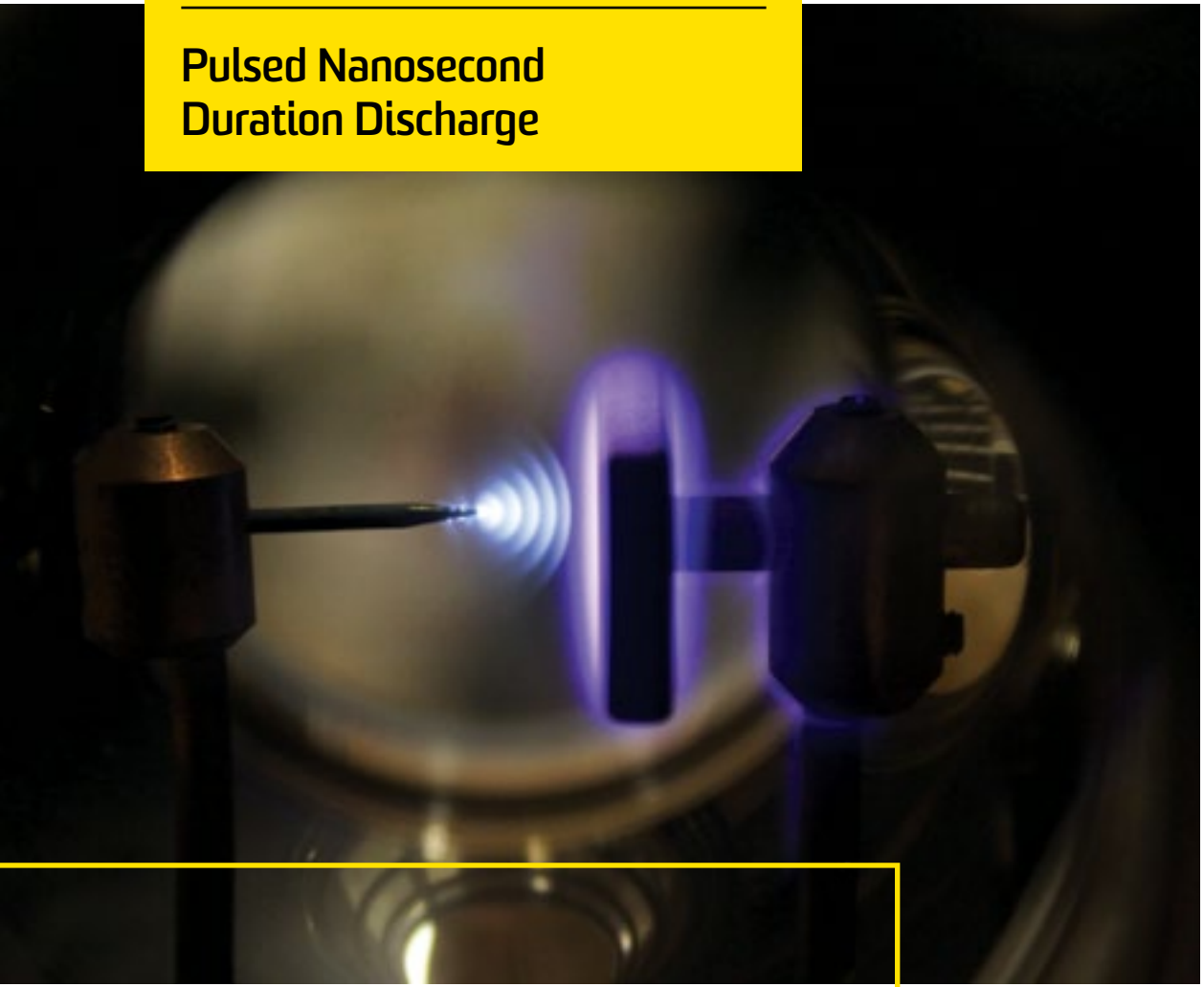
Pulsed Nanosecond Duration Discharge



Nanosecond-duration plasmas for a range of engineering applications.

Competitive advantage

- Technologies developed for the generation of nanosecond-duration plasma discharges. These plasmas can operate at very high voltages while maintaining cold plasma characteristics, as the pulse duration is too short for the plasma to transition to a spark under some conditions
- Laser-based diagnostics capable of nanosecond or shorter duration measurements of species concentration, temperature and electric field strength have also been developed

Impact

These devices have a range of possible applications, including

- Fuel ignition systems
- Sterilisation of medical equipment, foods and liquids
- Destruction of contaminants in water
- Thin film deposition technologies

Successful applications

- Built and characterised nanosecond repetitively pulsed power supplies
- Measurements of temperature and species concentration during and immediately after the pulsed discharge occurs

Capabilities and facilities

- D1.5 nanosecond commercial pulser
- 80+ nanosecond variable duration pulser developed in-house

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Electrically Conductive Nanocomposite Films

Synthesis of polymer nanoparticles with graphene oxide sheets via mini-emulsion polymerisation enabling electrically conductive films using an ambient temperature process. These films exhibit high electrical conductivity with a wide range of applications as conductive coatings.

Competitive advantage

- Technology represents first example of an approach for synthesis of electrically-conductive graphene/polymer films that form at ambient temperature
- Environmentally friendly process
- Amenable to industrial-scale applications

Impact

- Potential for advanced coatings and sensors with specified electrical, mechanical and barrier properties
- Such composite materials exhibit high performance, tailored mechanical and electrical properties. Applications of these materials include robust anti-corrosive coatings and barriers, supercapacitors and hardened electronics.

Capabilities and facilities

- Synthesis of polymer/graphene thin films with specified level of electrical conductivity
- Synthesis of hybrid polymer/graphene nanoparticles as hybrid materials
- Synthesis of polymer nanoparticles of various size, shape and internal morphology

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Electrolytes and Thin Films for Solid-State Batteries

Responding to the need to safely supply more and more energy from batteries by developing solid-state batteries with wider operating temperature ranges, improved shock tolerance and increased energy density.

Competitive advantage

- New battery chemistries can be implemented for:
  - Higher charge density (Li-S)
  - Lower cost (sodium-ion, potassium-ion)
  - Inherent safety (solid-state).
- Environmentally friendly, inexpensive materials
- Facilities for construction of a variety of battery designs
- Full structural, spectroscopic and electrochemical characterisation, particularly synchrotron X-ray diffraction, to elucidate structure-property relationships at bulk & atomic scale
- At the forefront of work towards development of all-solid-state thin film batteries

Impact

- Understanding the role of grains and grain boundaries on bulk diffusion
- Evaluating the type of atomic-scale diffusion
- Linking structure to local and long-range diffusion
- Using in situ methods to elucidate phase evolution, degradation mechanisms
- Failure analysis

Capabilities and facilities

- Materials synthesis
- Pulse laser deposition growth of certain electrodes
- Access to key analytical techniques such as solid-state NMR, surface analysis and electron microscopy
- Developed a testing apparatus for the operando study of thin film batteries using synchrotron X-ray diffraction during operation
- Use of unconventional techniques such as quasi-elastic and inelastic neutron scattering

Our partners

- The French Alternative Energies and Atomic Energy Commission (CEA)

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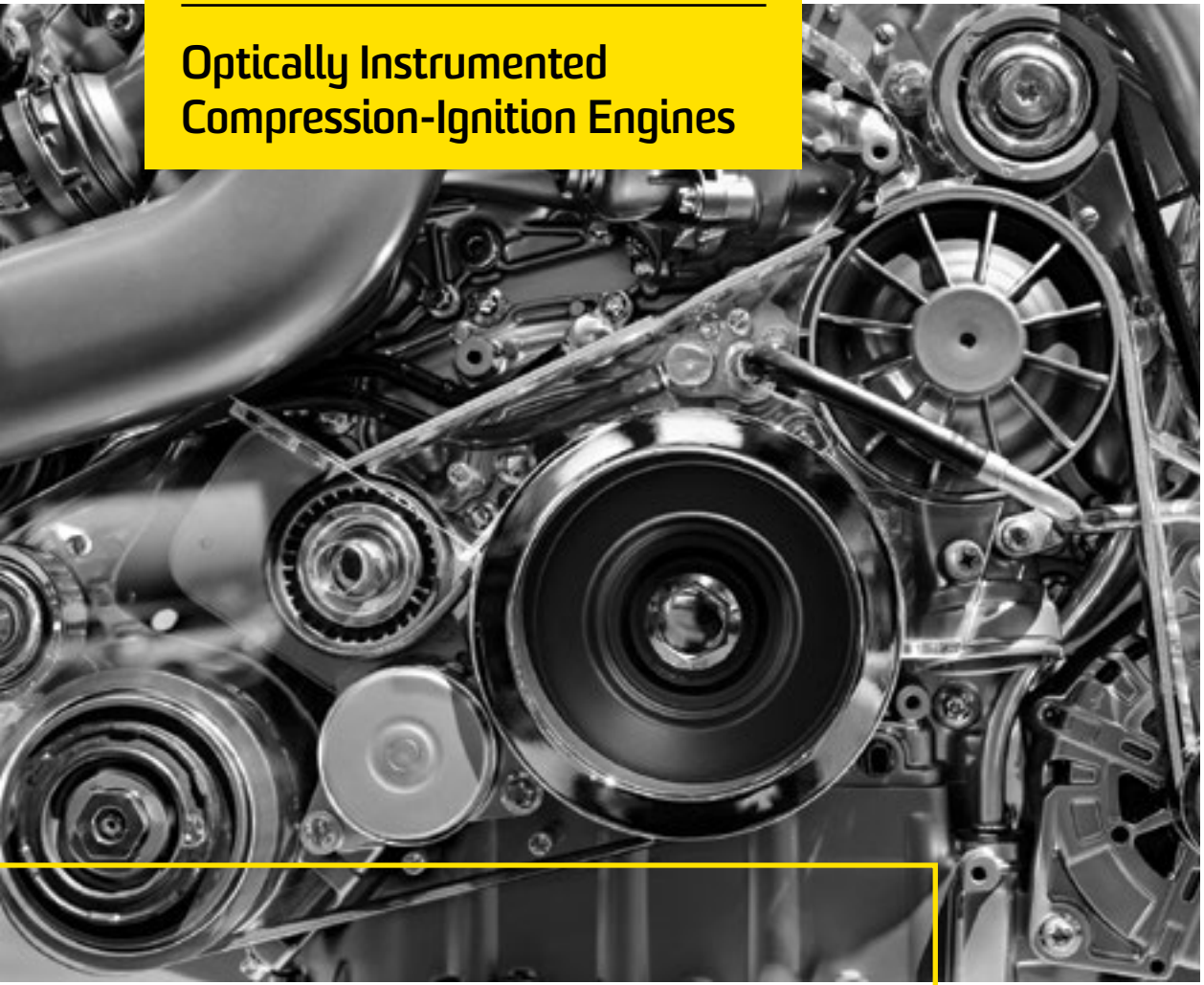
Optically Instrumented Compression-Ignition Engines



Enhancing and optimising propulsion systems for navy fleets, ground vehicles and unmanned aeroplanes capable of running on various fuel types, using optically-accessible compression ignition engines and laser-based two-dimensional imaging of the flames and pollutants inside.

Competitive advantage

- Readily available optical CI engines and laser-based imaging techniques/tools
- Full details of in-cylinder phenomena, not guess-and-check through trial-and-error tests
- Images and movies obtained from a running engine at realistic conditions and thus directly relevant to real-world applications

Impact

Through flame visualisation and air pollution species imaging, fuel injection strategies required for specific fuel types are identified and tested for practical applications. The results achieve extended range and lower infrared signature

Successful applications

- In-cylinder soot distribution imaging of US Office of Naval Research Global's (ONRG)'s biodiesel fuelled CI engines
- Development of soot particle sampling technique for structural analysis in US Army's diesel engines
- Fundamental ignition process and high-temperature reaction visualised in US Army's multi-fuel capable CI engines for UAS propulsion

Capabilities and facilities

- Group 3 (55-1320 lb) and Group 4 (>1320 lbs) CI engines with full optical access
- Dye and Nd:YAG lasers, high-speed intensified CMOS camera, and intensified CCD camera
- Fully trained postdoctoral researchers and postgraduate research students

Our partners

- Vehicle Research Lab, Army Research Laboratory, USA
- US Office of Naval Research Global

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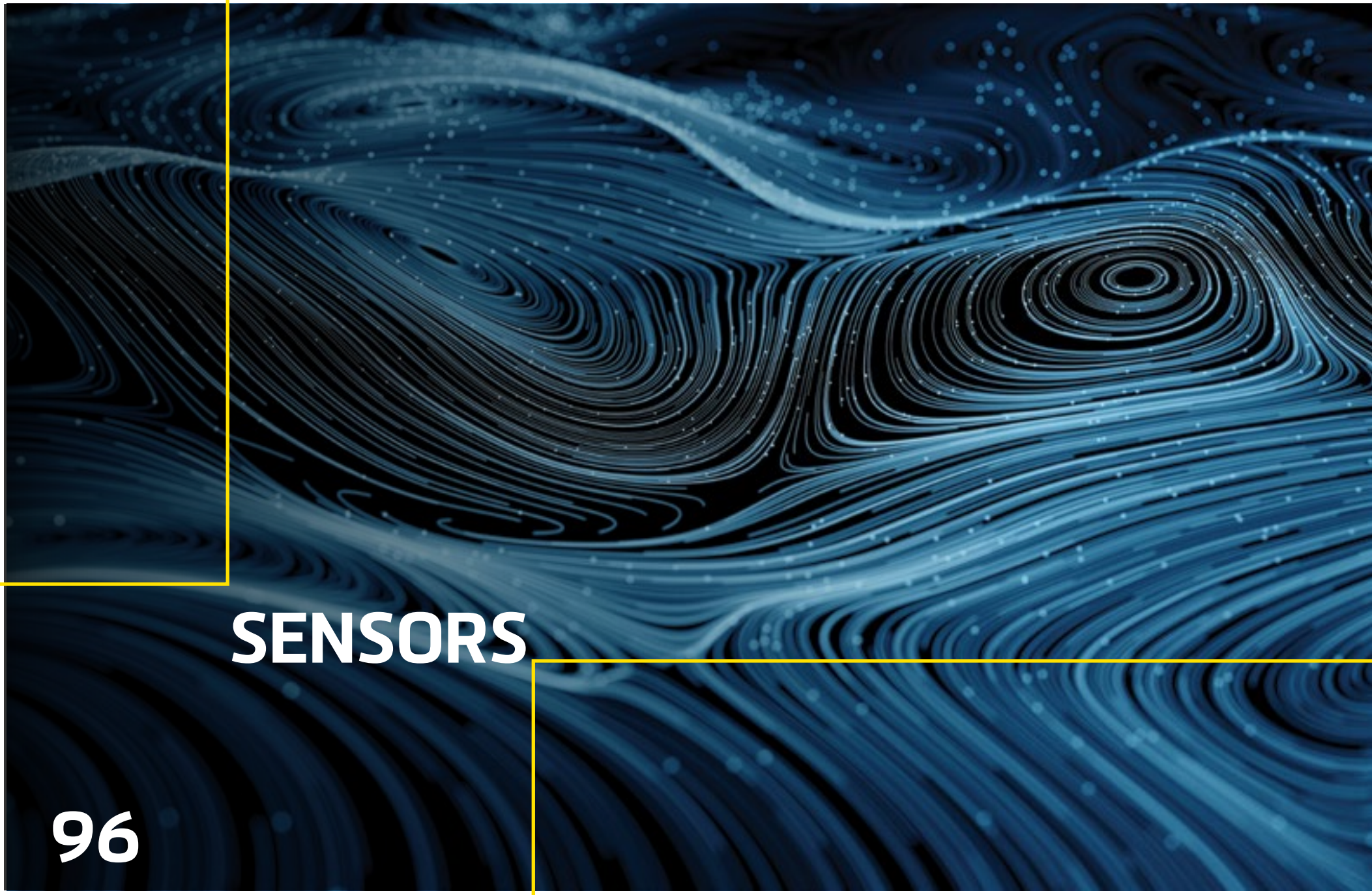

SENSORS

High–Strain Piezoelectric Ceramics for Sonar Applications

Electric-field-induced phase-change ceramics offer large strain actuation in sonar applications, allowing for the design of more efficient, accurate and compact sonar systems.

Competitive advantage

- Conventional piezoelectric ceramics for sonar applications operate by microstructural mechanisms, limiting their strain magnitudes
- Structural knowledge of phase change processes in an electric field opens the possibility of achieving larger strains
- Performance metrics of these materials can be superior for specific sonar applications
- Fabrication costs are in-line with conventional functional ceramic processing

Impact

- More efficient, accurate and compact sonar systems

Capabilities and facilities

- Ceramic fabrication facilities for small batch testing. Aqueous and nonaqueous processing
- Range of milling equipment from regular ball milling to high-energy planetary milling
- Furnace facilities for sintering under various atmospheres
- Electro-mechanical characterisation equipment for measurement of local and bulk properties
- In situ structural characterisation capabilities for observing grain-scale response of electro-ceramics during actuation

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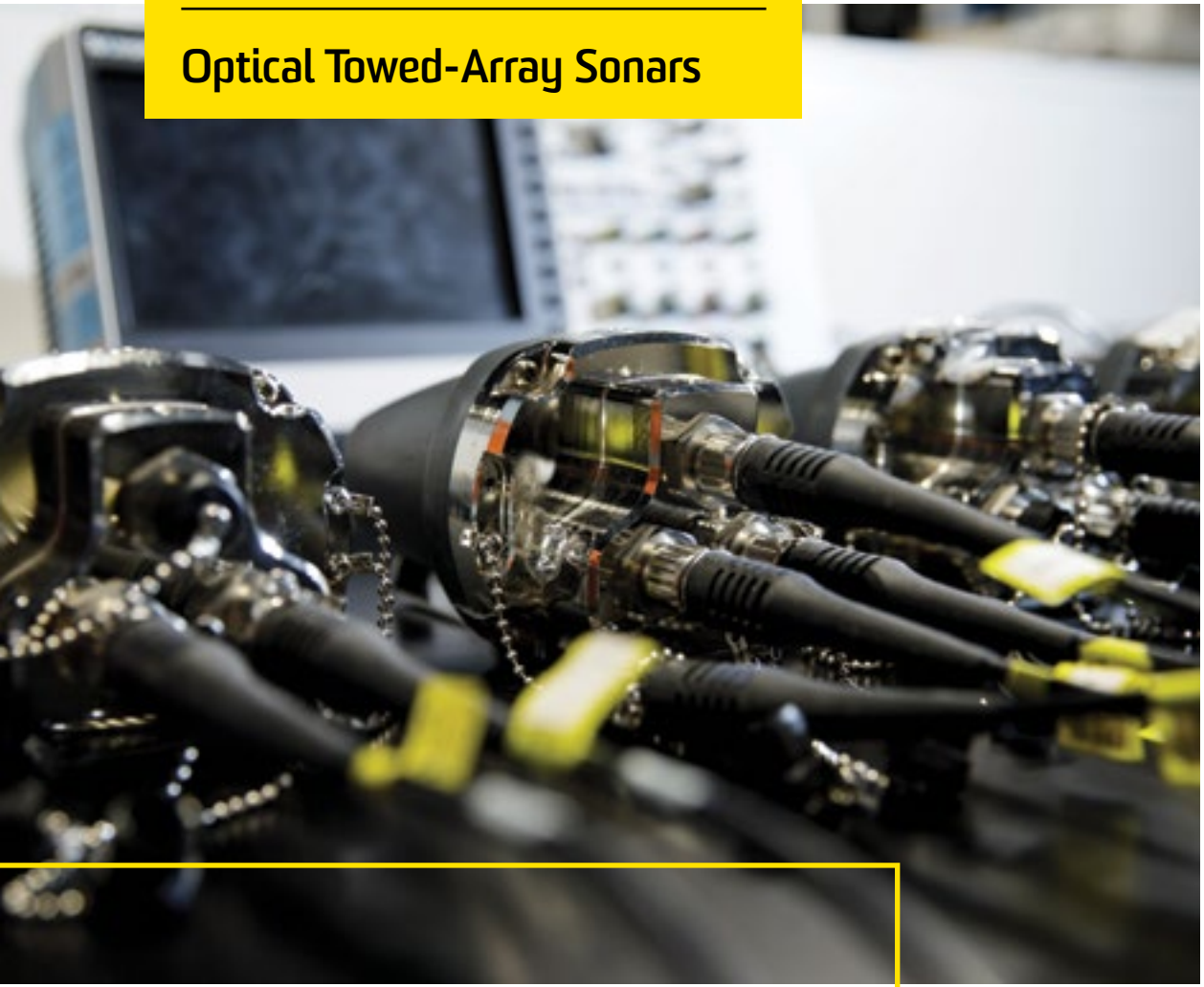
Optical Towed-Array Sonars



The security of coastlines can be greatly enhanced using sonar arrays including those towed by autonomous marine drones. This technology produces low-cost, robust, lightweight and power-efficient towed-array sonars based on optical sensing technologies developed in collaboration with industry partners.

Competitive advantage

There is a trend towards the use of marine drones to supplement crewed vessels. Central to the viability of this is the development of towed-array sonars suitable for such autonomous drones.

- Patented optical technology based on liquid-crystal transducers has been developed with industry partners. Liquid-crystal transducers translate analogue electrical signals into optical signals passively and linearly
- It is possible to read optically the output of virtually any sensor (e.g. microphone or hydrophone) and transmit its output over optical fibre, leveraging the advantages of optical networks
- This technology is cheap, robust, lightweight and very power efficient

Impact

- Better coastal security

Successful applications

Solutions for:

- The mining industry, Ampcontrol
- Ocean monitoring, Thales
- Industrial monitoring, Schneider Electric

Capabilities and facilities

- UNSW has world class fabrication and characterization facilities related to integrated optics and photonics
- Access to the world-class Australian National Fabrication Facilities (ANFF)

Our partners

- Thales Underwater Systems
- Zedelef Pty Limited

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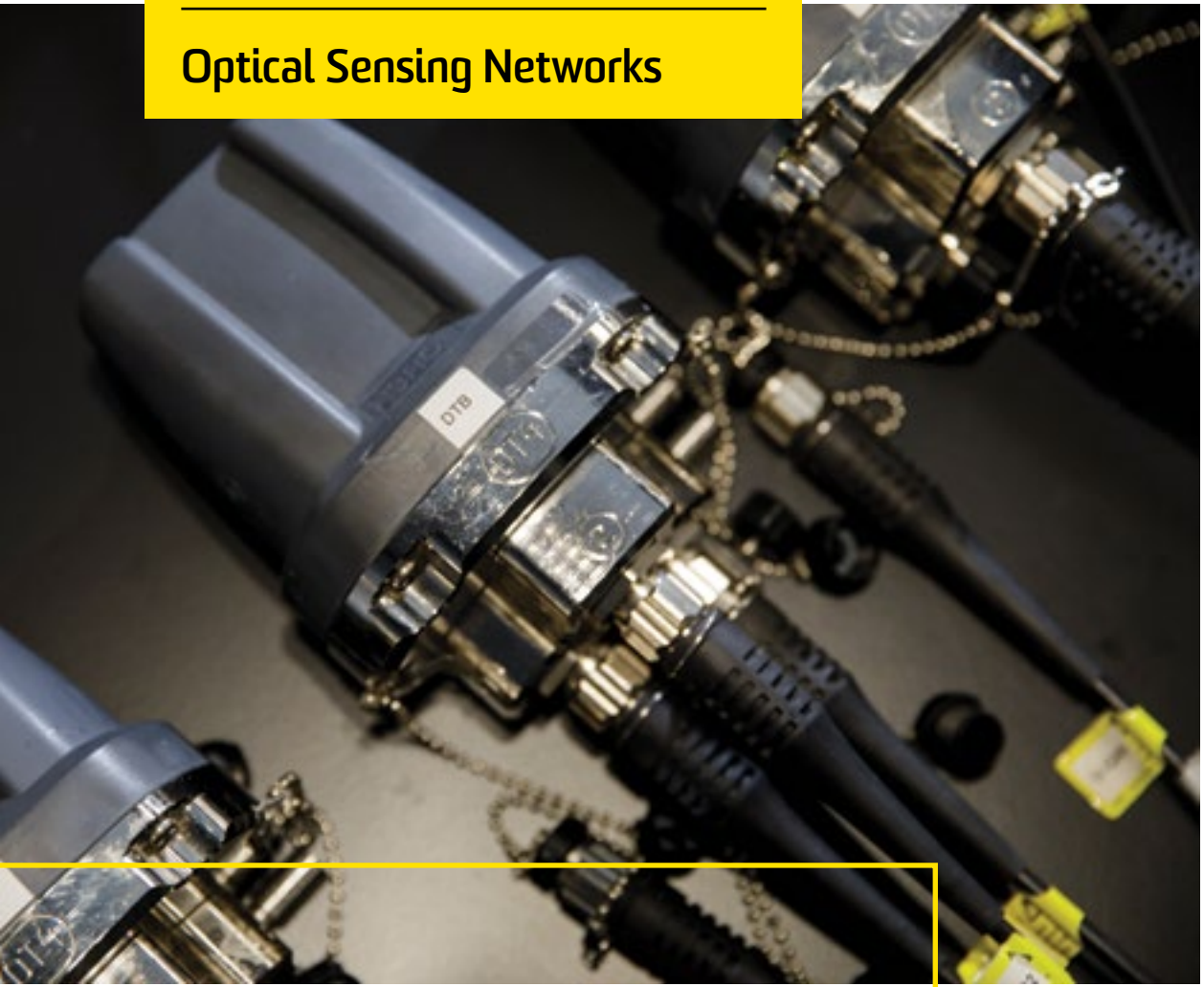
Optical Sensing Networks



Optical solutions for industrial and biomedical sensing applications. These include monitoring under hazardous conditions such as those found in petrochemical plants, mines and food processing environments, and monitoring and imaging of neuronal activities in biological tissues such as those found in the brain, retina and muscle.

Competitive advantage

Most sensing technologies are electronic in nature, requiring power and signal cables running back to a central location. Such systems are impractical in hazardous environments such as flammable or explosive atmospheres. This is a breakthrough platform technology in the form of optoelectronic transducers capable of optically reading the output of standard electronic sensors and transmitting their output via optical fibre for processing. This technology, based on ferro-electric liquid crystals, has also been applied to the detection of neural activities in biological tissues, providing a means to develop the next generation of brain–machine interfaces. It also forms the basis of a new class of monolithic integrated Q-switch lasers.

Strong track record in commercialisation of technology through collaboration with industry, creating start-ups and raising venture capital.

Impact

- New and safer sensing

Successful applications

- Zedelef —spinoff company created to commercialise research outcomes
- A new high performance optical telemetry system for ocean monitoring
- Currently commercialising two patented technologies: brain machine interface and integrated monolithic Q-switched lasers

Capabilities and facilities

Access to a number of important resources including:

- Two photonics labs for characterisation and materials
- The Australian National Fabrication Facility (ANFF)

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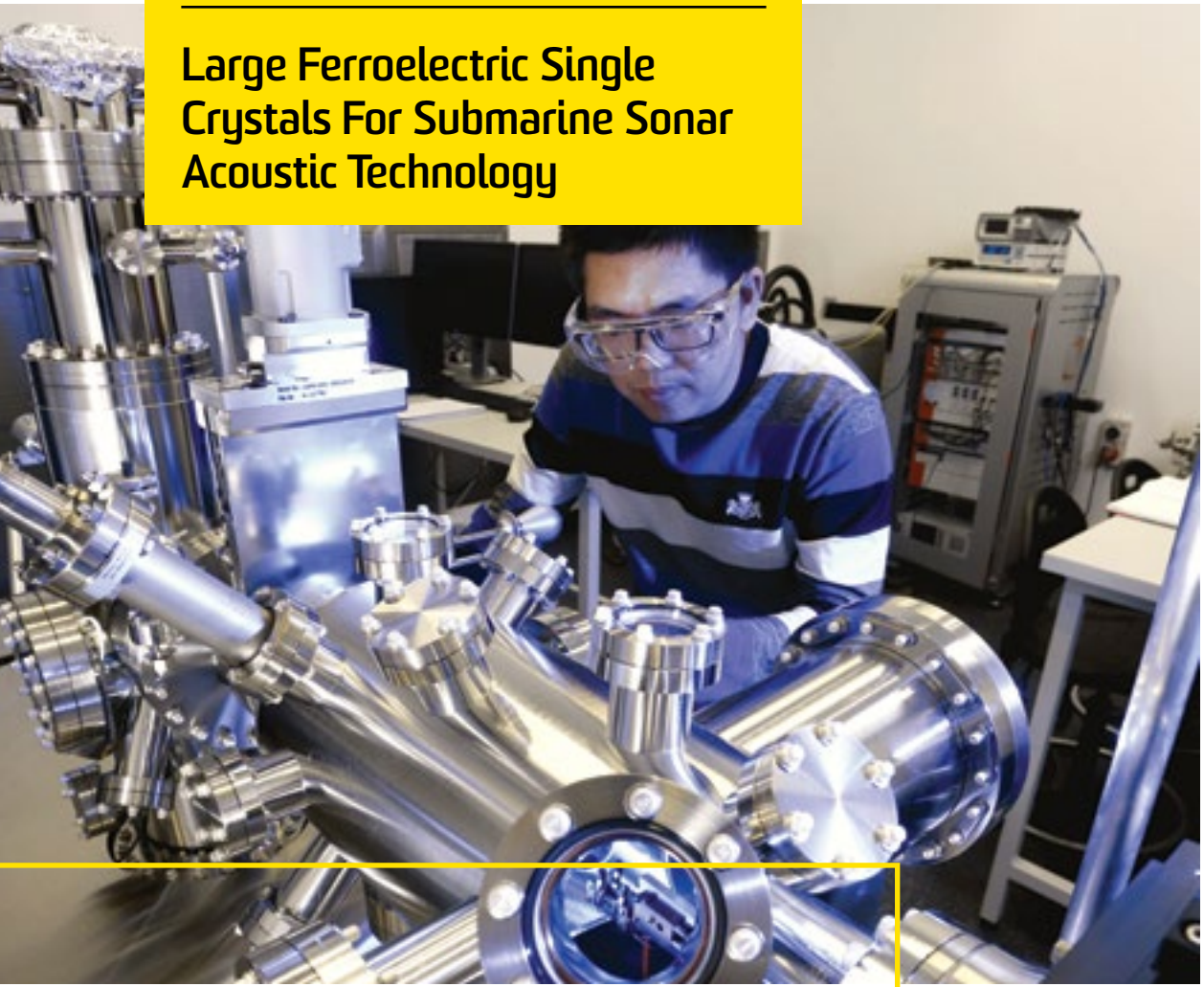
Large Ferroelectric Single Crystals For Submarine Sonar Acoustic Technology



Mirror furnace systems are used to produce very uniform high-quality single crystals of ferroelectric materials for use in sensors including those used in submarine sonar systems.

Competitive advantage

Expertise in using the optical floating zone method to produce very uniform, high-quality single crystals of ferroelectric materials. Single crystals are a key technology of the future for submarine sonar systems. Owing to their lower impurity levels and absence of grain boundaries, single crystals transmitters have less loss than conventional ceramic transmitters, while sensors using single crystals have significantly higher sensitivity than ceramic types.

Impact

- More sensitive, efficient and compact sonar systems

Successful applications

- Magnetoelectric sensor project, Office of Naval Research (ONR)

Capabilities and facilities

- Magneto-optical facility for the search of novel multifunctional materials
- Facility for electric and magnetic probes of materials at extreme conditions

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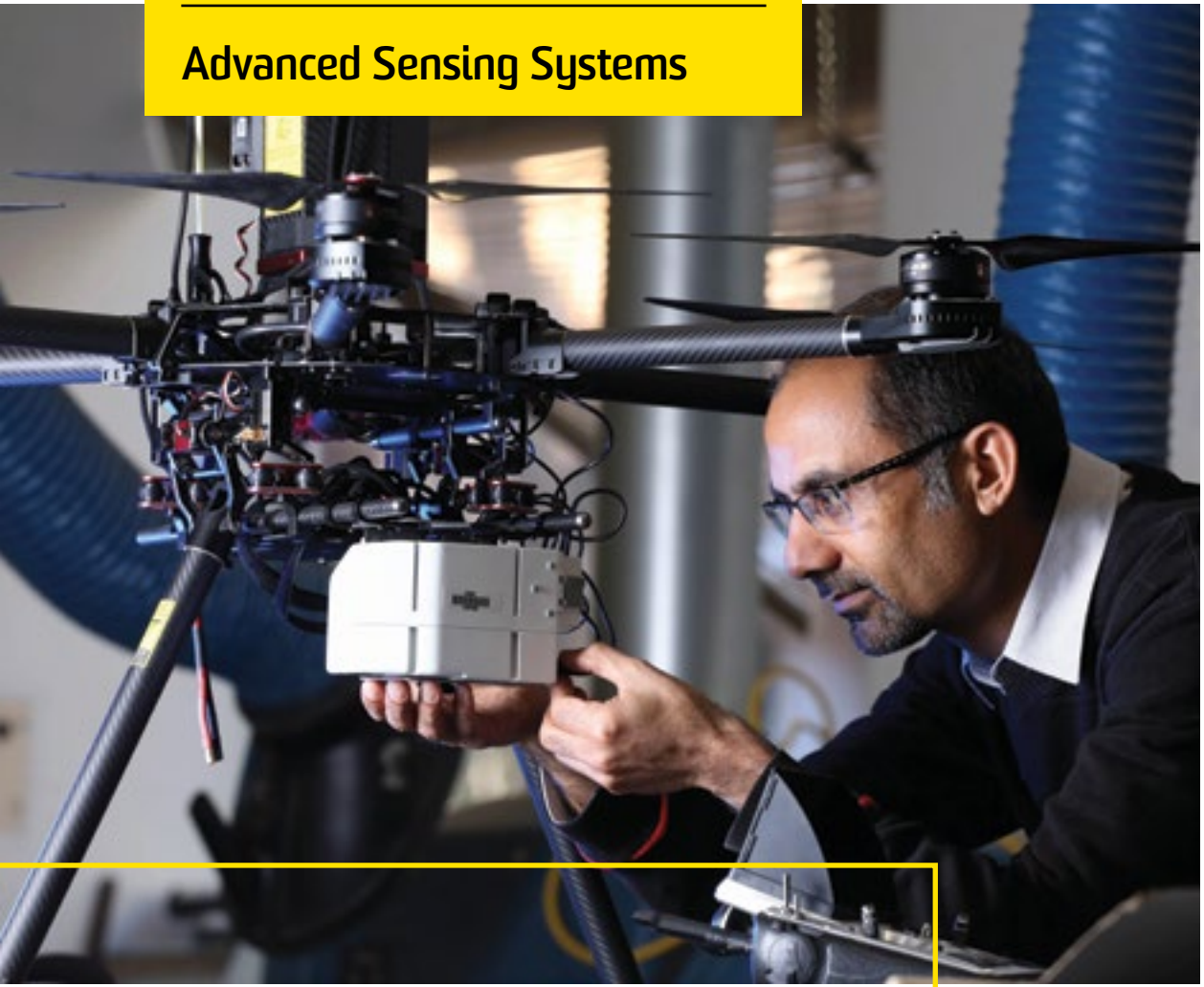
Advanced Sensing Systems



Advanced sensing systems provide an integrated solution for environmental and safety monitoring across a range of industries, including mining, defence, agriculture, forestry, food processing and health.

Competitive advantage

- Expertise in design of application-specific sensor hardware, data acquisition using various platforms including satellites and drones, and customised algorithms to convert the data into solutions
- Environmental monitoring expertise in challenging environments—remote water quality, sensitive ecosystem health, remote monitoring for temperature, pressure, gases etc
- Safety monitoring expertise, including structural deformation, hazardous spillage detection, in situ sampling and warning systems
- Expertise in machine vision—real-time object tracking, target recognition, resolving patterns, image enhancements, and 2D- and 3D-mapping

Impact

- Improved environmental sensing and safety management

Successful applications

- A drone-based scanning system for mapping structural parameters of pit walls, Glendell coal mine, Glencore
- Drone generated spatial data processing software, Agronomeye
- Drone based hyperspectral mapping system to monitor sensitive swamp vegetation, Russel Vale colliery, WCL
- Remote water sampling using drones, Glendell coal mine, Glencore
- Thermal hotspot mapping using drones, Ulan Coal mine

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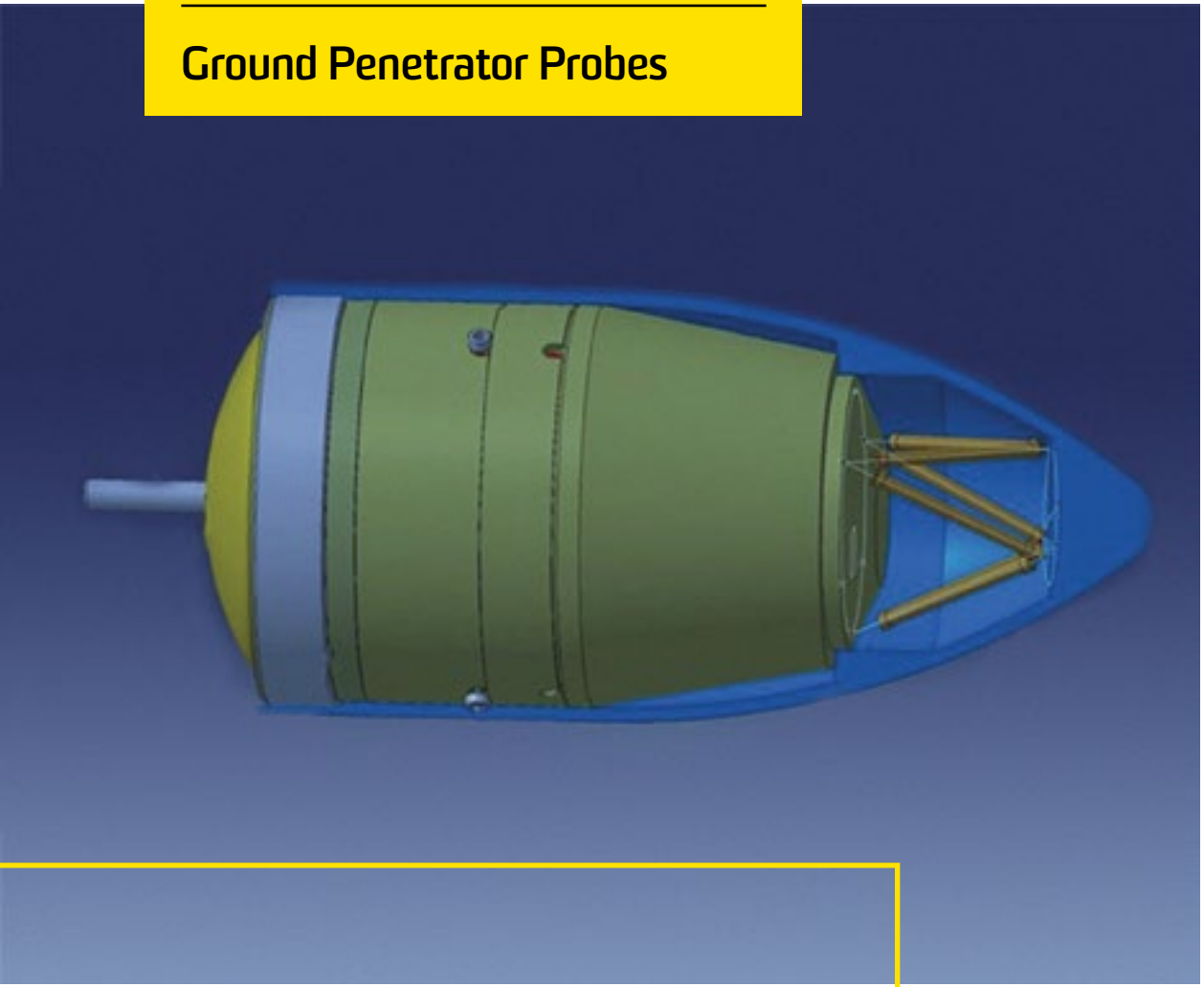
Ground Penetrator Probes



Penetrator probes dropped from a height can quickly deliver seismic monitoring and other geophysical equipment to the subsurface.

Competitive advantage

Expertise in ground penetrator probes. These offer a number of key advantages, including:

- Can be delivered via airplane, helicopter or UAV
- Can be used to quickly build up monitoring networks in remote areas
- Able to withstand impacts at up to several hundred metres per second
- Can contain multiple geophysical, geological and other sensing payloads
- Accelerometer on impact measures depth of penetration and identifies sediment layers, and
- Able to communicate with base station using radio

Impact

- More rapid and cost-effective geophysical monitoring and sensor networks, including remote deployment

Capabilities and facilities

- Mining Geomechanics Laboratory
- Advanced Visualisation and Interaction Environment

Our partners

- Jet Propulsion Laboratory Caltech
- NASA

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Hyperspectral Microscopy

Developing novel methods of biomedical diagnostics using hyperspectral microscopy to characterise natural colour and morphology of cells and tissues in the body, to determine whether they carry the early hallmarks of disease. This can yield early screening systems for detecting ill but pre-symptomatic individuals.

Competitive advantage

- The method is non-invasive, rapid and easily deployable in the clinic
- The first team to extract detailed biochemical-level information from cells and tissues
- The method is highly sensitive and provides subtle insight into biological processes
- Awarded the Eureka Prize for Innovative Use of Technology

Impact

This method is expected to impact a broad range of disease conditions, including:

- Improved therapies for regenerating cartilage injuries
- Improved diagnostics of cancer of ocular surface
- Early diagnostics of kidney disease
- Applications in fertility and IVF industry
- Veterinary applications
- Early diagnostics for pre-symptomatic individuals

Successful applications

- Early diagnostics of motor neurone diseases (clinical trial under way)
- Related start-up company is in its 5th year of operation

Capabilities and facilities

- High content, high throughput imaging
- Big data analytics
- Bioimaging, biosensing and data analytics

Our partners

- Sydney Eye Hospital
- Fertility SA
- Royal North Shore Hospital
- Macquarie University Hospital
- Macquarie Neurology
- Regeneus Pty Ltd
- Quantitative Pty Ltd
- Prince of Wales Hospital

More information

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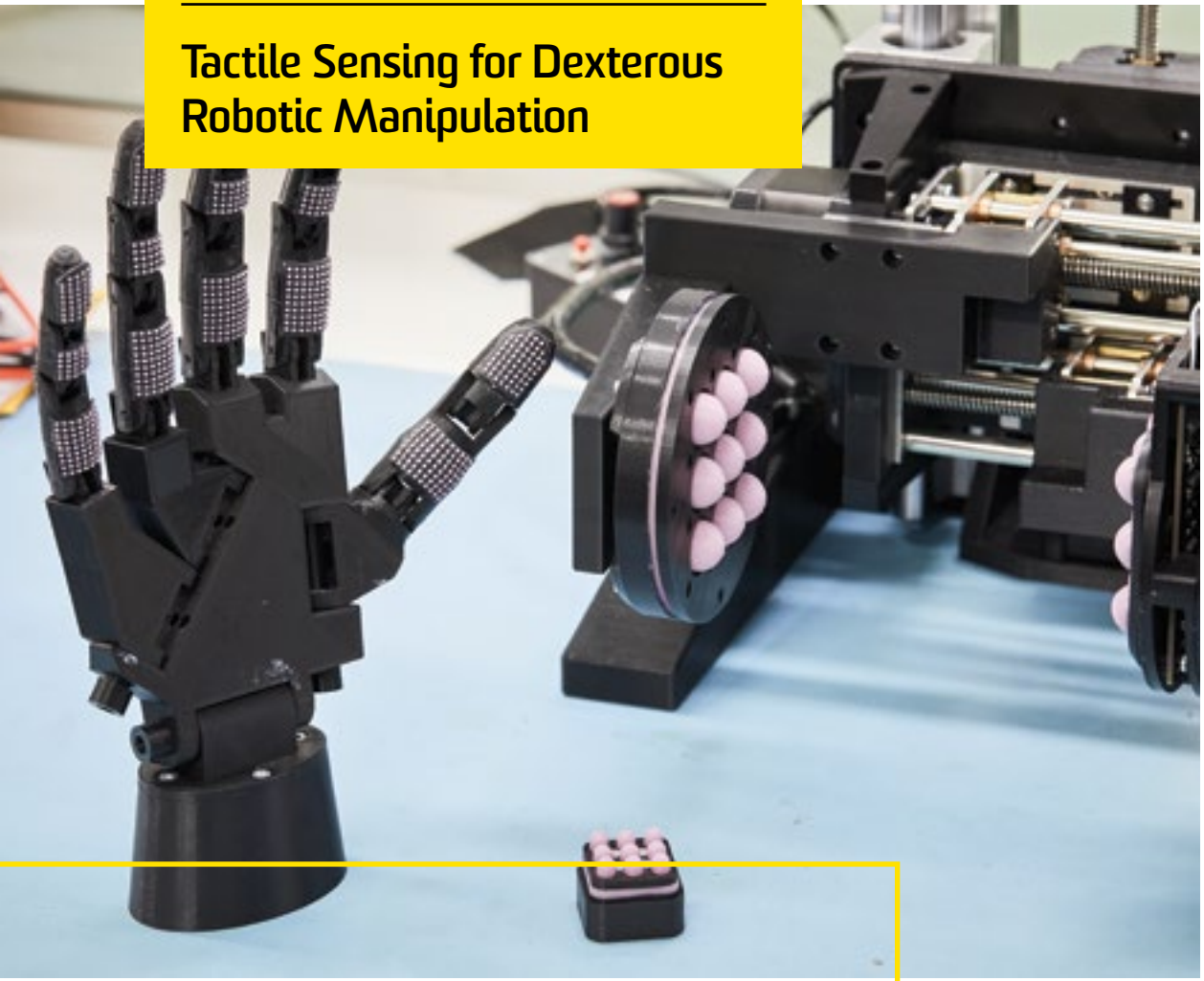
Tactile Sensing for Dexterous Robotic Manipulation



Robots need a sense of touch if they are to match human capabilities. This patented technology replicates the human sense of touch without being limited by size, strength, environment or fatigue.

Competitive advantage

- Soft sensor design can measure 3-D localised force, 3-D localised deflection, 3-D localised vibration, torque, incipient slip and friction at the gripper-object interface. All are the essential parameters for determining whether an object is securely grasped
- The size, density, compliance, measurement range and sensitivity of the sensor can be customised and there are no electronics in the contact surface
- The sensor is resistant to shock, water and chemicals and can be food safe

Impact

- Enhanced remote tactile sensing for applications such as surgery, unmanned exploration and disarming mines
- Improved robotic gripping for applications such as pick-and-place, disaster response and assistance robots
- More-precise slip sensing in feet for legged robots and exoskeletons

Successful applications

- Demonstrated large scale sensor prototype with 99% accuracy and 98% precision in force and deflection measurement.
- Demonstrated large scale intelligent gripper prototype with ability to grasp objects of varying friction and weight using an optimal grip force
- Participation in the Commonwealth Scientific and Industrial Research Organisation (CSIRO) ON Accelerate start-up accelerator program for commercialisation

Our partners

- US Office of Naval Research Global

More information

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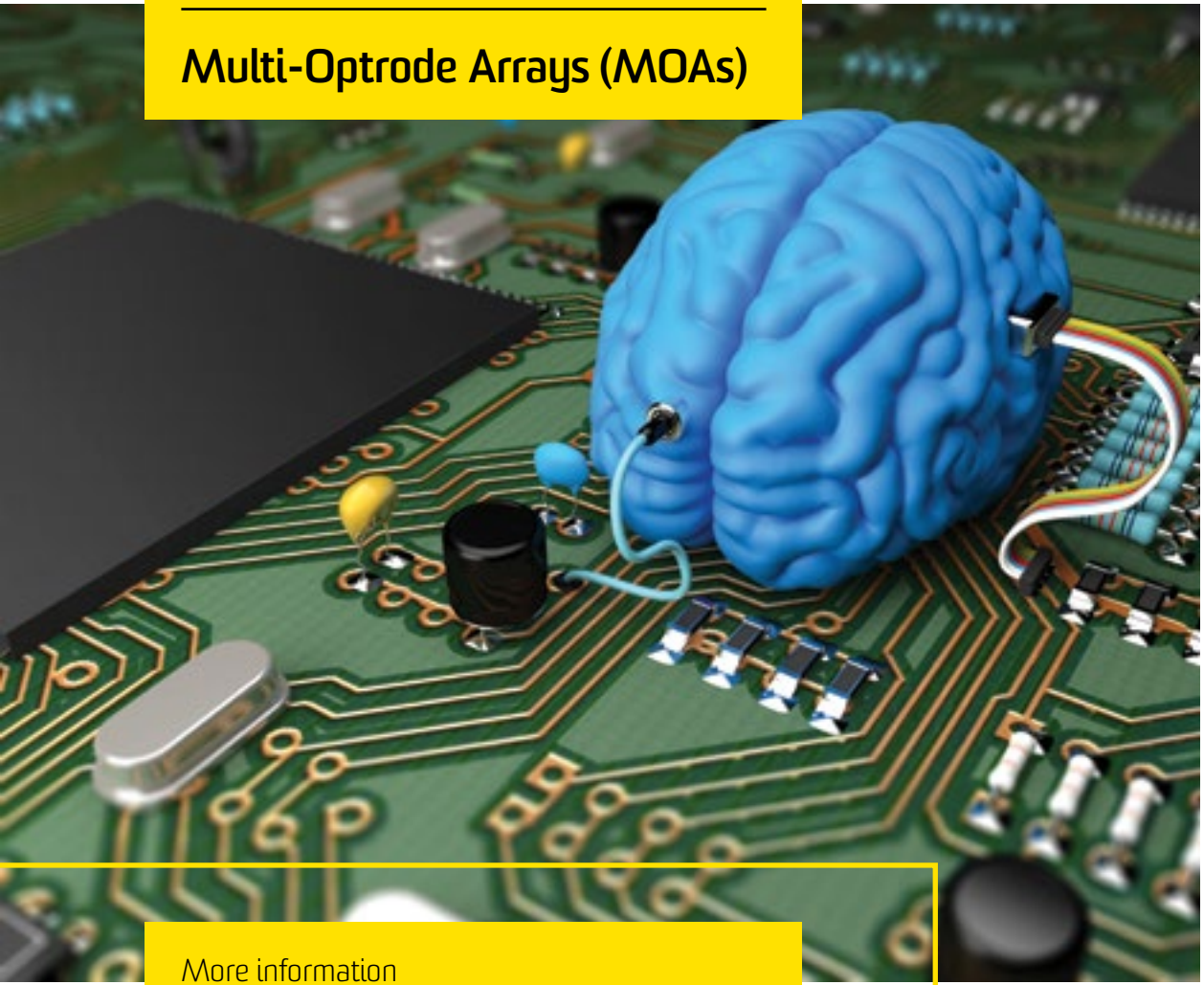
Multi-Optrode Arrays (MOAs)



Development and biological assessment of optical-electrode 'optrode' transducers for recording electrical activity in the body.

Competitive advantage

- Multi-disciplinary team working at the interface of biology and engineering
- A patent portfolio covering industrial and biomedical aspects of technology

Impact

MOAs overcome the limitation of current recording systems by using light to carry bioelectric signals. This work will lead to the next generation of brain-computer interfaces.

- It enables high-density, high channel count recording from neural and cardiac tissue
- Application for brain-machine interfacing and prostheses
- Application for cardiac diagnostic systems

The underlying technology of MOAs can also be applied in acoustic sensing networks to have many applications including:

- Ocean monitoring (distributed sonars)
- Mineral prospection (geoseismic exploration)
- Environmental protection (leak detection in water distribution networks)

Successful applications

- Demonstrated ability to map electrical activation in hearts in animal models
- Demonstrated ability to record peripheral nerve responses in animal models

Capabilities and facilities

- Biomedical microfabrication facility
- A range of electrophysiology, animal surgery, and microscopy setups for biological assessment of technology
- Access to engineers and infrastructure at the Australian National Fabrication Facility

Our partners

- Zedelef Ltd

More information

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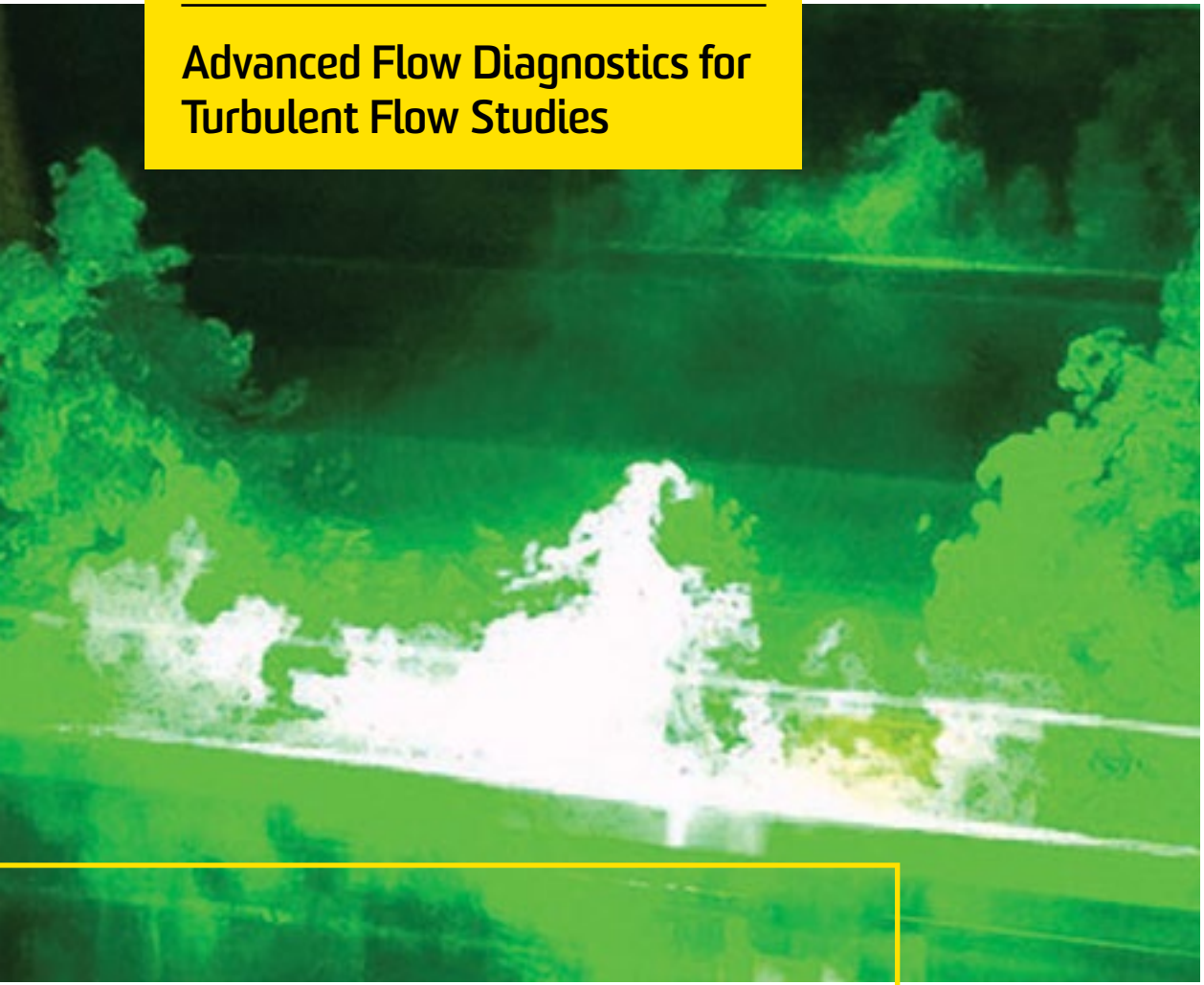
Advanced Flow Diagnostics for Turbulent Flow Studies



The development and application of laser-based flow diagnostics in a variety of environments from microfluidics to large-scale wind-tunnel testing.

Competitive advantage

- Novel flow measurement capability to capture fully-resolved three-dimensional flows using image-based techniques, spanning from micron-resolution measurements for microfluidic devices to large-scale wind-tunnel testing of rapid-prototype models
- Ability to capture aeroacoustics using a state-of-the-art anechoic wind-tunnel facility and to probe supersonic flows in a dedicated supersonic wind-tunnel facility

Impact

- Projects in microfluidics and biofluids have impact through improvements in public health, biotechnology and renewable energy technology. Examples include the design and testing of lab-on-chip devices and 3D flow measurement in patient-specific vascular flows
- High-resolution flow measurements in large-scale wind-tunnel facilities have led to societal benefits such as energy savings and reduced emissions through improved aerodynamic efficiency, better design optimisation and flow modelling capabilities. In particular, the development of measurement diagnostics to directly measure wall-shear stress (drag) over complex geometries from experiments

Successful applications

- Developed flow diagnostics, with accuracy beyond current industrial practices, which have been employed to examine turbulent flows in large-scale engineered transport systems (wall-turbulence), urban environments (scaled atmospheric boundary layer conditions) and micron-scaled biofluidic flows

Capabilities and facilities

- Large recirculating wind-tunnel facility for testing at speeds up to 50 m/s with a cross-sectional area of 1.2m x 1m
- Dedicated anechoic wind tunnel facility with simultaneous flow diagnostics
- Supersonic wind-tunnel facility
- Inverted epifluorescent microscopes with laser-based flow diagnostic systems
- Multiple laser-based flow diagnostic lasers and high-speed/high-resolution cameras for wind tunnel testing

Our partners

- Defence Science and Technology (DST)
- LaVision (Germany)

More information

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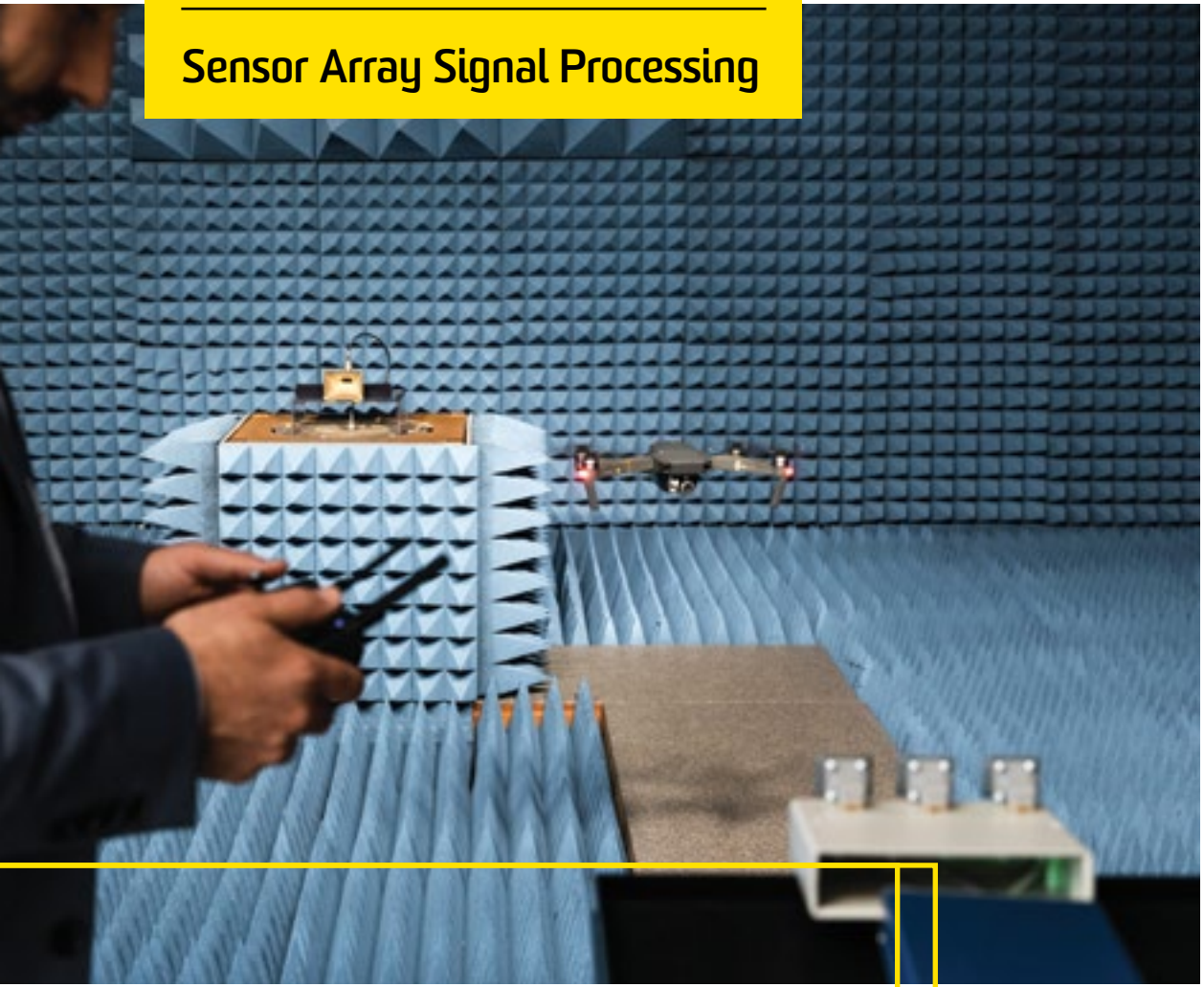
SIGNAL PROCESSING AND DATA FUSION

Sensor Array Signal Processing



Design of optimal algorithms for signal detection, and estimation of the parameters of signals obtained from sensor arrays and time series with a range of applications, including radar, sonar, GNSS (Global Navigation Satellite System), communications, nuclear magnetic resonance spectroscopy, and power systems.

Competitive advantage

- Expertise in the design of optimal sensor arrays and beamforming strategies
- Internationally recognised leadership in the development of fast and powerful algorithms for the extraction of information from noisy signals
- Theoretical and practical experience in various applications of signal processing

Impact

- Better, more reliable communications, sensing and imaging

Successful applications

- Maritime radar target detection
- High-altitude synthetic aperture radar
- Novel nuclear magnetic resonance (NMR) software
- Power systems parameter estimation
- Sparse array design for radar
- Radar for health applications

Capabilities and facilities

- Radar systems laboratory comprising a network of array and Multiple Input and Multiple Output (MIMO) radars
- Power systems laboratory for complete simulation of real power systems
- State-of-the-art Nuclear Magnetic Resonance facilities

Our partners

- Defence Science and Technology
- Mestrelab
- Data61

More information

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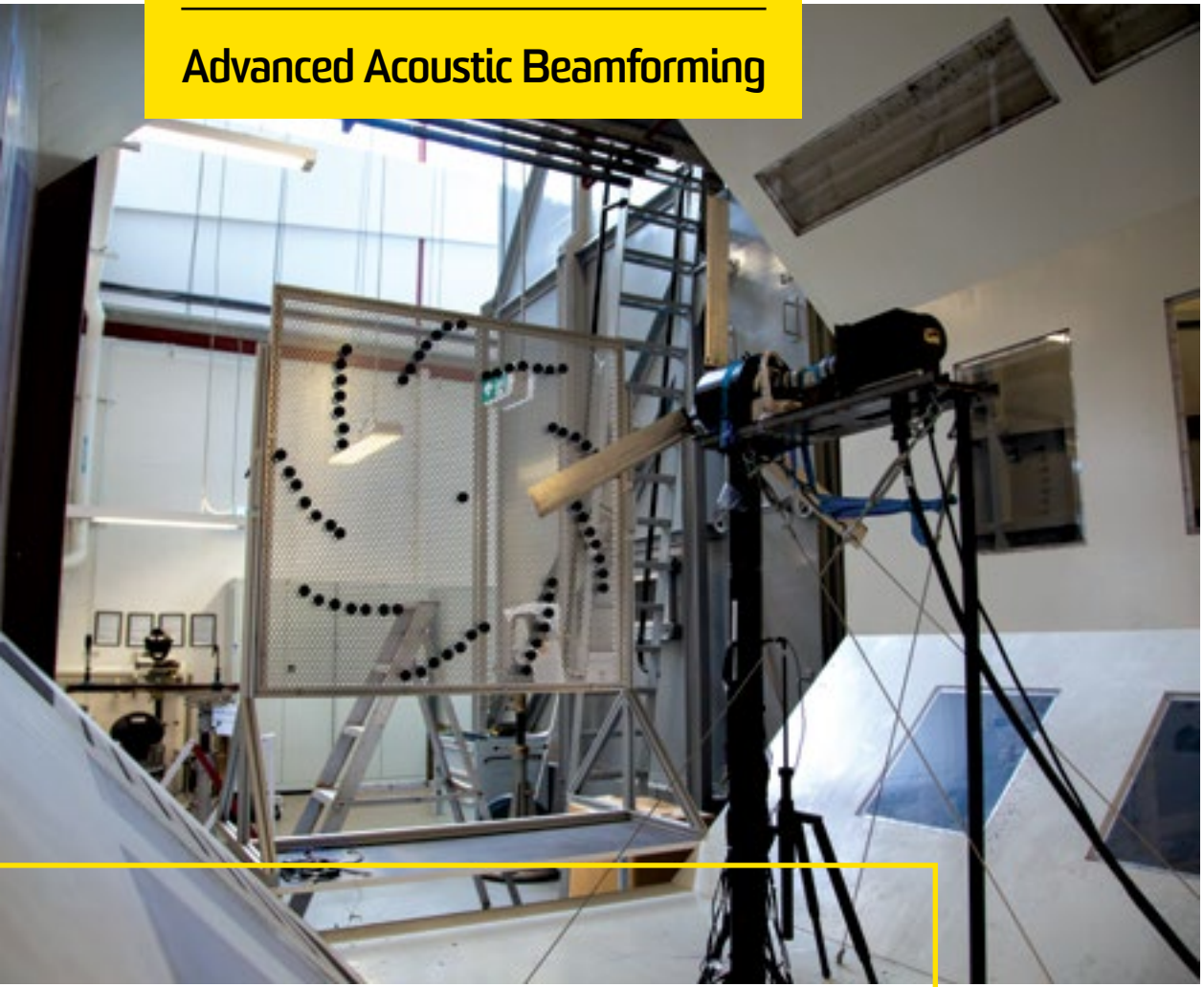
Advanced Acoustic Beamforming



Advanced methodologies for the localisation and characterisation of sound that can be used in challenging environments, such as wind tunnels, hydroacoustic testing tanks and factories, to improve the design of aircraft, submarines and wind turbines.

Competitive advantage

- Expertise in advanced acoustic source localisation and characterisation—leading performance in complex environments
- Ability to visualise noise sources—fast diagnosis of noise, allowing for rapid implementation of noise control solutions
- Unique signal processing for use in high-noise and reverberant environments, such as wind tunnels, wind turbines, fans, UAVs and industrial settings

Impact

- Quieter and more efficient aircraft, submarines and wind turbines

Successful applications

- Aero-acoustic beamforming array in wind tunnel for submarine noise evaluation, Defence Science and Technology (DST)
- Hydro-acoustic measurement capability in cavitation tunnel, Australian Maritime College
- Resolving the mechanics of wind turbine noise
- Physiological and sleep disruption characteristics of wind farm versus traffic noise disturbances in sleep
- Fine bubble characterisation facility using active acoustic monitoring
- Measurement and control of wind turbine noise

Capabilities and facilities

- Acoustic arrays, data acquisition and processing
- Advanced aero-acoustic laboratory
- Anechoic wind tunnels
- Wide variety of acoustic and fluid mechanics measurement equipment
- Acoustic array design and signal processing capability (air and water)

More information

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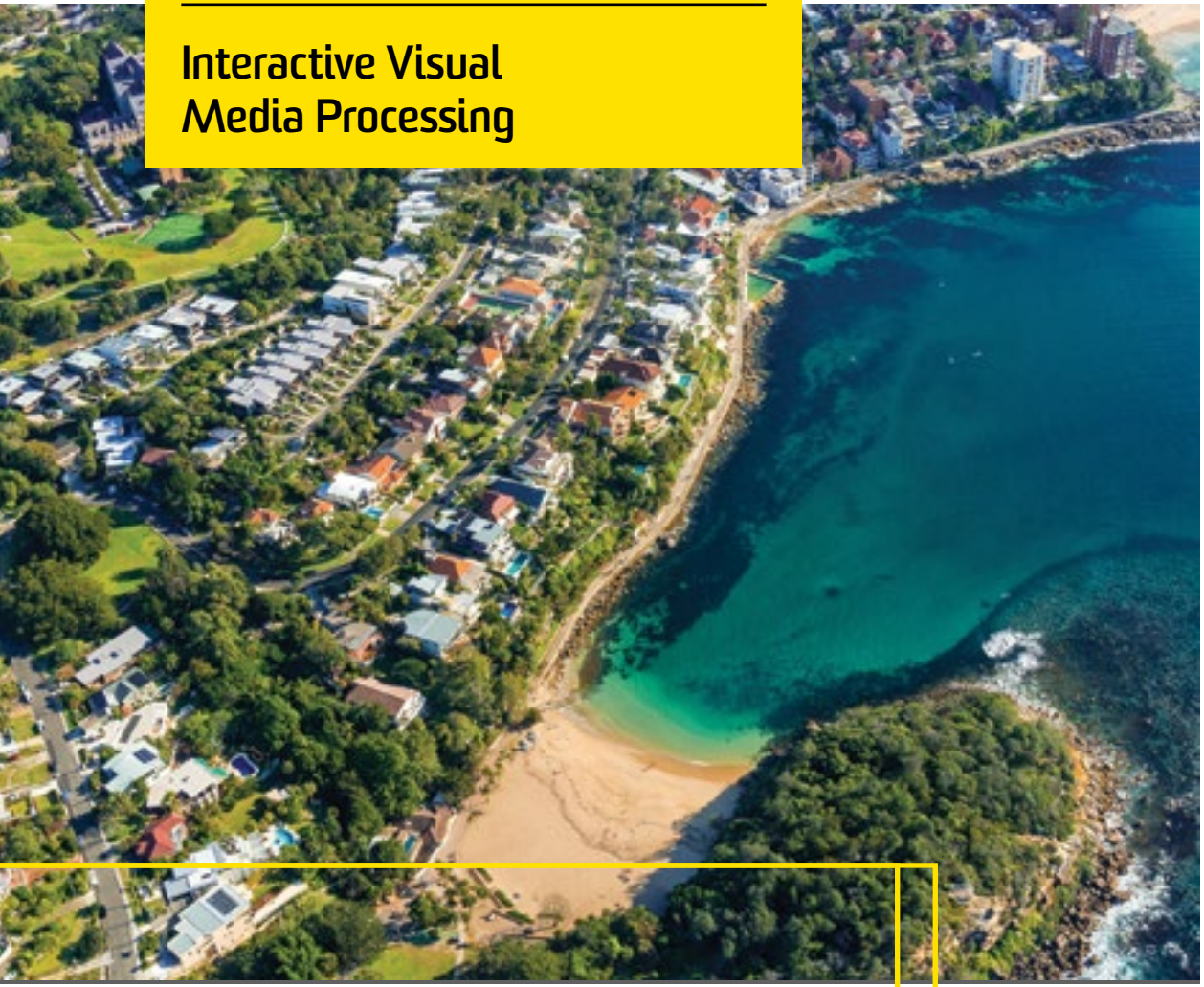
Interactive Visual Media Processing



The Interactive Visual Media Processing (IVMP) group is a world leader in developing coding, estimation and post-processing technologies for visual media, including images, video and higher dimensional media such as volumetric and plenoptic content.

Competitive advantage

Technology is widely deployed for both civilian and defence applications with multiple coding technologies that have been and are being standardised internationally, as well as a wide range of software systems for compression, estimation, interactive communication and post-processing of visual media, including the commercially successful Kakadu toolkit.

Technologies include:

- Scalable and accessible compression technologies
- Motion, depth and illuminant estimation for video and camera arrays
- Interactive visual communication for remote browsing of huge media, and
- Interpolation, denoising and analysis

Impact

- Faster image-based communication

Successful applications

- Kakadu Software toolkit for JPEG 2000, which is licensed to more than 400 commercial organisations and continues to gain traction
- JPIP technology for robust interactive image and video communication, which has been deployed on the battlefield by defence equipment manufacturers, as well as in many other sectors
- FBCOT algorithm, which has recently been adopted as the foundation of the new JPH image coding standard, which will become ISO/IEC CD 15444-15 (committee draft released July 2018)

Capabilities and facilities

The IVMP media processing laboratory is equipped with high resolution camera arrays, extensive fibre cabling, advanced Intel server platforms, controlled lighting and multi-projector visualisation equipment.

More information

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Visual Analytics

Learning object models, feature extraction and recognition from high resolution remotely sensed images, tracking and virtual reality, biomedical informatics, medical image analysis and robotic vision.

Competitive advantage

- Methods range from classical computer vision and machine learning to deep learning.
- Use-inspired research and development, resulting in strong industry partnerships

Impact

- Better analysis of images for a range of applications

Successful applications

- Framework for image analysis of ocular images, Brien Holden Vision Institute
- Diffuse lung disease feature recognition and quantification, i-Med Networks
- Automatic map updating module for ARC/INFO in Geographic Information Databases, Australian Surveying and Land Information Group
- Recognition of allergy dust mites in environment from visual images
- Data analytics for genocide forecasting
- Visual analytics for preserving privacy in a camera-rich world

Capabilities and facilities

- GPU servers for deep learning experiments

More information

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Underground Positioning Systems

A wide area geospatial positioning system for underground environments that features high accuracy, robust design, inertial measurement, geomagnetic sensing and low energy Bluetooth communications. Applicable in environments where GPS is unavailable.

Competitive advantage

- Low cost
- High accuracy, to 10 cm resolution
- Can be widely deployed quickly
- Suitable for all indoor and other environments where satellite navigation systems are unavailable
- Suitable for equipment tracking

Impact

- More efficient tracking and management of people and equipment in underground environments
- Geolocation in GPS-denied environments

More information

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SPACE

Australian Centre for Space Engineering Research (ACSER)

Launched in 2010, Australian Centre for Space Engineering Research (ACSER) develops space capabilities relevant to the nation's needs through research, innovation and education. ACSER builds and operates its own satellites and spins out technology to industry.

Competitive advantage

- Receiver design for global navigation satellite systems (GNSS)
- Earth observation satellite systems
- CubeSat development
- GNSS remote observation research and space resource utilisation
- Extensive stratospheric balloon experience
- Four experiments on the UNSW-EC0 CubeSat
- Internationally recognised research in off-earth mining

Impact

- Better satellite communication and navigation
- Technology commercialisation opportunities for industry

Successful applications

- Phase 0 of a synthetic aperture radar satellite system (Garada) that can map Australia for soil moisture every three days at 10 m resolution
- UAVs and their applications to develop Global Positioning System (GPS) reflectometry as a new method of remote sensing
- Built and successfully launched two Australian satellites in 2017
- Two models of Global Positioning System (GPS) receiver on-orbit
- Founded Delta V- space business accelerator
- New remote sensing technology: GNSS reflectometry, for Un-crewed Aerial Vehicles (UAV), High Altitude Platform Station (HAPS) and satellite platforms

Capabilities and facilities

- Laboratory facilities suitable for significant testing of CubeSats, including thermal vacuum chamber
- Satellite simulators for satellite navigation

Our partners

- Australian Space Research Program
- Seaskip
- Defence Materiel Technology Centre

More information

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Quantum Communications via Space

Quantum communication via low earth orbit (LEO) satellites offers a paradigm shift in telecommunications Development of new state-of-the art quantum communication protocols that optimise secure communication throughput over very large distances provide ultra-high information security in satellite communications This is major step forward in building a global quantum internet.

Competitive advantage

- Extensive experience in researching quantum communication for low-orbit satellites
- Expertise on quantum key distribution (QKD) protocols, and the resulting ultra-secret key rates that can be produced from the different variants of such protocols
- Expertise across quantum information systems, including those involving discrete variables coded into single photons, and continuous variables coded into weak laser pulses
- Patented technology in location verification in quantum communications

Impact

- Ultra-high security satellite communications

Successful applications

- Quantum Sensing and Processing, Quantum Key Distribution

More information

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Space Situational Awareness

Novel solutions to Space Situational Awareness (SSA) problems by combining cutting-edge approaches to machine learning within a multidisciplinary space physics, surveillance, astrodynamics and engineering team.

Competitive advantage

- Research strength in the field of ionospheric aerodynamic modelling
- Ability to combine high-fidelity numerical simulations with real-world data and machine learning approaches
- On-orbit small satellite capability and unique ground-based space environment simulation facilities to support benchmark quality SSA experiments

Impact

- Space mission experience that quantifies the impact of astrodynamics on spacecraft in Low Earth Orbits (LEO)
- Contributing to increased knowledge and preparedness within Defence regarding critical challenges relating to SSA

Successful applications

- Optical and numerical SSA techniques to the Buccaneer Risk Mitigation Mission spacecraft
- Aero-assisted formation control strategies for the Royal Australian Air Force (RAAF) M2 dual satellite program
- Multiple US Air Force Office of Scientific Research (AFOSR) grants for ionospheric aerodynamic research to enable improved orbital control of LEO spacecraft
- Imaging the deployment of the Planet Flock 3p (the largest number of satellites launched on a single rocket in history) two hours after launch

Capabilities and facilities

- Falcon Telescope Network node
- 0.3m Meade telescope
- Comprehensive space environment simulation laboratory
- Research lab with satellite wind tunnel and small thermal vacuum facility
- Dedicated flight assembly areas, plus assembly, integration and testing (AIT) expertise
- Australian National Concurrent Design Facility which is a national asset for developing space missions

Our partners

- Royal Australia Air Force
- Department of Defence Science and Technology (DST)
- The Air Force Office of Scientific Research

More information

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Satellite Navigation and Positioning (SNAP) Laboratory

The SNAP Laboratory has led Australian research in satellite navigation for more than 20 years.

Competitive advantage

Global Navigation Satellite System (GNSS) receiver design and signal processing capabilities, including:

- Multi-GNSS receivers
- Interference and spoofing
- GNSS remote sensing (reflectometry and radio occultation)
- Precise positioning algorithms
- Multi-sensor navigation, and the application of navigation technologies for transport
- Machine automation and unmanned aerial vehicles (UAVs)
- Satellite missions

Impact

- Improved precision and robustness of satellite and UAV navigation

Successful applications

- Synthetic aperture radar formation flying, Australian Space Research Program
- Unmanned aerial vehicles and their applications
- Improved detection of interference sources affecting Global Positioning Systems GPS and capability and technology demonstrator (CTD)
- Mapping radar for CubeSats
- Successfully commercialised product for geolocating GNSS jammers
- Company spun off to use reflectometry for sea state, target detection

Capabilities and facilities

- Hardware and software test facilities, including GNSS simulators and field-programmable gate array (FPGA) development tools
- GNSS receivers and other navigation sensor technologies
- Access to a wide variety of UAVs

Our partners

- Defence Science and Technology (DST)
- Australian Research Council Training Centre for CubeSats
- Defence Materials and Technology Centre (DMTC)

More information

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OUR CENTRES AND FACILITIES

Our partners can access a range of UNSW facilities by contacting the Defence Research Institute or Knowledge Exchange.

UNSW Sydney

Mark Wainwright Analytical Centre (MWAC)

The Mark Wainwright Analytical Centre (MWAC) houses contemporary instruments for materials characterisation. MWAC manages major instrumentation for the study of the structure and composition of biological, chemical and physical materials. Specific facilities include Electron Microscope Unit, Nuclear Magnetic Resonance Facility and Spectroscopy Laboratory. Facilities are accessible to external researchers, government and industry users.

Cyber Range

The Cyber Range is a C7000 blade enclosure connecting SAN storage over fibre channel plus other supporting infrastructure including networking devices. It provides war gaming, training and exercising - with state-of-the-art equipment unique in the Australian university system. The cyber range was co-designed with CSIRO for teaching, training and research.

Trusted Autonomy Laboratory (TAL)

TAL is a facility to enable R&D in Trusted Autonomous Systems. The facility contains a number of robots and allows the conduct of human-machine teaming research and experiments. It is equipped with a continuous audio-video capture system through four cameras and four microphones, two fixed eye trackers, one head-mounted eye tracker, two ECG, three EEG, two 2kx2k displays, two smart boards, and different type of sensors and human-machine interaction devices. The facility is surrounded by touch screens including two large plasma touch screens and a number of computer workstations with different network configurations. The laboratory has licenses for a range of cognitive and data analysis software.

Creative Robotics Lab

The Creative Robotics Lab is a cross-disciplinary research environment dedicated to understanding how humans can interact with three-dimensional robotic agents and responsive structures within the context of experimental arts and social robotics. The inhomogeneous nature of cross-disciplinary research demands dedicated spaces that provide appropriate technological infrastructure and a nurturing intellectual environment that encourages experimentation and appreciates the value of unpredictable outcomes. The lab has diverse expertise in sensing, perception, artificial intelligence and real-time systems, together with a long track record of fully engaged collaboration between media, arts and robotics.

EPIcentre

EPICentre (Expanded Perception & Interaction Centre) is a shared UNSW research centre undertaking visualisation research in the fields of art, design, science, medicine and engineering. The most advanced facility of its kind, EPIcentre represents the next generation in medical imaging technologies, engineering, high-performance visualisation, simulations and applied artificial intelligence. Incorporating an array interactive 3D environments, it enables researchers to simulate experiences such as dementia, psychosis, memory loss and other neurological conditions, providing a powerful way of understanding the experience of sufferers, through immersion in the condition. EPICentre allows, cross-connecting visualisation with applied computational simulation science, artificial intelligence, and creativity in arts and science. It also hosts modern Mixed Reality lab (XR-LAB), where visualisations are being deployed across VR, AR, hemispherical projections and upcoming multi-touch walls.

UNSW Canberra

Falcon Telescope Network

UNSW Canberra is the first place in Australia, and the second in the Southern Hemisphere, to host one of 12 telescopes as part of the Falcon Telescope Network (FTN) for monitoring fast moving space debris and satellites for space situational awareness. The 0.5m f8.1 semi-autonomous optical telescope observes spaceborne objects, such as debris and the growing Cubesat population, to evaluate the object interaction with the atmosphere.

Two-Stage Gas Gun

This facility contains 20 kN JJ Lyod and 5 kN MTS mechanical test machines for static testing, 100 kN and 250 kN dynamic test machines for fatigue testing, vertical low velocity gas gun and horizontal medium velocity gas gun, instrumented impact test machines, strain gauges and extensometers.

Hypersonics Laboratory

This laboratory contains the T-ADFA high-enthalpy free piston shock tunnel, capable of simulating flight at up to Mach 10 at 13 MJ/kg total enthalpy for external aero-thermodynamics, shock wave/boundary layer interaction and supersonic combustion (scramjet) research. The shock tunnel is combined with advanced laser-based diagnostic techniques for flow characterisation.

UNSW Canberra *cont.*

Mossbauer Spectroscopy Laboratory
Home to the most developed Mossbauer Spectroscopy Lab in Australia, UNSW Canberra has a suite of Mossbauer spectrometers (three cryostats 2-300 K; furnaces 300-720 K, Doppler speeds up to 800 mm/s).

Model Aviation Laboratory
This facility comprises a workshop, office and storage space for the design and construction of fixed and rotary wing UAV platforms. The laboratory includes hand tools and a 3D printing facility for production of parts and assembly.

Model Aircraft Laboratory
This lab consists of radio-controlled aircraft manufacture and maintenance facilities for the study of aircraft guidance, stability and control, particularly in relation to uninhabited aerial vehicle research. Radio controlled RMax helicopter platform and support equipment for field trials of autonomous UAV experiments.

Autonomous Vehicles Laboratory
This laboratory contains a range of unmanned aerial vehicles and wheeled platforms for the development and testing of autonomous robotic systems.

Aviation Safety Studio
The studio is equipped with two aircraft flight simulators and a large projection screen with 3 projectors which can be used to show a panoramic view from the cockpit of either flight simulator. Software that is run on the simulator includes the X-plane flight simulator which is interfaced with MATLAB/Simulink to allow the study of aircraft in Flight Dynamics and Aircraft Control (ZEIT3505). The facility can be used for recreating aircraft accidents in case studies. Most airports/regions, aircraft types, seasons, times of day and weather patterns are simulated.

Indoor Robotics Test Facility
A large netted area fitted with a VICON motion capture system (MCS) allows indoor testing of drones and other robots, as well as human motion studies, sensor calibrations etc. The facility is mainly used for closed loop testing of guidance algorithms for small unmanned aerial vehicles. The MCS provides full 6DOF motion monitoring with sub-millimetre accuracy at up to 200Hz update rates.

Laser Laboratories
UNSW Canberra has five Laser laboratories. Facilities include: dedicated laser laboratories sharing an acoustically isolated foundation; pneumatically isolated optical tables; two Argon-Ion lasers; one frequency-doubled Nd:YAG laser (1W CW@532nm); an infra-red Nd:YAG laser with feedback control of intensity noise (500mW CW@1064nm); an infra-red fibre laser with feedback control of intensity noise (1W CW@1550nm); several infra-red semiconductor lasers (10mW CW@1550nm); free-space and telecommunications optoelectronics; fast, quantum noise limited, linear photodetectors with associated electronics; an infra-red single-photon detector and radio-frequency and microwave test and measurement equipment. Work in adaptive optics and display surrounds two OKO deformable mirrors and various custom built Spatial Light Modulators. Materials work is conducted in a Class 100 clean room with sputtering facilities.

Rotary Wing Simulator Laboratory
This newly acquired laboratory consists of a dual and a single control cockpit. Each can be configured to replicate either rotary or fixed-wing aircraft and feature a 120° dome visual system. The new simulators provide a testbed for research activities for both rotorcraft and fixed-wing aviation classes.

Aerodynamics Laboratory
The Aerodynamics Laboratory is a teaching and research laboratory in the aerodynamics of subsonic and supersonic flows. Work includes aerodynamic testing of aeroplane, ship, train, car and truck models, roof ventilators and wind turbines. Calibration of instrumentation such as anemometers and pressure measuring devices is also conducted. The laboratory facilities include five subsonic wind tunnels (one with moving ground facility), one Mach 2 to 3 blowdown supersonic wind tunnel and a shock tube rig. It also has a wide range of equipment to measure air velocity, pressure, force and flow visualisation. Equipment for various schlieren and interferometric flow visualisation methods. High-speed video cameras with recording speed ranges from several thousand to ten million frames per second plus a SLR camera for single images. Surface pressure measurements – point and pressure sensitive paint surface-wide techniques.

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UNSW Defence Research Institute
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DEGREES AND PROFESSIONAL EDUCATION

Undergraduate and Postgraduate Degrees

UNSW offers undergraduate degrees and postgraduate degrees by research or coursework across the full spectrum of arts, built environment, business, design, law, social sciences, engineering, medicine and science. Since its inception in 1949, UNSW has maintained a strong scientific, technological and professional focus, and take pride in the broad range and high quality of educators and teaching programs. The career-focused educational programs gain strength and currency from research activities, strong industry links and strong regional and global engagement. Visit futurestudents.unsw.edu.au to search UNSW degrees.

Short Courses

UNSW offers a variety of professional education, non-award and Massive Open Online Courses (MOOCs) that cater for a wide range of needs for Defence, related industries and the general public in business, IT, languages, data science, law, architecture and planning, defence, visualisation and simulation, medicine and health, design, education and safety.

Courses are available online, on campus or in-house at an organisation's premises and can be developed to suit the specific staff development and training needs of your organisation.

Students who have successfully completed approved professional education courses may be able to use those courses as credit in eligible postgraduate programs.

Read more at shortcourses.unsw.edu.au and unsw.adfa.edu.au/study/professional-education-courses or contact the Professional Education Courses Unit on (02) 6268 8040 or ProfEdCourses@adfa.edu.au.

Professional Education Courses for Defence and Related Industries

Explosives and Explosive Ordnance

- Ammunition and Effects - Overview
- Ammunition and IED Effects
- Introduction to Explosive Ordnance

Lethality and Survivability

- Armour: Materials, Theory, and Design | Introduction
- Armour: Materials, Theory, and Design | Intermediate
- Armour: Materials, Theory, and Design | Advanced
- Gun Systems | Overview
- Gun Systems | Introduction
- Gun Systems | Advanced
- Impact Dynamics
- Introduction to Forensic Ballistics
- Survivability of Military Platforms

Communications and Information Systems

- Basic Communications Principles
- Satellite Communications | Overview
- Satellite Communications | Intermediate
- Satellite Communications | Advanced
- Target Detection with Advanced Optical Sensing
- Machine Learning and Data Mining

Cyber Security

- Advanced Exploit Development
- CISSP Training
- Code Review
- Critical Infrastructure Cyber Security (SCADA)
- Cyber Deception
- Cyber Defence
- Cyber Offence
- Cyber Security Boot Camp
- Digital Forensics
- Introduction to Exploit Development
- Introduction to Pen Testing
- Introduction to Python Scripting
- Intrusion Analysis and Response
- Reverse Engineering
- Wireless, Mobile and Internet of Things Security

Military Systems

- GPS and its Military Application
- Introduction to Electronic Warfare
- Introduction to Guided Weapons
- Modern Military Navigation Systems
- Optical Surveillance Systems
- Radar Fundamentals

Occupational Health & Safety/Laser Safety

- 5 Day Laser Safety | Level 1
- 1 Day Laser Safety | Level 2
- Ionising Radiation Protection
- Radio Frequency Radiation Safety
- ½ Day Operator Laser Safety | Level 3

Reliability, Availability and Maintainability

- Reliability, Availability and Maintainability (RAM) | Introduction
- Reliability, Availability and Maintainability (RAM) | Management
- Reliability, Availability and Maintainability (RAM) | Practitioners

Modelling and Simulation

- Designing a Simulation-Based Training Environment
- Building a Case for Immersive Training Technology
- Simulation Practices for Immersive Environments
- Modelling and Analysis of Non-Kinetic Effects in Live, Virtual and Constructive (LVC) Exercises
- Data Engineering and Architecture in LVC Environments
- Open Architectures and LVC Integration

Systems Engineering

- Introduction to Systems Engineering
- Requirements Practice
- Requirements Writing
- Systems Engineering Practice
- Systems Modelling Language

Capability Development

- Breakthrough Performance in Design for Successful Systems
- Capability Life Cycle (CLC) Management
- Function and Performance Specification Development Workshop
- JCNS and OCD Development Course
- Need Statement Development Workshop
- Operational Concept Document Development Workshop
- Scope Development Workshop

Project Management

- Introduction to Microsoft Project
- Introduction to Project Management
- Modelling Project Risks
- Project Schedule and Budget Control

Organisational and Contract Management

- Effective Writing for Defence
- Risk and Contract Management
- Understanding Contract Law

Operations and Decision Analysis

- Introduction to Decision Analytics
- Introduction to Evidence-Based Decision Making
- Introduction to Spreadsheet Based Data Analytics
- Introduction to Spreadsheet Based Decision Analytics
- Spreadsheet Based Decision Analytics

Addressing Complex Problems

- Addressing Complex Problems
- Ethical Decision Making for Professionals
- Systems Thinking and Modelling Practice

Leadership and Management

- Leading for High Performance
- Strategic and Adaptive Leadership
- Shaping Strategy to Create Value
- The Authentic Communicator: Activating Presence
- Developing Effective Negotiation and Influencing Skills
- Developing the Strategic Manager
- Leading Change with Impact
- Leading through Influence
- Leading from Within
- Adopting complex ways of working: tools for using systems thinking in practice
- Be an Effective Communicator using Data
- Commissioning bootcamp: How to operate effectively in a commissioning environment
- Crafting conversation to create high performance: A Masterclass
- Effective Writing in Organisations
- Making cost-benefit analysis work for you
- Principles of Financial Valuation for Projects
- Measuring and reporting WHS performance
- WHS Governance for Executives
- Workforce Planning

WORKING WITH UNSW

UNSW works with a variety of partners in the defence sector, including the Australian Department of Defence, armed forces, small-medium enterprises and prime contractors in Australia and overseas.

UNSW operates at the forefront of global science and technology to help deliver transformational innovations that advance Australia's defence capabilities and redefine the modern defence landscape.

By partnering with UNSW, your organisation will gain opportunities to access innovative research, ground-breaking discoveries and the very best students – the next generation of leaders in the defence sector.

We offer a broad range of engagement models and have decades of experience partnering with small and large organisations to deliver:

- Multidisciplinary expertise at the centre of leading and emerging research
- Access to world class technologies and infrastructure
- Dedicated organisational units – the UNSW Defence Research Institute and UNSW Knowledge Exchange
- Highly effective partnership models including research strategy advice and support
- Collaborative research leveraging third party and government funding
- Access to our national and global research partners including Group of 8, DST Group and the PLuS Alliance
- Access to students through professional development programs, projects and our industry placement program
- Customised and bespoke initiatives

We look forward to working with you to develop real world applications in defence.


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