



Deakin Security and Defence Futures

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► Introduction

Deakin University values and continues to build its contribution to supporting Australia's national interests, through our partnerships with the Australian Defence Force, national security agencies, and private defence industry companies. This research and innovation collaboration is a university-wide endeavour.

Deakin's leading researchers from science, information technology, social sciences, engineering and health work in close partnership with defence and national security colleagues, to find solutions to technical and social issues important to Australia's strategic interests.

Deakin seeks to make major positive impact for the better for our communities through Impact Themes based on our world leading capabilities that address global and national challenges. The two Impact Themes that encapsulate our defence and national security research and

innovation are *Building Safe and Secure Communities and Creating Smarter Technologies*. As an Australian university with global impact, research at Deakin creates value through the generation of ideas and their translation into innovations for impact, transforming knowledge and thinking into economic and social benefits in Australia's national interests.

Alfred Deakin Professor Julie Owens
Deputy Vice-Chancellor Research



► At the forefront of emerging technologies

The safety of personnel and the broadening of Australia's defence force capabilities, in an increasingly dynamic global defence ecosystem, demands the research and development of cutting-edge emerging technologies.



Deakin University's world-class researchers are working with industry partners on future-focused solutions to enable our defence industry to remain in the vanguard of technological innovation.

We focus on the development of AI and RAS, enhanced battlespace awareness, active real-time monitoring, modelling and decision support, embedded systems engineering for unmanned vehicles, and enhanced detection and protection against malicious cyber-attacks.

From reducing potential harm to personnel to enhancing our ability to protect assets, our innovative work in emerging technologies is improving defence readiness for safeguarding Australia.

This research and development is undertaken at our Applied Artificial Intelligence Institute; Faculty of Science, Engineering and Built Environment; Centre for Cyber Security Research and Innovation; Institute for Frontier Materials; and Institute for Intelligent Systems Research and Innovation.

The Geelong Future Economy Precinct at our Waurin Ponds Campus extends the capacity of the Institute for Intelligent Systems Research and Innovation to build on its industry-leading research and development in the fields of motion simulation, robotics and haptics, defence systems, modelling and simulation.

► Our capabilities and technologies

- Tailored machine learning algorithms
- Facial recognition systems
- AI analysis of video/social media monitoring
- Advanced AI algorithm for heart rate identification through video streams
- AI in medical research, surveillance, and anomaly detection
- Evaluation of vulnerability to cyber-attack
- Next-gen biomechanical modelling and sensor-making technologies
- Computational intelligence
- Intelligent Analyst Assistant
- Algorithmic assurance - ensuring that the decisions made by algorithms are in congruence with human users
- Large-scale data analytics
- Integration of machine learning and data analytics in AR/VR
- Large-scale software development
- Complex system modelling through systems modelling, AI, machine learning and fuzzy systems



► Our facilities

- Haptics Lab
- Robotics and Internet of Things Lab
- Defence Applied AI Experiential Co-Lab
- Centre for Cyber Security Research and Innovation
- Centre for Advanced Design in Engineering Training

► Improving defence AI readiness

The rapidly evolving AI landscape has the potential to significantly transform and disrupt all aspects of the defence operating environment. Incorporating AI into the design of new and existing technologies is vital to increasing the capabilities of Australia's defence forces. Second order impacts from AI innovation will improve cyber defence, decision-support systems, risk management, pattern recognition, cyber situation awareness and malware detection.

The Defence Applied AI Experiential CoLab is a new partnership between Deakin's Applied Artificial Intelligence Institute (A2I2) and the Defence Artificial Intelligence Centre. The partnership aims to solve complex and challenging problems and grow advanced AI skills and experience across defence to support national security, ethical application of AI, defence healthcare and human resource management.

In addition to identifying and accelerating the application of AI solutions, the CoLab delivers educational seminars on fundamental AI technologies for defence and runs hands-on coding workshops to improve AI literacy.

► Zero trust architectures

The information warfare space has seen a significant increase in sophisticated threats against critical infrastructures. The need to increase the level of protection and resilience of these infrastructures and its associated significance to national security cannot be overstated.

Zero Trust Architectures is emerging as a new paradigm for securing network infrastructures and is seen as the defensive approach of choice as we move into an increasingly interconnected world.

Deakin's Centre for Cyber Security Research and Innovation (CSRI) researchers were awarded an Australian Government Department of Defence grant to work with the Australian Department of Defence's Information Warfare Division on the development of Zero Trust Architectures for Australia's Critical Infrastructure Security.

In this project, a Zero Trust scheme was proposed to enhance the security posture of critical infrastructures that are increasingly less air-gapped, rapidly IoT-enabled and therefore susceptible to a wider attack surface than ever before. The outcomes included a continuous authentication solution that was reliant upon physical layer IoT token generation, continuous two-way handshaking and light-weighted security credential exchanges for IoT-enabled military systems.

► Together we can be ready for tomorrow

If you would like to join Deakin and our partners at the forefront of emerging technologies contact:

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► Cultivating intelligence to keep communities safe

Understanding local contexts and laws surrounding armed conflict is essential to peacekeeping, the prevention of human rights abuses and countering violent extremism during conflict or war.



Deakin University's research is helping to ensure communities remain safe during conflict. We're using our expert knowledge in international relations, civil wars, social movements, local civil society and violent religious extremism to establish regional security, enhance peacekeeping efforts and prevent further conflict in regions such as South East Asia and the Middle East.

From developing counterterrorism and violent extremism measures to research into humanitarian leadership and development in post-conflict situations, our expertise is improving Australia's ability to safeguard communities.

This research is undertaken through our Alfred Deakin Institute; Faculty of Arts and Education; Centre for Cyber Security Research and Innovation; Institute for Intelligent Systems Research and Innovation; Faculty of Science, Engineering and Built Environment; and Applied Artificial Intelligence Institute.

► Our capabilities and technologies

Counter terrorism and cybersecurity:

- Terrorism, cultural terrorism and Middle Eastern studies expertise
- Evaluation of vulnerability to cyber-attack
- Datasets for defence operations in Syria and Iraq
- OzTouch product (on OzBot platform) uses multi-point haptic technology to allow operation on hazardous materials, C-IED and EOD from 0.5km away
- Algorithmic assurance - ensuring that the decisions made by algorithms are in congruence with human users



Training:

- Large-scale capacity building on Middle East politics
- Training on cultural property protection during international operations
- Workshops and briefings on peace, security and development in South and Central Asia
- Training programs on peacekeeping, peacebuilding, prevention of violent extremism through education and conflict sensitive project planning
- High-G Human Centrifuge System (CYCLONE) sovereign pilot training capability

► Our facilities

- [Centre for Cyber Security Research and Innovation](#)
- [High-G Human Centrifuge System \(CYCLONE\)](#)

► Improving defence AI readiness

Deakin has been awarded a significant Australian War College contract to provide academic and support services to the Australian Defence Force, public servants and international military students.

From January 2023, Deakin will commence two flagship courses: the Australian Command and Staff Course and the Defence and Strategic Studies Course.

Selected senior Defence leaders also have the opportunity to make a significant contribution to new knowledge on defence and national security issues through our PhD by Folio program. This deeper level of study is important in developing the ability of strategic leaders to engage intellectually in debates about the present and future of their profession and nation.

Strengthening a partnership that first began in 2006, Deakin will maintain a dedicated academic and professional support team at the Australian War College, leveraging Deakin's expertise in professional military education, learning design and research skills.

The Australian War College and Australian Defence College have identified the importance of reaching a broad and geographically dispersed workforce. Deakin is recognised as an industry leader in online learning and will continue to support the Australian War College in the development of new approaches to education for senior defence practitioners.

► Together we can be ready for tomorrow

If you would like to join Deakin and our partners in safeguarding communities, contact:

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► Leading the way in health, wellbeing and performance

The physical and mental health of all personnel must be a top priority to ensure the success of Australia's defence force. Our research and development is focused on in-field and laboratory measures for physiological and psychological responses in different defence and security scenarios. These include the design and delivery of task and operations simulations, the capacity to enhance human performance and personnel resilience, cognitive assessment, job task analyses, and long-term health management for veterans.

Deakin University researchers use a deep understanding of clinical practice and a human-centred approach to develop innovative, ethical and practical technologies for health and medicine.

From medical and pharmaceutical technologies, psychological support to training, our work is improving the wellbeing of defence personnel. Our successful outcomes include a world-first trauma management system, Trauma R&R. Developed in collaboration with Alfred Hospital Trauma Centre for medic responders in conflict, Trauma R&R has reduced errors of omission by nearly one-quarter.

Health and medicine research and development is undertaken through Deakin's Faculty of Health; Institute for Physical Activity and Nutrition; Institute for Mental and Physical Health and Clinical Translation; Applied Artificial Intelligence Institute; Institute for Intelligent Systems Research and Innovation; and Faculty of Science, Engineering and Built Environment.

► Our capabilities and technologies

Artificial intelligence, robotics, haptics and decision-support:

- Hospital decision-support systems
- Smartphone applications to promote quality care
- Advanced AI algorithms (e.g. ward monitoring)
- Delivery of remote health services for rehabilitation and training
- HeroSurg provides robotic-assisted, haptic, minimally-invasive surgery, enhancing precision, with real-time visualisation of surgery scene. (Developed with Harvard School of Medicine, Royal Adelaide Hospital, Barwon Heath and Epworth Health Care)
- HaptiScan provides haptic, remote operation of ultrasound machines

Advanced psychological and psychiatric research:

- Trauma R&R
- Psychology - behavioural and dementia medicine
- Psychiatric - bipolar/other conditions
- Health systems - prevention, treatment, haptics, wearable sensors
- Addressing patient experience, safety and workforce development

- Long-term health management for veterans, including healthy ageing
- Capabilities in rehabilitation, disability support, digital health technologies (e.g. passive sensor technology to assist those with acquired brain injury)
- Community health, chronic health, humanitarian care of communities, advanced patient assessment, triage, critical illness, intensive care, emergency nursing
- Preventive health and secondary prevention

Post-traumatic stress disorder:

- AI methods for early detection of PTSD
- Early detection of suicide risk
- Unique identification and treatment for a range of mental health conditions, including PTSD (The Institute for Mental and Physical Health and Clinical Translation)

Simulator technology applications in medical training:

- Advanced haptic research lab
- VR-based PCNL training simulator
- Haptically-enabled simulator technologies, supporting optometry, needle thoracostomy and nurse training

Cognitive and physical ability assessment and training:

- Tools to measure job-specific fitness, psychological/physiological load and stress management
- Physical response assessment for new loads and simulations
- Physical training and diet during sleep deprivation
- Applied human research for actionable insights by combining in-field and lab-based assessments
- Expertise in training female defence force members (muscle mass and load carriage) and injury prevention/management
- Cognitive assessment, optimising physical performance in different scenarios
- In-field measures for physical activity, load, stress, sleep, mood and vigour
- Expertise in muscle, stress, cardiovascular, bone and neural physiology



► Our facilities

- Specialist technology facilities, including dual energy x-ray absorptiometry, electron microscopy, quantitative computed tomography, and magnetic resonance imaging.
- Biomechanics laboratory and climate chamber.

► A world-leading human performance monitoring platform

Analysing human performance often involves observing a multitude of human physiological indicators, such as eye tracking, blood oxygenation levels, pulse rates, motion data, body temperature and metabolic expenditure.

Most high-quality human performance sensors require distinct, proprietary platforms to operate and collect physiological data. Operating the devices simultaneously and synchronising the acquired data can be cumbersome, complex and restrictive.

Deakin's Human Monitoring System (HUMS) is the world's first all-in-one platform for human performance monitoring. It integrates a range of state-of-the-art sensing systems in a single, easy-to-use platform.

The real time data capture and visualisation featured in HUMS lets users dynamically assess a subject in the desired setting. Customisation is straight forward with a lightweight, reconfigurable system. Thanks to advanced signal processing equipped with the latest artificial intelligence techniques, it can also apply complex sense-making functions to data sets with ease in the field.

► Soldier performance management

Monitoring soldier status can facilitate optimised performance outcomes through improved personnel management and modified training practices.

Deakin's researchers have been funded by Defence's Human Performance Research Network to assess and describe the physical demands, as well as the physiological and psychophysiological responses, of Australian Army recruits to their training environments. Identifying the early warning signs of excessive stress exposure can mitigate the risk of negative outcomes including training attrition and musculoskeletal injury.

By adopting a multidisciplinary approach to this research, Deakin has identified a suite of measures that may provide early warning signs for the likely onset of maladaptive responses in the training force. Researchers are also investigating the role wearable devices could play in capturing the required data and how this may operate at scale.

Deakin is well positioned to understand psychophysiological responses to the training and work environments of Defence personnel and to help maximise their performance and resilience. Our School of Exercise and Nutrition Sciences is the leading sport science school in Australia. It is home to state-of-the-art facilities including a climate chamber with room for up to 12 people, a world-class biomechanics laboratory and facilities for the analysis of a suite of biomarkers in the School's PC2/PC3 laboratories.

► Together we can be ready for tomorrow

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► Next-generation materials, manufacturing and energy

Innovative materials, cutting-edge manufacturing processes and world-leading energy solutions are not merely the domain of the civil sector but have profound implications for the future of the Australian defence force.

Deakin University's work in materials, advanced manufacturing and energy is focused on lightweight, tough and high wear-resistant materials; the latest flexible and adaptive manufacturing processes for prototyping and production; machine learning algorithms to profile battery usage; and the enhancement of manufacturing and global supply chain processes.

From the customisation of carbon fibre properties to the development of advanced battery technologies, our cutting-edge work in materials, manufacturing and energy is improving defence readiness for safeguarding Australia.

We have a unique partnership with Australia's only producer of commercial 18650 Li-ion cells and are one of only a few institutions around the world that can hot form titanium. We're also the only place in the world to offer the combination of a high-end dilatometer, hot forming limit tooling and metallurgy to create new alloys for performance and modelling capability.

Deakin is the first university in Australia to provide a highly secure research environment suitable for the Department of Defence and the defence industry with a Zone 4-capable classified secret-rated space.

This research and development is undertaken at our Institute for Frontier Materials; Institute for Intelligent Systems Research and Innovation; Faculty of Science, Engineering and Built Environment; and Applied Artificial Intelligence Institute.

Our capabilities and technologies

Composite materials:

- Technological development and fundamental research across the entire carbon fibre value chain, from molecules to manufacturing to smart materials
- Versatile tailoring of fibre-to-matrix interfaces carbon fibre-reinforced polymer composites with controllable characteristics (e.g. toughness, impact strength, thermal qualities, durability, fire resistance, self-healing)
- Low cost, rapid manufacture of composite components carbon fibre characterisation SAXS/WAXS/synchrotron production and testing of prototypes using in-house 3D printing

Smart materials:

- Molecular modelling/surface modification
- Organic and polymer chemistry
- Tailoring resin systems/structure property relationships.
- Additive manufacturing (upscaling of swarf)
- Inserting energy source within components (i.e. wing or UAV body)
- Self-sensing capacity for reinforced concrete
- Increased battery efficiency (up to x7), reducing weight for soldiers or small autonomous systems
- Bayesian Optimisation
- Unique capacity to create new high-performance alloys

Energy management:

- Energy generation - thermocells
- Energy storage - advanced metal batteries
- Membrane design and development
- Machine learning to profile battery usage and estimate state of change
- Cognitive assessment, optimising physical performance in different scenarios
- In-field measures for physical activity, load, stress, sleep, mood and vigour
- Expertise in muscle, stress, cardiovascular, bone and neural physiology



► Our facilities

- [Additive manufacturing labs](#)
- [Electron Microscope Facility](#)
- [BatTRI Hub and energy storage](#)
- [The Digital Manufacturing Lab](#)
- [Zone 4-capable classified secret rated space](#)

► BatTRI-Hub

Deakin's Battery Technology Research and Innovation Hub (BatTRI-Hub) is a unique, world-class research and innovation centre focused on advanced battery prototyping and the commercialisation of energy storage technologies.

With the expertise to design, build and test customised batteries with better performance, BatTRI-Hub's lighter-weight, higher-capacity batteries using safer chemistries will be ideal for soldier use in extreme environments.

BatTRI-Hub's researchers are also investigating how waste heat produced through both natural and industrial processes can be harvested and converted into electricity. In the future, this technology could be applied to wearable technologies, where body heat could be exploited to run smart devices for field operations or implantable medical devices. Another key focus of the facility is the recycling, refurbishing and repurposing of batteries.

BatTRI-Hub is chemistry agnostic, meaning it can produce different battery chemistries not just Lithium-ion batteries. This, as well as its other cutting-edge capabilities, enables the tailoring of research programs to meet specific defence needs as battery technology and requirements continue to evolve.

► Building an additive manufacturing blueprint

A team from the Deakin Digital Design and Engineering Centre in the School of Engineering worked with the Logistics Branch of the Royal Australian Air Force (RAAF), to explore the provision of novel Air Force use cases for 3D printing and additive manufacturing technology (AM) and introduction into the workforce of the RAAF.

In the pilot phase of the project, three progressive workshops were conducted to explore the potential AM applications within the Air Force operating context and identify the pathway for the progressive adoption of this technology within the RAAF.

The workshops mapped out the cultural changes required for the uptake of AM and provided initial assessments for the development of disruptive and design thinking training. This initial success has provided the impetus for further collaboration to develop a Virtual Trade Project for the Air Force and new methodologies to encourage innovation across all levels of RAAF personnel, where the advantages can be capitalised upon well into the future.

► Together we can be ready for tomorrow

If you would like to join Deakin and our partners in creating the materials, manufacturing and energy solutions of the future, contact:

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► The future of defence logistics

A shifting defence landscape highlights the imperative for resilient and adaptive logistics. The capacity to analyse the threats and opportunities present in future defence operating environments is essential to enhancing Australia's capabilities and safeguarding the country.

Deakin University is a leading innovator in logistics, developing future-focused solutions that ensure effective support for our defence force.



Our research and development focuses on scenario planning, defence force supply chain reengineering, situation awareness technology, workforce and cultural change, and world-leading human performance monitoring. We use industrial engineering, operations research, logistics, data science, decision science and fuzzy systems to complement custom-optimised solutions to logistics problems.

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► Our capabilities and technologies

- Identification of defence vehicles requiring preventive maintenance
- VR/AR based engine diagnosis and maintenance training
- Systems modelling, AI, machine learning and fuzzy systems to model complex systems
- Simulation of large-scale disparate systems
- Facial recognition systems
- Complex systems modelling, including systems/scenario mapping, temporal event analytics, discrete and cyber event simulation, knowledge/business rule encoding, visualisation and storytelling
- Drone threat mapping
- Resource planning and risk quantification
- Tender evaluation
- Systems design and evaluation
- Realtime and look ahead simulation, scheduling and optimisation
- Workforce planning
- Field Trial Support



► Our facilities

- [Deakin's DISCOVERY Lab \(DISC\)](#)
- [Virtual Reality Lab](#)

► Secure autonomous vehicles

Deakin researchers are developing new platforms and software to support self-driving technologies and build greater resilience in vehicles of the future. Ensuring the secure exchange of information between vehicles is key to the success of this technology.

Connected automotive systems benefit substantially from connectivity to internet services and other vehicles. However, network connectivity also exposes them to cyber threats that, although common in computer systems, are relatively new in automotive systems.

World-leading cyber security researchers from our Centre for Cyber Security Research and Innovation (CSRI) are working with Bosch Australia to help ensure next-generation vehicles are cyber-safe and can engage in secure and trusted cooperation. By enabling early detection of intrusion and preventing unauthorised access, the researchers are seeking to mitigate the impact of cyber security attacks.

This research encompasses a range of topics, from secure firmware and software updates through to secure connectivity and trusted cooperation. The training component of the project involves the development of PhD-trained cyber security specialists for the automotive sector, which is particularly affected by the global shortage of cyber security professionals.

Deakin's research and development in secure autonomous vehicles is essential to ensuring the efficiency of supply chains, which allow critical goods such as medical supplies and food to be distributed effectively.

► Bolt-on driverless vehicle technology

Deakin has developed technology that gives vehicles autonomous capability allowing a group of vehicles to easily move from A to B. This technology lets vehicles travel off-road on unstructured and rough terrain.

The project builds on our 30+ years of research into robotics and haptics to provide a vehicle agnostic solution that can be retroactively fitted to a range of vehicles, including tanks, transporters, trucks and bulldozers.

Aspects of the bolt-on pack will also have the capability to be used in air and sea domains and the technology can be easily adopted in non-defence sectors, such as transportation and logistics, mining and agriculture.

In 2020, The Australian Army partnered with Deakin's Institute for Intelligent Systems Research and Innovation (IISRI) to boost this research. The partnership supports the second phase of IISRI's leader-follower driverless vehicle program, which is primarily for large vehicle convoys.

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► Innovation in robotics and autonomous systems

With the adoption of emerging and disruptive technologies, the character of defence is changing. While it remains human-focused, a technological advantage in robotics and autonomous systems is essential to ensure the safety of personnel and strengthen Australia's defence force capabilities.

Deakin University is working with industry partners to develop and deliver innovative remote controlled and fully autonomous technologies that will enhance our defence capabilities. Robotic and autonomous systems are crucial to meeting Australia's future operational requirements, including for humanitarian assistance and disaster relief, and in combat operations.

Deakin's Institute for Intelligent Systems Research and Innovation (IISRI) has in-depth expertise in robotics and autonomous systems. With years of partnership with Australian Defence Force as well as defence industry, IISRI's translational research and technology innovation focuses on intelligent automation via fusion of sensors; machine learning and robotics that enable research for land and aerial vehicles; diverse robotics solutions, including the OzBot platform, Universal Motion Simulator, HeroSurg and Haptiscan; autonomous navigation; obstacle avoidance technologies; and energy dense, lightweight batteries for autonomous systems.

We have a proven track record of success, with the ability to deliver commercial robotics systems, develop high quality robotic vehicles, robotic hands and haptics products, and collaborate with Defence Science and Technology Group on synthetic scene creation.

Robotics and autonomous systems research and development is undertaken at our Institute for Intelligent Systems Research and Innovation; Faculty of Science, Engineering and Built Environment; Applied Artificial Intelligence Institute; and Institute for Frontier Materials.

► Our capabilities and technologies

Robotics:

- Open-source architecture for robotics
- Integration of high-precision sensors in robotics platform
- Robotic vehicle development for use in security and defence scenarios
- Deep learning in robotic hands for production and assembly chains
- Intelligent automation via fusion of sensors, machine learning and robotics
- Drone development
- Universal Motion Simulator
- HeroSurg provides robotic-assisted, haptic, minimally-invasive surgery
- Additive manufacturing
- 3D printing

Autonomous systems:

- Simulation of autonomous platforms
- Autonomous navigation
- Obstacle avoidance
- High-energy density, lightweight battery for autonomous systems

Haptics:

- Firearms training through VR, haptics and motion capture
- Haptically-enabled VR/AR firefighting training simulator
- Gesture-based tank marshalling training
- VR based haptic PCNL training simulator
- Haptically-enabled optometry training simulator
- Development of synthetic scenes to demonstrate the effects of different marine platforms, platform configurations and environmental conditions on visible signatures
- Haptically-enabled remote diagnostic system

► Our facilities

- [Haptics Lab](#)
- [Robotics and Internet of Things Lab](#)
- [Motion Simulation Lab](#)





► Exoskeleton technologies

Deakin researchers are leading the way in innovative exoskeleton technologies.

Originally developed to assist soldiers to carry heavy equipment over long distances, FORTIS is a passive exoskeleton that can make tools weighing up to 16 kilograms feel weightless. It reduces fatigue and improves user safety, making tasks between two and 17 times more efficient, depending on the tools and tasks required.

Our researchers used signal processing techniques and motion capture, obtained from sensors on the arms and shoulders of exoskeleton operators, to test the ergonomic effects of specific power tools on the human body. They then designed and 3D-printed new attachments to expand FORTIS' functionality, including a new housing that allows it to carry external loads, which would otherwise be mounted on an individual's back.

In Deakin's first project with Lockheed Martin the Institute for Intelligent Systems Research and Innovation (IISRI) will continue to improve FORTIS' capabilities.

► Autonomous system for pilot training

The world-leading researchers and facilities at IISRI have put Australia at the forefront of aviation and space training technologies with cutting-edge research in advanced motion training platforms.

Designed, built and tested at Deakin's Waurin Ponds campus, CYCLONE is Australia's first high-G centrifuge platform for safely training astronauts and Royal Australian Air Force pilots to cope with the high levels of acceleration associated with modern aircraft.

New generations of fighter aircraft are consistently increasing in performance, speed, power and manoeuvrability. CYCLONE can reduce the risk of G-induced loss of consciousness, protecting the life of the pilot and multi-million-dollar aircraft.

The system will increase Australia's defence capability in air combat training by providing a platform for simulation and training here in the country and removing the need for Australian trainee pilots to relocate overseas.



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