FACULTY OF SCIENCE
AND ENGINEERING

MACQUARIE
University
SYDNEY·AUSTRALIA

School of Engineering

RESEARCH EXPO

WEDNESDAY 8 NOVEMBER 2023

Welcome from the Dean of Engineering

Macquarie University plays a significant role in advancing research in engineering, technology and innovation. Our dedication to research excellence, sustainability, and inclusive and accessible education drives our commitment to making a positive impact. By bringing together academics and researchers from diverse backgrounds, we actively develop solutions that benefit our communities, environment and future.

We are delighted to share the School of Engineering's research strengths and capabilities with you. Recently, the school conducted a comprehensive review of its research framework, aiming to enhance collaboration, elevate research performance, improve quality, increase visibility and amplify our overall impact. Through a collaborative consultation process, we have restructured our research entities into seven core research themes: Energy and Decarbonisation, Advanced Materials and Manufacturing, Future Communications and IoT, Microelectronics and Optics, Health Technologies, Buildings and Infrastructure, Engineering Education.

By consolidating our research centres and laboratories around our core themes, we are capitalising on our existing strengths while focusing on the present and future needs of communities and industries. Our multidisciplinary research spanning fields such as artificial intelligence, health technologies and zero-carbon technology promises to shape our future profoundly. These innovations can be practically applied across various sectors, including education, healthcare, manufacturing, and transportation.

We are firmly committed to fostering collaborations with industry partners and delivering high-quality research that provides timely solutions. In addition, we are enhancing our performance and visibility through active external engagement, recognising its crucial role in bridging the gap between research and teaching. This enriches our students' education with up-to-date knowledge and real-world applications. The advancement of technological innovation, reliant on capability and investment, thrives through productive collaboration between academia and industry.

The dedicated academics and researchers at the School of Engineering have the passion and expertise needed to collaborate with organisations, government bodies and the broader research community in Australia and across the globe.

Professor Aman Oo
DEAN OF ENGINEERING
SCHOOL OF ENGINEERING
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Research Expo program 8 November 2023

3PM REGISTRATION

3.30PM WELCOME FROM THE MC
Professor Grant Hose, Faculty of Science and Engineering

3.35PM WELCOME ADDRESS
Professor S Bruce Dowton, Vice-Chancellor, Macquarie University

3.45PM OPENING ADDRESS
Professor Aman Oo, Dean of Engineering, Macquarie University

3.55PM PANEL DISCUSSION
Topic: Leveraging industry–academia collaboration for sustainable solutions

PANEL MEMBERS:
- Professor Lucy Marshall, Executive Dean, Faculty of Science and Engineering
- Ms Clare Tubolets, Chief Executive Officer, SmartCrete Cooperative Research Centre
- Dr Anumitra Mirti, Senior Associate – Sustainability, Beca Group
- Ms Alanna Leighton, Head of Design and Innovation, Multigate Medical Products
- Mr Wayne Rylands, Chief Executive Officer, City of Ryde

4.25PM RESEARCH SHOWCASE
Guests are invited to explore the groundbreaking research taking place at the Macquarie University's School of Engineering by visiting the showcase exhibition stations highlighting each core research theme:
1. Energy and Decarbonisation
2. Advanced Materials and Manufacturing
3. Future Communications and IoT
4. Microelectronics and Optics
5. Health Technologies
6. Buildings and Infrastructure

6PM PROGRAM CONCLUDES

Core research themes

Our research strengths and expertise provide an ideal opportunity to engage in collaborative projects with industry and, together, advance technological innovation in engineering.

To achieve our research vision, we have identified our core research themes and their associated pillars.

1 ENERGY AND DECARBONISATION

Renewable Energy and Power Systems
Photovoltaics
Life-Cycle Engineering
Hydrogen and Clean Fuels

2 ADVANCED MATERIALS AND MANUFACTURING

Nanomaterials and Nanotechnology
Composite and Manufacturing
Functional Coatings and Surface Engineering

3 FUTURE COMMUNICATIONS AND IOT

Mobile Communications
Satellite and UAV Systems
Machine Learning and IoT Systems

4 MICROELECTRONICS AND OPTICS

High Frequency and IC Design
Photonics and Lasers
Embedded Systems

5 HEALTH TECHNOLOGIES

Sensors and Imaging
Microfluidics
Biomechanics

6 BUILDINGS AND INFRASTRUCTURE

Construction Materials and Automation
Asset Integrity Management
Smart Infrastructure Systems

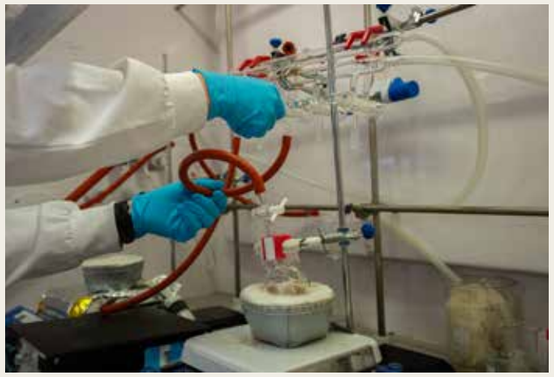
The School of Engineering is actively engaged in all research areas related to our core themes and receives an annual average of $5 million in external funding to deliver impactful outcomes. The following pages contain descriptions of our research themes, along with notable examples of our research projects.

THEME 1: ENERGY AND DECARBONISATION

Our research on energy and decarbonisation encompasses a dynamic approach to address the critical challenges of energy consumption and its environmental impact. This theme is built to pave the way towards a sustainable future. Our research in renewable energy and power systems focus on innovative methods to integrate renewable energy with the grid. Our researchers are at the forefront of advancing solar energy technologies, aiming to enhance the efficiency and affordability of photovoltaic systems for widespread adoption. We are undertaking the intricate analysis of energy systems to implement efficient energy management practices. Our recent focus on emergent clean fuels, such as hydrogen, centres around producing solutions to revolutionise carbon-free and carbon-neutral energy technologies. The Energy and Decarbonisation research theme strives to accelerate the global transition towards a more sustainable and greener energy landscape through these interconnected pillars.

DYNAMIC VIRTUAL POWER PLANTS (DVPP)

We develop smart charging with DVPP for electric vehicles (EVs). The technology optimises power usage and price signals based on consumer preferences to improve grid performance. Smart charging trial data assess EV behaviour, pricing, and V2G impact through DVPP integration. The project will accelerate EV adoption, enhance grid impact and consumer satisfaction.



HIGH-PERFORMING PHOTOVOLTAIC (PV) CELLS

To capture the large environmental and security benefits of developing smart networks, we build high-performing PV cells that can harvest indoor light to power IoT devices. We develop nanoscale materials integrated into devices that meet the operation requirements under the indoor spectrum. The devices are low cost and made using low-embodied energy processes, suitable for massive deployment of next generation IoT systems.

WASTE-TO-RESOURCES CONVERSION

We have developed two-stage sorption-enhanced thermochemical technology for converting large-scale municipal solid waste into high-yield hydrogen and valuable carbon-based products. By mitigating municipal solid waste from going to landfills, this technology will create new revenue streams for waste management and generate income from the sale of valuable products from the upcycling process, contributing to the growth of the circular economy.

ADVANCED MODELS FOR ENERGY APPLICATIONS

We integrate experimental measurements, advanced computational models and probabilistic risk assessment to evaluate the consequences of hydrogen-related incidents, from hydrogen production and storage to its transportation and utilisation. Our models enable decision-makers to make informed choices for reliable design and safe operation, accounting for a wide range of environmental and operational variables.

THEME 2: ADVANCED MATERIALS AND MANUFACTURING

Our research strength in this theme propels us to the forefront of innovation and cutting-edge technologies. Within the pillars of our research, we delve into the intricate domain of nanomaterials and nanotechnology, where novel materials are ingeniously engineered at the atomic scale, promising unique properties for unparalleled applications. Explore the domain of composite and manufacturing to witness the craftsmanship behind forging strength and adaptability, yielding materials customised for a wide range of sectors – from aerospace and automotive to health and medical applications. Elevate functionality through our specialisation in functional coatings and surface engineering, where surfaces transcend their inherent properties – embracing traits such as hydrophobicity, hydrophilicity, self-cleaning capabilities, and even self-healing attributes. Our focus on these advanced functionalities is to unleash innovative potential in industries by creating surfaces that interact intelligently with their environment.

CANCER DIAGNOSES DEVICES

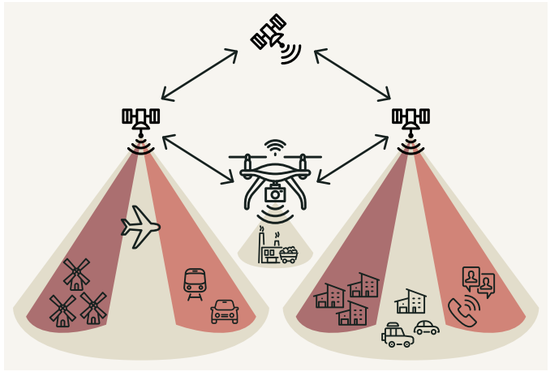
Skin cancer accounts for more diagnoses than all other cancers combined and costs more than $750 million annually to treat. This project will drive rapid and significant improvements in skin cancer prevention by designing, developing and implementing the Sunwatch, a personalised and wearable UV sensor to alert users of overexposure.

SENSING TECHNOLOGY

This project aims to develop cutting-edge, non-invasive sensing technology revolutionising cattle management in the meat, livestock and dairy industries to enable producers to conduct safe and accurate pregnancy testing when it suits, without relying on a veterinarian.

THEME 3: FUTURE COMMUNICATIONS AND IOT

Our research focuses on communication technologies and networks for applications, including 5G/6G mobile networks, satellite communications, IoT, and ad hoc and UAV networks. These communication technologies continue to underpin industry activities and operations across the broad spectrum of sectors and society more generally. Our research addresses connectivity and data speed for these future network technologies and cuts across traditional discipline boundaries. Our key strengths are in wireless network design and communication link optimisation. We have world-leading expertise in cellular network optimisation, resource allocation, mm-wave network deployment design, user terminal scheduling, multi-antenna MIMO systems, mm-wave communication link design, beamforming, low Earth orbit satellite communications, heterogeneous networks, and secure communications. Our applied research is underpinned by fundamental capabilities in information theory and communication theory.



TACTICAL COMMUNICATIONS

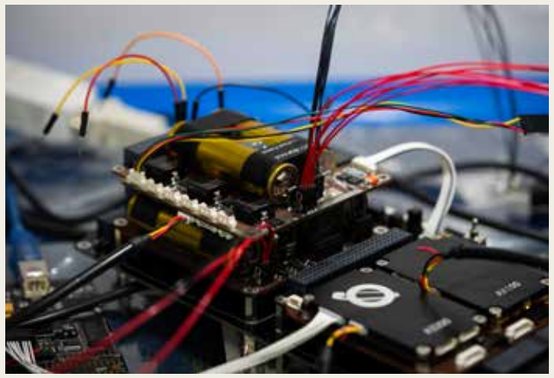
We are working closely with various industry partners in developing technology for tactical communications to mobile users on the ground using a constellation of low Earth orbit (LEO) satellites. Tactical includes soldiers with handsets, communications to vehicles, UAVs and aircraft.

DRONES AS FLYING IOTS

In our MQ Drones Lab, we are developing high-performance drones used as the brain for flying IoT devices. These drones are equipped with a fusion of sensors, computer vision and depth-sensing cameras to detect markers. They enable communication between the flight controller and Jetson, functioning as a master and slave, while incorporating a control system that excels in wind resistance and ensures good flight stability.

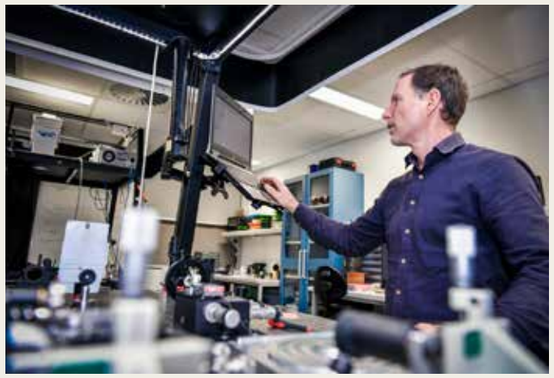
THEME 4: MICROELECTRONICS AND OPTICS

Microelectronics and optics are fundamental tools underpinning modern society's advancement, enabling a broad range of civil, industrial and defence applications. The School of Engineering leads research in these key areas, including high-frequency and IC design, photonics and lasers, and embedded systems. Highlights of successful outcomes and impact include demonstrating low-noise integrated circuits based on advanced semiconductors (GaN, GaAs and SiGe) operating at the limits of power and frequency, high-quality mid-infrared lasers at unconventional wavelengths for specialised medical and defence applications, ultra-sensitive photonic probes uncovering new biomarkers for clinic translation, and custom wireless devices powered by FPGAs for novel satellite systems and hearing aids. With increasing industrial engagement, these research pillars will form the foundation for critical developments in Industry 4.0, future communications beyond 5G, big data and AI, smart cities, space technologies, security and defence, biomedical engineering and more – benefiting Australia and humanity. Through our Macquarie Analog Devices Laboratory (MAD Lab), our team pushes the horizons of industry-driven wireless electronics for applications such as satellite systems, test instruments, phased array, high-capacity microwave radio applications, 5G/6G radio access and backhaul.



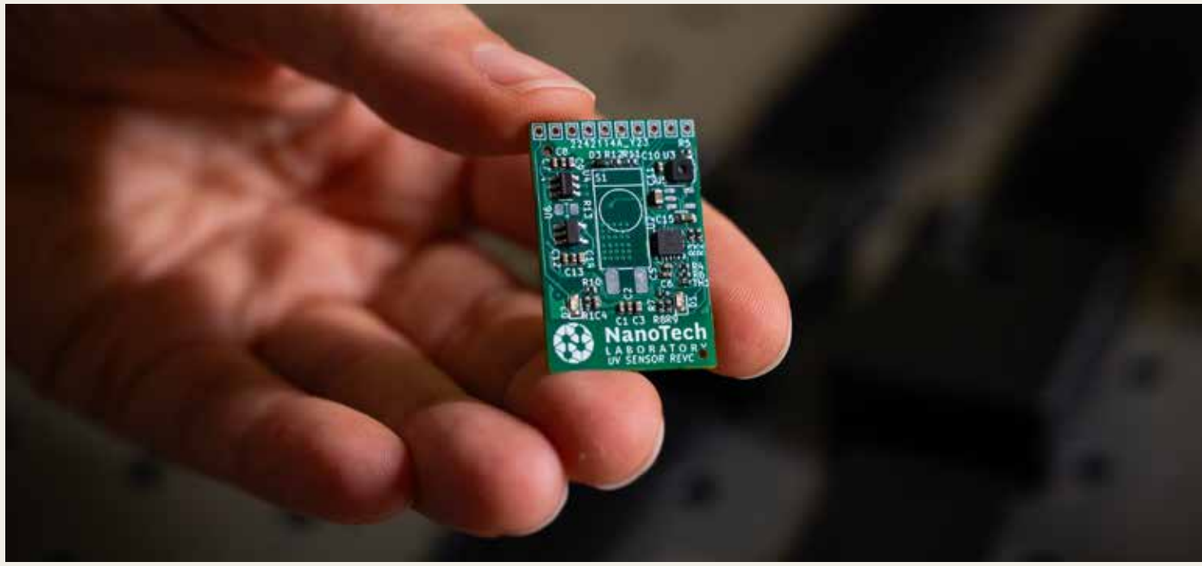
NEXT GENERATION OF SENSOR INSTRUMENT

Methane is a potent greenhouse gas under immense scrutiny. In collaboration with industry partners, we are developing the next generation of a sensor instrument, a laser heterodyne radiometer, to fingerprint and classify methane emission sources from space, thereby identifying their source type (eg natural gas or agriculture). The sensor's fingerprinting ability, when combined with a satellite's global coverage, provides a powerful platform to quantify, classify and subsequently address methane emissions.



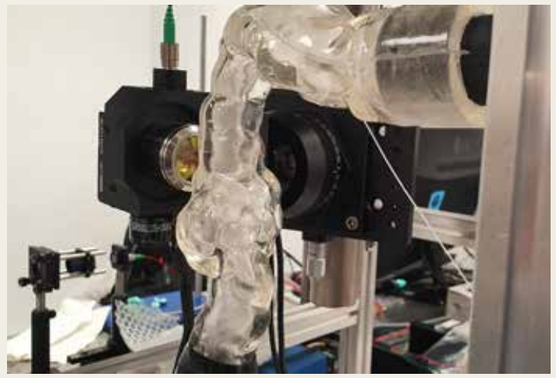
HIGH-POWER FIBRES

We lead a well-funded national research program focused on developing high-power fibres that emit wavelengths between 580 nm and 3500 nm. We are creating advanced optical systems for materials processing (inorganic and biological), directed energy applications in defence and broadband sensors for security applications.



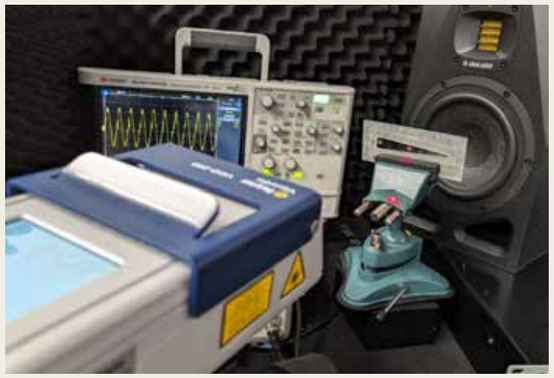
THEME 5: HEALTH TECHNOLOGIES

Our research in this theme aims to improve healthcare outcomes through innovative scientific exploration in sensors and imaging, microfluidics and biomechanics – all working together to transform medical care. Advanced tools in sensors and imaging allow for non-invasive visualisation within the body, aiding in diagnoses and treatment monitoring. Microfluidics deals with minute fluids, making medicines more precise and tests more effective. Biomechanics studies how living things move, providing valuable insights for advancing medical knowledge and improving sports performance. This collective effort is reshaping healthcare through smart technology and science, improving medical practices and people's health. At the School of Engineering, our specialised group focuses on biosensing, microfluidics, imaging and advanced drug delivery technologies. This expertise empowers healthcare professionals to use the latest technologies, paving the way for improved health strategies.



HUMAN RESPIRATORY DEVICES

Our multidisciplinary research creates physiologically accurate human airways to assess respiratory device efficacies, pollutant effects and drug delivery mechanisms. Harnessing advanced imaging, laser diagnostics, computational modelling and tissue engineering, our unique model aims to redefine depth and fidelity in the field.

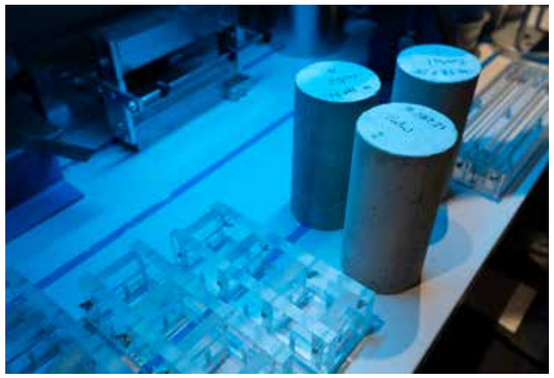


ARTIFICIAL INNER EAR HAIR CELL SENSORS

Developing artificial inner ear hair cell sensors is vital in medical technology and sensory restoration. By using nanotechnology and advanced manufacturing techniques, we have successfully created hair cell sensors closely resembling the complex structure of natural inner ear hair cells. These devices represent a significant advancement in addressing these widespread sensory challenges.

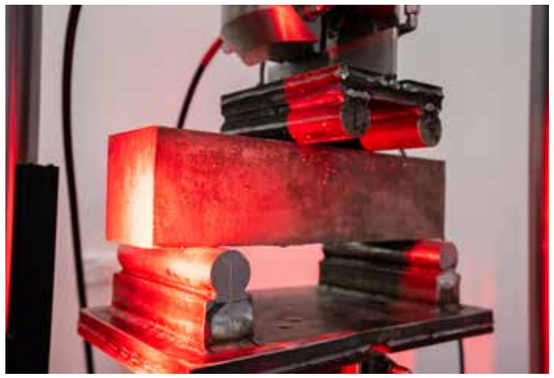
THEME 6: BUILDINGS AND INFRASTRUCTURE

Our research strength in this theme lies at the intersection of construction materials and automation, asset integrity management and intelligent systems. This strength is fortified by our expertise in these areas, collectively contributing to shaping the future of sustainable and resilient built environments. We closely collaborate with industry partners to innovate green construction materials that lower CO_2 emissions and enhance structural longevity. Additionally, our efforts encompass developing automated buildings and inspection equipment, infrastructure health monitoring and post-construction management algorithms, all contributing to improved safety and reliability of structures. As we forge ahead in this research field, we are committed to advancing these disciplines and addressing the pressing challenges of modern construction and development.



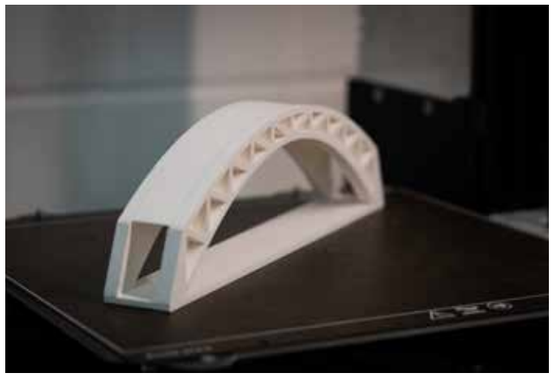
ADVANCED MATERIALS IN STRUCTURES

This project focuses on developing an upscaling process to correlate micro-nano properties of engineering materials with their comprehensive physico-chemical properties using systematic mechanical and statistical analysis approaches and nanoindentation technology. This process enables assessing material mechanical and viscoelastic properties at microscales, generating new knowledge to increase material efficiency, assess existing structures, and strengthen and repair materials within structures.



RISK AND SAFETY ENGINEERING

We specialise in risk analysis for various engineering operations, focusing on enhancing safety and reliability. Our developed innovative models enhance the integrity of assets in onshore and offshore infrastructures. These models bolster operational reliability and contribute to minimising environmental footprints and reducing costs, aligning engineering practices with sustainability and efficiency.



BIOCOMPOSITES MATERIALS

We use cutting-edge 3D-printing technology with biocomposites, using recycled bio-based materials widely available as residue in Australia. The project benefits from a product-driven approach, resulting in structurally tested and evaluated 3D-printed beams and columns, paving the way for future large-scale applications.

Panel members

CLARE TUBOLETS
CHIEF EXECUTIVE OFFICER
SMARTCRETE COOPERATIVE RESEARCH CENTRE (CRC)
The SmartCrete CRC has proudly partnered with Macquarie University to help transition Australia's concrete industry towards sustainability. Under Clare's leadership, SmartCrete invests in industry-driven, impact-enabled research and development projects to drive a shift towards net-zero emissions in Australia's concrete ecosystem. Clare is dedicated to unlocking collaborative potential by bringing together world-leading research and industry specialists to solve real-world problems.

LUCY MARSHALL
PROFESSOR OF ENGINEERING
EXECUTIVE DEAN, FACULTY OF SCIENCE AND ENGINEERING
Lucy is a water resources engineer with expertise in hydrologic modelling, optimising environmental models, and quantifying water resource analysis uncertainty. She is interested in understanding how environmental observations can be used to quantify uncertainty in systems undergoing change. Lucy is passionate about promoting inclusive education in STEMM and championing the next generation of STEMM leaders to become innovators and problem-solvers.

ANUMITRA MIRTI
SENIOR ASSOCIATE – SUSTAINABILITY
BECA GROUP
Anumitra is a sustainability and climate resilience expert with 23+ years of professional experience, having worked both internationally and nationally across NGO's, government, and academia. She currently serves as the Sustainability and Climate Resilience Lead for Beca in Australia, a professional advisory, design and engineering consultancy. Anumitra is a systems thinker and a strategist whose work focuses on driving sustainability in design, regenerative and circular design approach in infrastructure planning, design and delivery over the life of the asset and embedding holistic approach to plan for the changing climate.

ALANNA LEIGHTON
HEAD OF DESIGN AND INNOVATION
MULTIGATE MEDICAL PRODUCTS
Alanna is responsible for developing and managing all aspects of Multigate's design and creative output. She leads a team of industrial designers and external consultants, and is responsible for recruiting and managing multidisciplinary third-party suppliers, as well as internal design resources. In her role, she ensures that design and creative deliverables align with all stakeholder expectations and are executed within budget and timescales. This role also involves collaborating with internal and external clients to understand their needs.

WAYNE RYLANDS
CHIEF EXECUTIVE OFFICER
CITY OF RYDE
Wayne has more than 30 years' experience in local government. Prior to his appointment as Chief Executive Officer, he spent four years as City of Ryde's Director of City Works. Before commencing at the City of Ryde, he was also the Director of City Delivery at Campbelltown City Council where he oversaw the provision of infrastructure, asset management, open space, city safety and security, and operations functions. Prior to that, he was the Executive Manager (Director) Open Space and Urban Services at Lane Cove Council for 10 years. The extensive management experience Wayne brings to his role has enabled him to review the City of Ryde organisation structure to more closely align with the council's vision to develop a modern city that will provide the great places and spaces that our community desires and deserves.

Contacts for future research collaborations

At the School of Engineering, our passion lies in pushing the boundaries of innovation and technology. We believe that the most effective solutions emerge from collaboration. We eagerly seek opportunities to collaborate with industry leaders to tackle real-world challenges and co-create groundbreaking solutions. Your expertise, combined with our cutting-edge research and talent, can pave the way for transformative projects.

For enquiries on future collaborations, we invite you to contact our team dedicated to fostering meaningful industry partnerships across our core research themes.

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THEME LEADERS

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BUILDINGS AND INFRASTRUCTURE
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We look forward to exploring exciting possibilities and shaping the future of technology through collaborative projects. Join us in making a lasting impact on industries and communities alike.

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