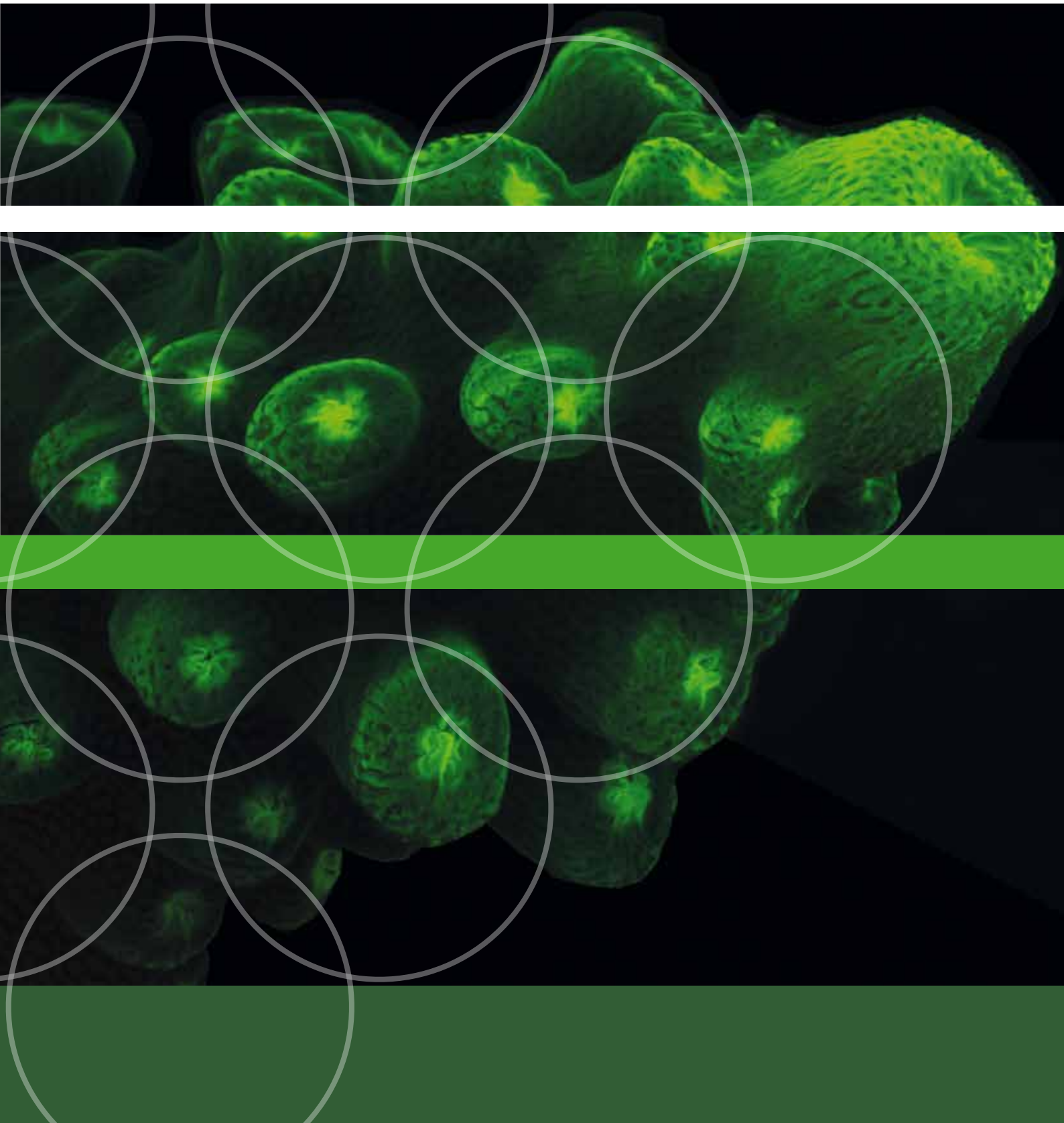
QUT ife
Institute for Future Environments

ANNUAL REPORT 2014



ABOUT US

The Institute for Future Environments (IFE) is a transdisciplinary research and innovation institute at Queensland University of Technology (QUT) in Brisbane, Australia. Hundreds of QUT researchers and students from across the fields of science, engineering, law, business, education and the creative industries collaborate at the IFE on large-scale research and development projects. Our mission is to generate knowledge, technology and practices that make our world more sustainable, secure and resilient.

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Cover image This image of a live coral branch immersed in seawater won first prize in the 2014 QUT Nikon Small World Competition (see page 49). The image was taken by Dr Luke Nothdurft, a Senior Lecturer in the QUT Science and Engineering Faculty, using a stereo microscope in the Central Analytical Research Facility (CARF). The coral was grown in the Marine Invertebrate Aquarium Facility at QUT. Dr Nothdurft is studying the geology and biology of coral reef systems.

2014 SNAPSHOT

Research and innovation

- Cube Globe released for the G20 Leaders Summit – p12
- Addressing the world food crisis – p14
- Australia-China Centre for Air Quality Science and Management launched – p16
- Protecting our infrastructure from cyber attacks – p18
- Powering the next generation of electric vehicles – p20
- Managing residential peak energy demand – p22
- Robotic boat to make our waters safer and healthier – p24
- Training farmers to reduce crop losses – p26

Facilities and infrastructure

- Science and Engineering Centre – p28:
  - Occupied by 221 QUT staff, 140 QUT research students, 15 visiting academics and 28 affiliates from partner organisations
  - Project rooms used for R&D in nanotechnology, high-performance materials, greenhouse gas monitoring, aquatic robots, cyber security, serious games and more
- Central Analytical Research Facility (CARF) – p30:
  - More users: 401 active users in 2014, up 23 per cent from 2013
  - Higher usage: 3350 instrument hours per month, up 95 per cent from 2013
  - Greater income: $698K in commercial partnerships and consultancies, up 35 per cent from 2013
- Skunkworks visualisation, simulation and interaction lab established – p33

Engagement and outreach

- 15+ public engagement events, including:
  - Renowned futurist Dr Michio Kaku's Brisbane show, attended by 1568 people – p48
  - 11 Grand Challenge Lectures, with an average audience of 120 in theatre, 35 via live stream and 220 on YouTube – p47
- 30+ academic, industry and government engagement events, including:
  - Big Biology and Bioinformatics (B^3) Symposium, attended by 180 people, up 56 per cent from 2013 – p44
  - Statistical Modelling and Analysis of Big Data Workshop, attended by 320 people – p44
  - Microbiology at QUT and Beyond Workshop for Researchers and Industry, attended by 80 people – p45
  - Mathematics in Industry Study Group (MISG), attended by more than 100 people – p46
- Expanded digital and social media presence:
  - Website visitors up 59 per cent from 2013 – p51
  - New Twitter feed, new Flickr photo albums and more lectures in YouTube – p51

Our people

- Senior appointments: Professors Bronwyn Harch and Stephen Blanksby – p6

MESSAGE FROM THE EXECUTIVE DIRECTOR

The Institute for Future Environments (IFE) was formally established in July 2011 after extensive consultation with the broader community, which recognised that transdisciplinary research and innovation at QUT in science, technology, engineering and mathematics (STEM) required dedicated resources to provide national and international leadership.

From mid-2011 to 2013, the IFE was essentially in a start-up phase. Staff from two predecessor institutes, the Institute for Sustainable Resources (ISR) and the Information Security Institute (ISI), formed the nucleus of our new Institute. In the process, IFE incorporated the research programs of the ISR and the ISI, and then broadened and deepened the mission and research agenda. Additional staff and researchers joined the IFE team over this period, steadily building up the research, technical and operational skills and capacity of the Institute.

In November 2012 we transferred the Directorate and some activities into the IFE's current home, the Science and Engineering Centre (SEC) at the Gardens Point Campus. Within the SEC and R Block at Gardens Point, we established the Central Analytical Research Facility (CARF), which now houses a world-class array of analytical instruments and, just as importantly, first-class academic and professional staff who know how to make the most of the technology. We also established the Visualisation and eResearch (ViseR) lab and several other multi-purpose project rooms in the SEC. During this early phase, key off-campus research facilities, such as the Samford Ecological Research Facility and the Banyo Pilot Plant Precinct, were further developed.

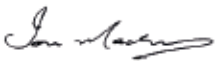
A wide-ranging engagement program has been implemented since mid-2011. Engagement activities include visitor/exchange programmes, e-newsletters, research conferences, sector briefings, industry workshops, professional and technical training, public lectures, infrastructure acquisition and installation, international missions and collaborative research projects – either as 'seed' projects or as larger-scale transdisciplinary programs. The basic IFE framework is well positioned and ready to fulfil the IFE's mission to generate knowledge, technology and practices that will make our world more sustainable, secure and resilient.

In 2014, we built upon and fine-tuned this framework in several ways. For example, we commenced a review of the Institute's research themes, added key senior staff and accepted overall reporting responsibility for major research centres within the STEM area, such as the Centre for Tropical Crops and Biocommodities (CTCB). Key appointments during 2014 included Professor Bronwyn Harch (Deputy Executive Director, Research) and Professor Stephen Blanksby (Director, Central Analytical Research Facility). Operational responsibility for the Mackay Renewable Biocommodities Pilot Plant (MRBPP) and the Da Vinci Precinct (the focus of the Australian Research Centre for Aerospace Automation's activities) was also taken up by the IFE in 2014.

Many research projects were commenced or continued in 2014 and just a few are profiled in the Research and Innovation section of this report. On the international front, the IFE is playing a key role in the establishment of the Australia-China Centre for Air Quality Science and Management (ACC-AQSM), a major collaboration between Australian and Chinese universities, government agencies and academies.

Developing an Institute and transforming research cultures to embrace a collaborative, transdisciplinary approach is not straightforward. The path to success depends on many factors, but the most important is the quality and passion of the people involved. The IFE's staff have stepped up to the mark at every opportunity, and our University is grateful to them all for their enthusiasm, professionalism and sheer hard work in these formative years.

I am particularly grateful to the QUT Chancellery and the University Council for the vision, guidance and support in establishing the IFE and to our faculties, divisions and our partner institute, the Institute for Health and Biomedical Innovation (IHBI), who have worked closely with us to ensure the success of the IFE – up to now and into the future.



Professor Ian Mackinnon
IFE Executive Director

OUR PEOPLE

The IFE team includes core academic and professional staff from many fields, collaborating researchers from QUT's faculties and higher degree research students.

The IFE team

The IFE catalyses, supports and conducts research and innovation projects aligned with its mission and research themes.

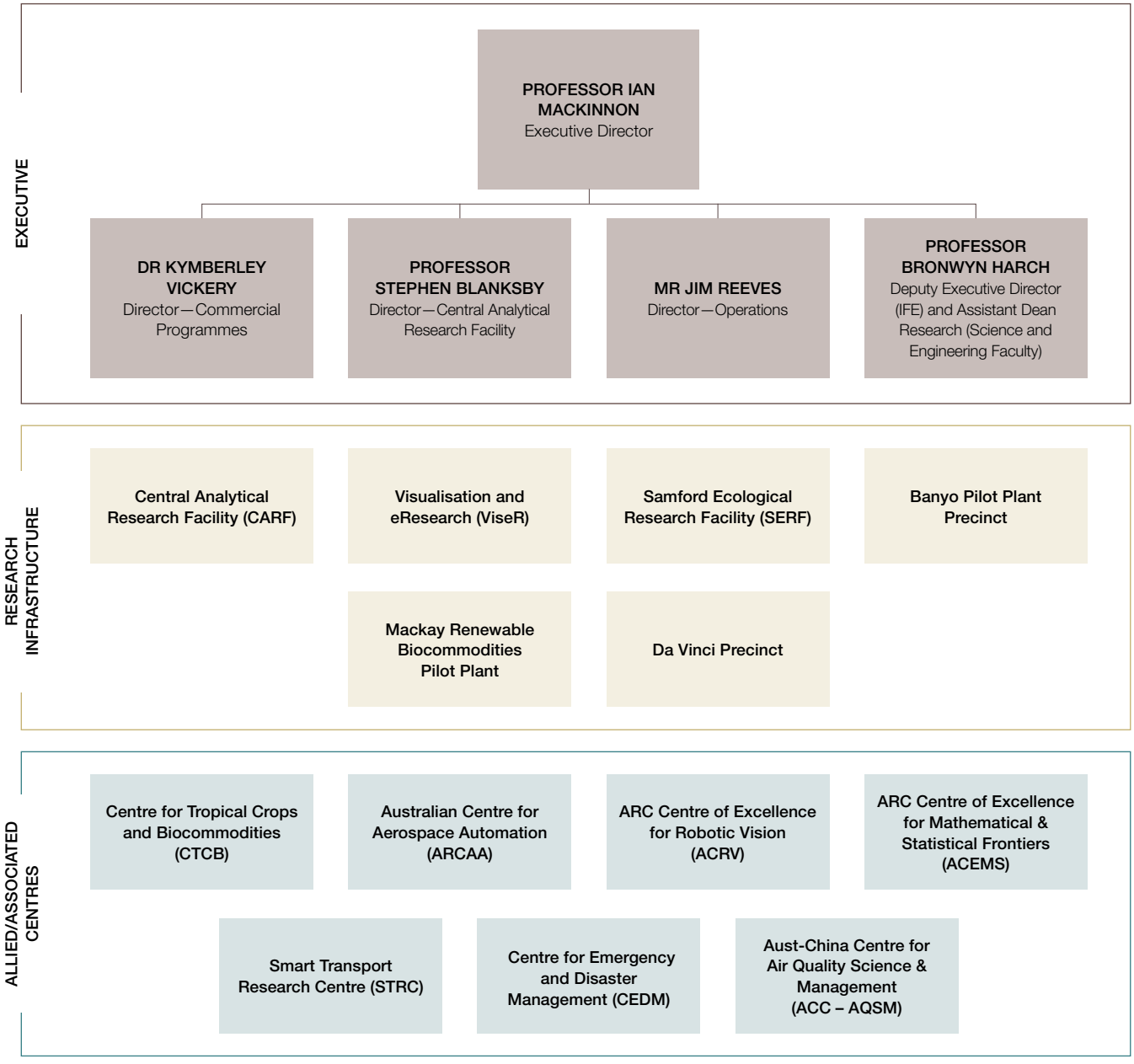
The IFE team is a mix of:

- core academic staff, including research theme leaders, industry chairs, research fellows and 'connector' researchers (who assist with connecting academics across QUT's faculties)
- collaborating academic staff from QUT's faculties (especially the Science and Engineering Faculty) who have deep expertise in specific disciplines
- Institute-funded professional staff across many areas, including commercial programmes, facility management, finance, HR, administration and communications
- higher degree research (HDR) students working on projects supervised by IFE academic staff
- researchers who are fully supported by external funds, such as Australian Research Council (ARC) Future Fellows.

The number of academic staff working with the IFE increased significantly in 2014. New academic staff included research fellows in several areas, externally funded researchers, and staff from the Centre for Tropical Crops and Biocommodities (CTCB), which was incorporated into the IFE in 2014. The number of professional staff also rose, as the IFE continued to build its capacity to provide research, technical and administrative support for large-scale, transdisciplinary projects.

While the IFE does not directly enrol students (students are enrolled through the faculties at QUT), we support higher degree research (HDR) students in various ways. This includes providing scholarships, working spaces and projects rooms, access to IFE laboratories and other facilities, and invitations to most IFE events.

Organisational structure



Appointments

In conjunction with the QUT Science and Engineering Faculty, the IFE appointed several key academic staff in 2014:

PROFESSOR BRONWYN HARCH

Deputy Executive Director (Research) for the IFE and Assistant Dean (Research) for the Science and Engineering Faculty

In her dual role at QUT, Professor Harch is developing the research and innovation strategy and priorities for both the IFE and QUT's largest faculty, the Science and Engineering Faculty. Before joining QUT in June 2014, Professor Harch was the Chief of CSIRO's Division of Computational Informatics and previously the Deputy Director of CSIRO's Sustainable Agriculture Flagship. She had worked at the CSIRO for twenty years as a researcher and research strategist. Her own research has focused on statistical design of landscape-scale sampling protocols and monitoring programs, as well as the statistical modelling of complex systems, particularly agri-environmental systems. She has developed transdisciplinary research, engagement and commercialisation strategies and partnerships with state and federal governments and their agencies, Australian and multinational companies, and other research organisations.

PROFESSOR STEPHEN BLANKSBY

Director, Central Analytical Research Facility (CARF)

Professor Blanksby manages the IFE's Central Analytical Research Facility, a group of laboratories, supported by expert scientific and technical staff, specialising in analytical chemistry, electron and light microscopy, physical and mechanical properties, X-ray diffraction, molecular genetics, proteomics and metabolomics. He also maintains a research program exploring the unique properties of gas phase radical ions and developing new mass spectrometric approaches to surface analysis. Stephen completed his PhD in the field of gas phase ion chemistry at the University of Adelaide in 1999, then undertook postdoctoral research at the Technical University of Berlin and the University of Colorado. In 2002 he joined the School of Chemistry at the University of Wollongong, where he built a research group whose discoveries have been successfully used to develop new analytical technologies for lipidomics and polymer coatings research.

PROFESSOR TIM FORESMAN

SIBA Chair in Spatial Information

World-renowned environmental scientist Professor Tim Foresman is the inaugural SIBA Chair in Spatial Information, a position created by the IFE, the QUT Science and Engineering Faculty and the Spatial Industries Business Association (SIBA). In this role, Professor Foresman is focused on driving the spatial information revolution in academia, industry and government, showing them how cutting-edge spatial information research and technology can be used to solve problems and make decisions for the benefit of whole countries and communities. Professor Foresman has three decades of experience as a senior researcher, advisor, executive and educator for a variety of organisations. He worked at NASA Headquarters in 1998–2000 as the national manager for the Digital Earth Initiative, which paved the way for many major developments, including Google Earth. In the early 2000s he served as the United Nations' Chief Environmental Scientist with the UN Environment Programme in Nairobi, Kenya. Since leaving the UN he has consulted, taught and conducted workshops worldwide on the challenges of creating a carbon-conscious world, the foundations for sustainability, and using community-based decision support to promote healthy and environmentally sound development.

ASSOCIATE PROFESSOR VALENTINO SETOA JUNIOR TE'O

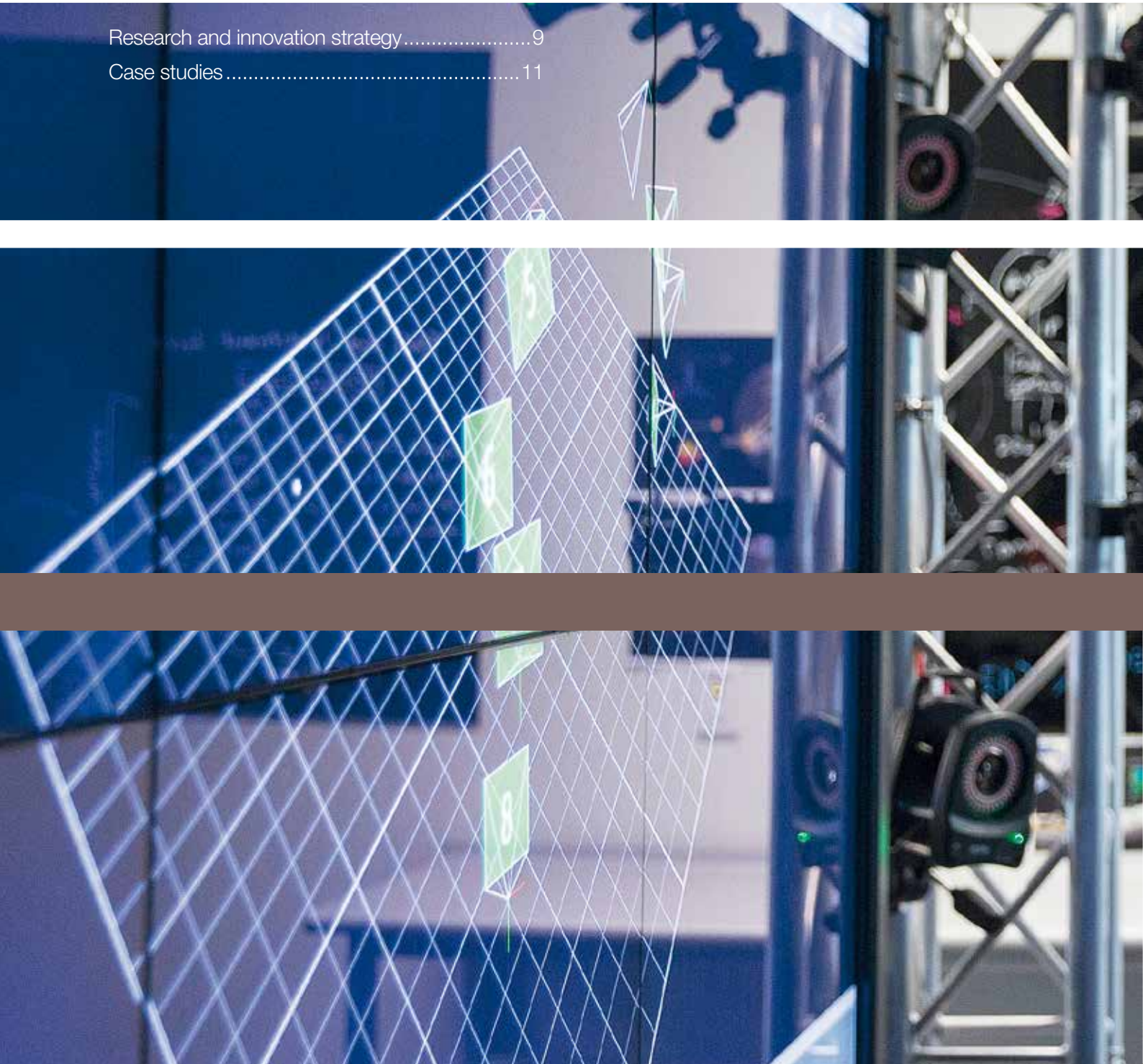
Associate Professor Valentino Setoa Junior Te'o is an expert in industrial and microbial biotechnology and his role at QUT involves both teaching and academic and commercial research. Prior to joining QUT, Associate Professor Junior Te'o was a Vice Chancellor Innovation Fellow at Macquarie University, Sydney, where he taught in the areas of molecular biology, microbiology and biotechnology and ran a research group focusing on the development of sustainable microorganisms for the production of industrial products with applications in wide-ranging areas, such as biofuels, nutraceuticals, bioremediation, and oil and gas. From 2005 to 2010 he was a co-founding scientist and production manager of a spin-off biotechnology company that built on his research at Macquarie University. During this time, he was responsible for research and product development encompassing recombinant gene expression, microbial strain improvement and laboratory-to-industry-scale fermentation, together with technology transfer.

ASSOCIATE PROFESSOR ROBERT SPEIGHT

Robert Speight is leading collaborative biotechnology research projects focused on enzyme development and protein production systems for industrial and agricultural applications. He is also engaged in demonstration work at QUT's Mackay Renewable Biocommodities Pilot Plant, supporting school engagement, and teaching in microbiology and process engineering. His research has an applied focus and he has spent most of his career in industry. He co-founded the UK industrial biosciences company Ingenza Ltd, leading the biotechnology research team that worked extensively on the directed evolution of enzymes for altered specificity and improved stability in industrial manufacturing processes. Prior to joining QUT he was at the Australian Institute for Bioengineering and Nanotechnology at The University of Queensland. At the AIBN he researched biofuel and protein technologies (focused on animal feed enzymes) in parallel with operational management of the Systems and Synthetic Biology Group. He was the project manager of the multi-partner Queensland Sustainable Aviation Fuel Initiative, working with companies such as Boeing, Virgin Australia and GE, and a start-up manager for the UQ Dow Centre for Sustainable Engineering Innovation. He has a degree in chemistry from Imperial College London and a PhD in biochemistry from the University of Cambridge.

RESEARCH AND INNOVATION

Our researchers study our natural, built and virtual environments and find ways to make them more sustainable, secure and resilient.

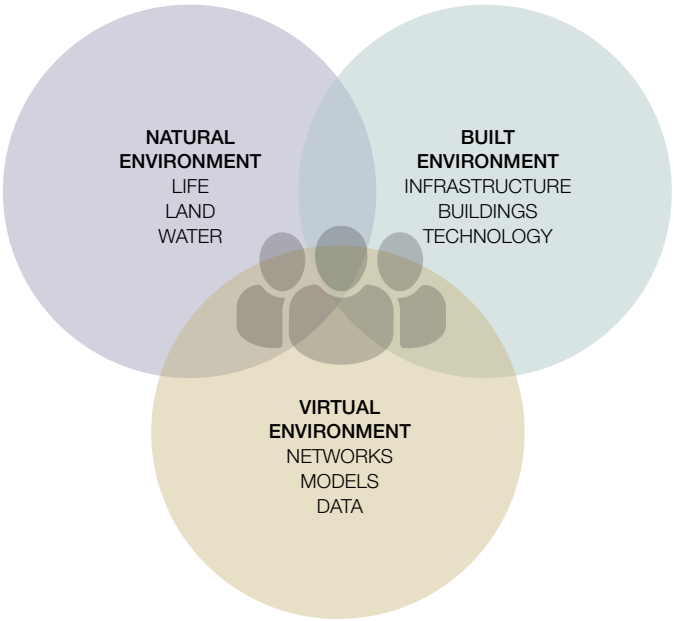


Research and innovation strategy

Seeking a sustainable, secure, resilient world

The planet and its problems do not divide neatly into traditional academic categories, so researchers must go beyond conventional ways of thinking and working. The IFE is at the forefront of a shift to transdisciplinary integration and collaboration. We bring together experts from a diverse range of fields from microbiology and robotics to information security and property law—to address some of the grand challenges facing humanity this century.

The IFE's mission is to generate knowledge, technology and practices that make our world more sustainable, secure and resilient. Our research focuses on the complex relationships between the overlapping environments we live in:



The range and scale of our projects—from research through to development and demonstration—vary depending on the nature of the problem at hand but are always determined in collaboration with partners, advisors and end-users. The IFE's primary faculty partner at QUT is the Science and Engineering Faculty, but the Faculties of Health, Law, Business, Creative Industries and Education are also participants in IFE research and innovation. In 2014, the IFE's research and innovation work was aligned with seven research themes.

Our research themes

FUTURE ENERGY SYSTEMS AND CLEAN TECHNOLOGIES

Reducing our carbon footprint; recycling and reusing our energy resources

Theme Leader: Professor Gerard Ledwich

Clean technologies are essential for many industries, including energy, agriculture, water and wastewater treatment, waste recycling, transport and manufacturing. Our research includes investigations into generating power and solar fuels from concentrated solar thermal systems, new plasma-generation methods that consume waste products, and effective low-cost water treatment.

Our researchers are exploring how to transform centralised power grids into efficient networked grids using:

- widespread local power generation
- new energy technologies, including solar photovoltaics and biofuels
- energy control and storage systems that support renewable technologies
- equipment monitoring to manage peak demand and reduce network costs.

GEOSYSTEMS AND RESOURCES

Identifying and sustainably using our natural resources

Theme Leader: Professor Peter McCabe (until February 2014)

The geosystems field covers the disciplines of geology and geomorphology and the study of geomaterials, including their provenance, properties, formation and evolution. Our researchers are developing better methods to identify, evaluate and visualise natural resources, so they can be used more efficiently and sustainably.

One of our major focus areas is groundwater systems. We can model and evaluate subsurface data on the chemistry, quality, connectivity, depth and location of groundwater associated with Queensland's sedimentary basins to assess how extracting resources affects groundwater use and resupply.

HEALTHY ECOSYSTEMS AND ENVIRONMENTAL MONITORING

Monitoring and documenting the health of our planet

Theme Leader: Professor Peter Grace

To protect the planet's ecosystems, we need to know how human activity and the climate influence carbon, nutrient and water cycles, and how ecosystems operate at field, landscape and regional scales. Our researchers monitor soils, waters and atmospheres to assess the impact of climate change on plants, animals, air, water and ecosystems.

We acquire and analyse environmental data using innovative methods like:

- acoustic and video sensors
- trace gas and particulate analysis at nano-scale
- unmanned aerial vehicles and autonomous robots
- geographic information systems (GIS) and simulation modelling.

INTELLIGENT ENVIRONMENTS

Designing and deploying intelligent systems and machines that support sustainable living

Theme Leader: Professor Peter Corke

Intelligent systems and machines are responsive to their environments and learn from experience. Using virtual models and scenarios and drawing on our knowledge of human responses, we can design intelligent systems that help communities develop sustainable living and working conditions.

Our researchers are studying the:

- application of intelligent systems and machines in many areas, including airports, transport networks and corporations
- use of networked robots and machines to monitor oceans, coastlines and infrastructure
- vulnerability, coping capacities and adaptation responses of humans and systems
- convergence of the natural and built environments.

MATHS, COMPUTATION, SIMULATION AND E-RESEARCH

Using maths, models and computers to solve real-world problems

Theme Leaders: Professor Peter Bartlett and Professor Kevin Burrage

Many practical problems arising from complex systems, decisions and data sources can be solved through mathematical or computational analysis. Our researchers are working on solutions to real-world problems involving:

- global changes in demographics and climate
- resource management and environmental impacts
- changes in the service industries (particularly health, finance and information)
- efficient planning and management of the built environment
- capturing, analysing and delivering large data sets.

SECURE AND RESILIENT INFRASTRUCTURE

Designing and constructing secure infrastructure; protecting infrastructure from failure and decay

Theme Leader: Professor Laurie Buys

Secure and resilient infrastructure is critical to individual, group and organisational wellbeing. Our researchers model and analyse physical, social and virtual infrastructure systems to optimise their performance and security. We study how infrastructure systems respond to disturbances like natural disasters and attacks, and how they can be made more secure and resilient through better design, construction and management.

Systems we are studying include:

- utilities, transport systems and urban communities
- businesses and their processes
- buildings in tropical and subtropical environments
- information and communication networks, including the World Wide Web.

SUSTAINABLE TROPICAL AND SUBTROPICAL PRODUCTION

Producing nutritious, resilient foods for a rapidly growing global population

Theme Leader: Distinguished Professor James Dale

Australia is the only developed country located predominantly in the tropics or subtropics. Our researchers are studying tropical crops including pulses, sugarcane and bananas, and their related pests. We're also studying tropical livestock including fish, crustaceans and other farmed species.

Our current research includes:

- genetically manipulating crops and livestock to improve nutritional value, increase disease resistance and improve stress tolerance
- developing advanced techniques to diagnose and control diseases
- restricting exotic pest entry and managing pests (including tropical fruit flies and invasive weeds)
- developing diverse products from particular crops, boosting the economic sustainability of these industries.

Case studies

Eight major transdisciplinary projects from 2014 are profiled in the following pages:

Many other projects involving IFE facilities are discussed in the Facilities and Infrastructure section of this report (pages 27–42).

Showcasing Queensland to the world's leaders

VISER Manager Gavin Winter (right) showing the Cube Globe to an Indonesian delegation led by President Joko Widodo (third from left)

IFE research theme	Maths, Computation, Simulation and eResearch
Project title	The Cube Globe
Project director	Steve Jacoby (Queensland Department of Natural Resources and Mines)
Project leader	Gavin Winter (QUT)
Team members	Tim Gurnett (QUT), Gleb Sechenov (QUT), Allan James (QUT), Alan Burden (QUT), Warwick Mellow (QUT), Ben Kleverlaan (QUT), Sarah Quijano (QUT), Alex Koszarvcz (QUT), Alexis McGourty (QUT), Thom Saunders (ZONE4 Digital Media), Ack Kinmonth
Partner organisations	Queensland Government, CRC for Spatial Information (CRC SI), NICTA, Bennett + Bennett Surveyors and Planners
Timeline	2014

Why it matters

In the age of big data, one of the greatest challenges facing governments, businesses and individuals is making sense of the oceans of information around us. How can we best use data to help us understand the world and our place in it, to communicate ideas, solve problems and make decisions? To use data effectively, we need to find engaging and illuminating ways to synthesise, present and analyse data using advanced IT, design and multimedia skills and facilities.

Goals and strategies

The Cube Globe was developed specifically for the G20 Leaders Summit, held in Brisbane on 15–16 November 2014. The overriding goal was to showcase Queensland's economic strengths, investment opportunities and international links to visitors from around the world. The project was also designed to demonstrate how the Queensland Government, QUT and local industry are taking a leading role in nurturing research and innovation in the area of interactive geospatial open data applications.

During 2014, the IFE's Visualisation and eResearch (ViseR) team developed the Cube Globe application, which displays a vast amount of the government's open data sets and satellite imagery. The project employed the capability of The Cube as an interactive platform to visualise and present key messages and relationships. The project used state-of-the-art immersive visualisation, interactive maps, animation and multimedia design to depict the key sectors of the Queensland economy at the time.

Achievements

In the days around the G20 Leaders Summit, several world leaders visited the QUT Science and Engineering Centre and explored The Cube Globe, including Indian Prime Minister Narendra Modi, Indonesian President Joko Widodo, OECD Secretary-General Angel Gurria and His Excellency Zhu Xiaodan, Governor of Quangdong, China's most populous province.

Since the G20 Summit, The Cube Globe has become part of the regular programming on The Cube and has been visited by thousands of people, from interstate and international delegations to the general public.

The development of The Cube Globe, with all the IT intelligence and skills behind it, gives QUT a platform to build further projects exploring the visualisation of open data sets and spatial information.

Addressing the world food crisis

Professor Sagadevan Mundree (left) briefs Prime Minister of the Republic of India Mr Narendra Modi (right) on the project in the rooftop greenhouse on the QUT Science and Engineering Centre (Photo credit: AAP, Dan Peled)

IFE research theme	Sustainable Tropical and Subtropical Production
Project title	Tropical Pulses for Queensland
Project leader	Professor Sagadevan Mundree
Team members	**QUT:** Dr Brett Williams, Dr My Linh Hoang, Dr Sudipta Das Bhowmik, Mr Alam Cheng (Research Assistant), Mr Hao Long (Research Assistant), Mr Tom Noble (Research Assistant), Miss Grace Tan (PhD Student), Mr Michael Dodt (PhD Student) **QLD Department of Agriculture and Fisheries:** Dr Rex Williams, Dr Yash Chauhan, Mr Col Douglas **CSIRO:** Dr TJ Higgins
Partner organisations	Queensland Government
Timeline	2013–2016

Why it matters

The world's current dependence on animals for dietary protein is not sustainable. As population and income levels rise, particularly in Asia, there will be an unprecedented demand for protein and this demand is likely to be met with pulses rather than livestock. New pulse varieties could not only play a large role in global efforts to address the looming food crisis; they could also enable Australia (already the world's leading exporter of chickpeas and mungbeans) to greatly expand its activity within this market.

Goals and strategies

Professor Sagadevan Mundree's research, supported by the Queensland Government, aims to develop new drought- and disease-resistant varieties of tropical pulses, such as chickpea and mungbean, that Australian farmers could grow on land currently considered marginal for production.

The project involves five areas of focus:

1. Developing a new chemical pre-treatment for chickpea and mungbean seeds that improves their resilience in the face of changing environmental conditions. The project team is currently running field trials of a low-cost natural compound at the Queensland Government Department of Agriculture and Fisheries Research Station at Hermitage at Warwick. The compound increases fine root architecture, allowing it to absorb more water and nutrients.
2. Generating elite transgenic chickpea varieties with greater drought tolerance and resistance to the disease *Botrytis cinerea*.
3. Biofortifying chickpea to increase its iron content and hence its nutritional value.
4. Identifying novel traits for stress tolerance in mungbean through the development of a 'nested association mapping' (NAM) population that will diversify the gene pool of mungbean and help identify markers of drought tolerance within crop varieties.
5. Developing computer models to enhance chickpea and mungbean production levels by identifying advances in genetics and agronomy and the best genotypes for specific environments.

Achievements

The project's achievements to date include:

- development of a novel seed treatment protocol for the chemical pre-treatment of chickpea and mungbean seeds for enhanced fine root development
- demonstrated improved fine root development in chickpea and mungbean following pre-treatment with a novel chemical in tissue culture and the newly constructed glasshouse on the roof of the QUT Science and Engineering Centre
- demonstrated improvement of fine root development *in situ* using X-ray tomography
- development and optimisation of a chickpea transformation protocol
- generation of transgenic chickpea expression stress tolerance and disease resistance genes
- elemental analysis of chickpea varieties cultivated in different environments
- fast-tracking of the mungbean NAM population using new protocols developed for glasshouse and shadehouse during 2014
- genotyping or 'genetic fingerprinting' of almost six hundred mungbean lines from the Australian mungbean collection
- optimising models of the relationships between chickpea and mungbean genetics, environment and crop management.

International research centre to fight air pollution

QUT Professor Lidia Moraswska, one of the founding directors of the new centre

IFE research theme	Healthy Ecosystems and Environmental Monitoring
Centre name	The Australia-China Centre for Air Quality Science and Management
Centre directors	Professor Lidia Morawska (QUT), Professor Fahe Chai (Chinese Research Academy of Environmental Sciences) and Professor Chris Chao (Hong Kong University of Science and Technology)
Partner organisations	Chinese Research Academy of Environmental Sciences; Shanghai Academy of Environmental Sciences; Tsinghua University; Peking University; East China University of Science and Technology; Fudan University; Hong Kong University; Hong Kong University of Science and Technology; Hong Kong Polytechnic University; Hong Kong City University; CSIRO Marine and Atmospheric Research; The University of Sydney; The University of New South Wales
Timeline	2014–

Why it matters

Air pollution is a large, complex and borderless problem that does immense damage to people and the environment. That damage is expected to intensify as the populations, economies and cities of China and other developing countries expand over the coming decades. Pollutants from vehicles, factories and power plants, as well as airborne dust from deserts and exposed soil, cause or contribute to many health problems, especially cardiovascular and respiratory diseases and cancer. The scale of the problem demands a massive international and interdisciplinary response from researchers and governments.

Goals and strategies

The new Australia-China Centre for Air Quality Science and Management, which was launched in December 2014, will investigate the science of, and solutions to, all forms of air pollution. The Centre's researchers will:

- study the origins and scales of air pollution and how it affects human health and the environment
- develop new technologies and techniques to better monitor, prevent and mitigate air pollution
- participate in national and international policy discussions about air pollution
- nurture the next generation of Australian and Chinese researchers in this broad, transdisciplinary field.

QUT has a strong air pollution research program through its World Health Organization-designated International Laboratory for Air Quality and Health. Led by Professor Morawska, one of the founding directors of the new Centre, the laboratory has contributed to all WHO global policy documents on this topic since 1996. In addition, the QUT Biofuels Engine Research Facility plays a key role in examining the impact of new bio-based hydrocarbon fuels on emissions. Much of this work at QUT is led by Professor Zoran Ristovski, who collaborates closely with Chinese colleagues in Shanghai, Beijing and Hong Kong. The new Australia-China Centre will expand this research effort and enhance its impact, particularly in the Western Pacific region.

The Centre will develop a suite of research programs that focus on key areas of required understanding, such as secondary aerosol generation, pollution source identification and regional-scale climate influence. The centre will run postgraduate training programs for young Australian and Chinese scientists. Technological breakthroughs—in quality analysis, modelling, validation and management—will be jointly developed and shared through these training programs and researcher exchanges.

Achievements

The Centre was officially launched on 5 December 2014 at Beijing's Chinese Research Academy for Environmental Sciences (CRAES).The centre is the culmination of years of discussion and collaboration between QUT and more than twenty universities and government agencies in Australia and China. Professor Ian Mackinnon, Executive Director of the IFE, played a key role in planning the new centre, along with several other senior QUT researchers and staff.

Protecting our infrastructure from cyber attacks

Dr Ernest Foo in the Supervisory Control and Data Acquisition (SCADA) Security Research Laboratory in the Science and Engineering Centre

IFE research theme	Secure and Resilient Infrastructure
Project title	SCADA Security Research Laboratory
Project leader	Dr Ernest Foo (QUT)
Team members	Dr Kenneth Radke (QUT), Professor Colin Fidge (QUT)
Partner organisations	Powerlink Queensland
Timeline	2013–2016

Why it matters

The computerised security systems that protect some of Australia's most valuable infrastructure, such as dams and power plants, are not immune from cyber attacks. Over the past decade, many of the nation's key infrastructure facilities and systems, which had previously been operated by stand-alone IT systems, have been connected to the internet, making them vulnerable to hackers. Part of the problem is that organisations that have spent millions if not billions on major infrastructure projects have expected that infrastructure to last for 20 years or more, but normal IT security systems need a much shorter refresh and update cycle to keep them resistant to attack. This requirement just isn't factored into most industrial control systems.

Goals and strategies

Dr Ernest Foo from the IFE is the chief investigator for this Australian Research Council Linkage project studying the security of industrial control systems. The project's three main goals are to:

- discover exactly how vulnerable our infrastructure's control systems are. What kinds of things can hackers do? What can they turn on or off? Can they stop messages or signals getting through?
- establish how an attack can be detected while it is happening using automated intrusion detection algorithms rather than operators.
- design new devices and redesign existing devices so that they are secure and we are in a better position to prevent and repel attacks.

Within the Science and Engineering Centre, Dr Foo and his colleagues have set up a Supervisory Control and Data Acquisitions (SCADA) Security Research Laboratory in which to study SCADA communication protocols and hardware devices.

The main stages for most projects in the laboratory are as follows:

1. Explore vulnerabilities and exploit vectors.
2. Develop methods to detect cyber attacks.
3. Design new inherently secure systems.
4. Develop techniques for incident response.

This general approach can be applied to a large number of control system examples. The SCADA Security Research Laboratory is a transdisciplinary endeavour where information security researchers from QUT and industrial control system engineers from Powerlink Queensland (an electricity transmission organisation) work towards finding solutions for each of the above stages.

Achievements

The SCADA Security Research Laboratory was profiled on ABC's Catalyst television program: visit http://ow.ly/JC9of to watch the story or read the transcript. The project team has presented papers on their research at several international conferences, including:

- the 2014 and 2015 Australasian Information Security Conferences (AISC)
- the 2015 Australasian Computer Science Conference (ACSC)
- the 2014 IEEE International Conference on Communications (ICC)
- the 2013 Hawaii International Conference on System Sciences
- the World Conference on Information Security Education (WISE).

Powering the next generation of electric vehicles

Project leader Professor Peter Talbot

IFE research theme	Future Energy Systems and Clean Technologies
Project title	Lithium-ion Battery Material Manufacturing Scale-up and Process Optimisation
Project leader	Professor Peter Talbot (QUT)
Team members	Professor Jose Alarco (QUT), Dr Jawahar Nerkar (QUT), Mr Felix Lo (QUT), Mr Mark Quinlan (QUT)
Partner organisations	Automotive Australia 2020 CRC (AutoCRC), Malaysia Automotive Institute (MAI)
Timeline	2014–2017

Why it matters

A global shift to electric cars could help wean the world off fossil fuels and reduce greenhouse gas emissions and air pollution. But the technology and production processes for electric vehicles must keep improving so that their driving range keeps increasing and their prices keep falling. The most important—and most expensive—component of an electric car is the battery. The greater the energy-density of the battery, the further the car can travel before it needs recharging.

Goals and strategies

Professor Talbot and his project team are developing improved methods of manufacturing the advanced materials used in electric vehicle batteries. Every aspect of the project is designed to ensure the results can be applied quickly in the burgeoning electric vehicle industry globally. The project aims to encourage technology transfer from QUT to enterprises in ASEAN countries and Australia via the AutoCRC.

Most electric vehicles currently on the market use lithium-ion rechargeable batteries. Professor Talbot and his team will identify the most promising lithium-based powders to use in these batteries and then optimise the process of producing them at a commercial scale.

The team will test and refine new production processes at:

- lab scale (producing <100 grams of powder)
- concept scale (<1kg)
- pilot scale (>10kg)
- commercial scale (>100kg).

The lab- and concept-scale testing will be done in the Central Analytical Research Facility and the pilot-scale testing will be conducted at the Banyo Pilot Plant Precinct.

The team will use off-the-shelf equipment that is energy-efficient, environmentally friendly and capable of producing lithium-ion powders at commercial quantities, and techniques and methods that any manufacturing company can use. This will make the transfer of technology to the automotive industry as efficient as possible.

Achievements

Agreements to begin this research have been signed and key team members have been recruited to QUT. Staff of the Malaysia Automotive Institute, the AutoCRC and QUT have made frequent visits to and from Australia and Malaysia to ensure that the project's research plan is aligned to the rapidly evolving commercial implementation plan. Discussions with potential commercial partners for both chemical and battery manufacturing have commenced to enable their participation in the project.

Managing residential peak energy demand

Project leader Professor Laurie Buys

IFE research themes	Secure and Resilient Infrastructure; Future Energy Systems and Clean Technologies
Project title	Electricity Demand Management Prediction, Control and Engagement
Project leader	Professor Laurie Buys (QUT)
Team members	Professors Gerard Ledwich, John Bell and Kerrie Mengersen, Dr Desley Vine, Mr Peter Morris, Mr Jim Lewis (all QUT)
Partner organisations	Ergon Energy
Timeline	2012–2015

Why it matters

Electricity generation, transmission and distribution systems need to cater for periods of peak demand, which amount to around 40 hours per year. By lowering peak demand, societies can reduce both infrastructure costs and greenhouse gas emissions from electricity generation. Residential consumers account for more than 30 per cent of peak electricity demand, so addressing residential peak consumption will significantly help governments and utilities to limit the environmental and economic impact of our electricity usage.

Goals and strategies

A team of QUT researchers, led by Professor Laurie Buys, are developing ways to reduce peak demand using improved methods of predicting and controlling residential electricity demand. The findings will help Ergon Energy to make investment decisions about load control initiatives and non-network alternatives based on customer insights.

In practical terms, the project will:

- facilitate future innovation related to energy conservation and peak demand reduction
- create policy tools to improve long-term energy security and avoid over-capitalisation in the electricity network
- cut electricity bills for consumers.

The project will illustrate the potential of multilevel, spatial modelling approaches in understanding the determinants of residential peak energy demand.

The project team is developing processes for successful residential peak energy delivery and demand management by identifying critical factors and better understanding the complex interactions between the environmental, social, technical and economic components of the system. Using an evidence-based approach, they will:

- provide information (and underpinning data) to guide policy and decision making, including a baseline on key aspects of customer behaviour
- identify trigger points at which changes could be made to maximise behavioural change aimed at reducing peak demand
- recommend adaptation strategies, tested by 'what if' scenarios.

Achievements

Professor Buys and the team have created a new model to better understand the relationships between and changes in key variables (environmental, social, technical and economic) within an energy system. The model addresses complex, interactive issues from a whole-of-system perspective, allowing researchers to rigorously assess impacts, model likely future scenarios and identify the best possible strategies to secure electricity supply at peak times.

Robotic boat to make our waters safer and healthier

The Inference, a robotic boat developed by Dr Matt Dunbabin

IFE research theme	Intelligent Environments
Project title	Inference: Robotic Adaptive Sampling System
Project leader	Dr Matt Dunbabin (QUT)
Timeline	2014–ongoing

Why it matters

How can we efficiently monitor and model the health of the world's lakes and oceans? How can we quickly find and safely clean up debris, oil slicks and other waste from marine accidents? How can we protect our ports from biosecurity threats? These are just a few examples of activities that potentially could be carried out more safely, efficiently and cost-effectively by autonomous robotic boats than by boats with crews.

Goals and strategies

Dr Matt Dunbabin is developing light-weight, solar-powered, driverless robotic boats that can be used for environmental monitoring—for example, collecting data on water quality and greenhouse gas emissions –and various other civilian applications. Named the *Inference Robotic Adaptive Sampling System*, it is designed to operate as a fleet of four or more robotic boats that can communicate with each other and collect more data than a single boat could. The goals of the project are to:

- develop a small, durable prototype boat that can be adapted for various applications
- provide a shared resource of multiple networked boats (or Autonomous Surface Vehicles) to allow researchers to remotely evaluate new sampling algorithms on real-world processes over extended periods of time
- develop software that facilitates autonomous control of the boat and remote access to the data it collects
- evaluate a fleet of the boats on various kinds of waterways in Australia
- identify the potential research and commercial applications of the technology and produce customised boats for these applications.

Achievements

Dr Dunbabin built four of the *Inference* robotic boats in 2014. The boats are custom designed for persistent and cooperative operation in challenging inland waterways. Each boat is fitted with a suite of sensors, allowing them to autonomously explore a body of water and measure a range of environmental parameters. Their navigation capabilities were tested in Gold Creek Dam and Hinze Dam in South East Queensland.

Dr Dunbabin developed a set of monitoring and sampling systems and tested them on-board the robotic boats. These included a greenhouse gas sampling system, a profiling sonar system (for bathymetry) and a first prototype of a water sampler. Through these trials, Dr Dunbabin identified several new potential applications for the boats, such as image-based riparian zone assessment, water sampling in hostile environments, and debris containment and clean-up.

In 2015, the robotic boats will be taken to a South East Queensland water reservoir for extended sampling trials over many months. These boats will be monitored online and remotely, with new sampling algorithms evaluated on their ability to capture and model complex environmental processes. Additionally, new sampling systems will be developed, including a water sampling system capable of collecting specimens as deep as 40 metres below the surface.

Training farmers to reduce crop losses

IFE research theme	Maths, Computation, Simulation and eResearch
Project title	Plant Doctor
Project sponsor	Professor Ian Mackinnon (QUT)
Team members	Geoff Suttor (QUT), Marty Portier (QUT), Sam Clifton (QUT), Josh Hall (QUT), Ray Johnson (QUT), Jonathan Marshall (Bondi Labs)
Partner organisations	Centre for Agricultural Bioscience International (CABI), Bondi Labs
Timeline	October 2014–ongoing

Why it matters

The Centre for Agricultural Bioscience International (CABI, www.cabi.org) is an international non-profit organisation that aims to improve small-holder farmers' lives by providing advice and training on agriculture and the environment. The organisation advises farmers in developing economies on how to improve food production while losing fewer crops, sustaining local biodiversity and safeguarding the environment. For many farmers, pests and diseases threaten the safety and security of their crops and their livelihoods. Worldwide, an estimated 30–40 per cent of crops are lost to pests and diseases each year, a figure that may increase due to climate change.

Reducing crop losses by a small percentage could help feed significantly more people—particularly in the 48 member nations of CABI. To this end, CABI's educational program Plantwise is helping farmers in more than 30 countries to lose less of what they grow. Working closely with national governments and agricultural advisory services, Plantwise establishes sustainable networks of plant clinics run by trained local 'plant doctors' who help farmers to reduce crop losses through better disease and pest diagnosis. It increases the stock of knowledge in a farming community and translates into more productive farms.

Goals and strategies

To rapidly apply existing plant health knowledge in many countries, many more plant doctors are required. The plant doctors are deployed in remote rural areas of developing countries that lack the resources commonly available in highly populated centres of learning. CABI wanted to educate plant doctors in an engaging, innovative and cost-effective way using a 'serious game' for mobile smart devices. Serious games (i.e. computer games with a serious use) can be very effective training tools, because they can quickly and safely simulate a diverse range of realistic situations and experiences and give instant feedback to the trainee. With the additional resources provided by a simulation training platform, CABI plans to reach more than 6 million farmers in 33 countries by 2020, an increase from 600 000 farmers by current best practice.

The transdisciplinary project team draws together a range of skill sets and disciplines, including software development, visualisation and imagery, computer science, human computer interaction, interaction design, cognitive psychology and educational technology. The capacity to draw upon a wide range of expertise while working to production-level, industry timelines and standards has been greatly facilitated by the use of project spaces and infrastructure at the IFE.

Achievements

The project team has developed a serious game prototype that collates CABI's Plantwise data on pests and diseases—targeted at specific regions and countries—so that more farmers can be trained in the symptoms and causes of plant health. The simulation training tool is based on actual plant health diagnostic processes and Integrated Pest Management principles. The prototype is being trialled with Vietnamese agricultural extension workers in 2015. Other innovations include a new Factsheet Library app, which enables farmers and agricultural advisors to take open access data with them to the field and to undertake tablet-based 'e-plant clinic' pilot trials in Kenya and India.

FACILITIES AND INFRASTRUCTURE

Our researchers use state-of-the-art facilities for modelling complex systems, monitoring the environment, testing pilot equipment and processes, and analysing the properties of soids, liquids and gases.

Science and Engineering Centre

P Block at the Gardens Point campus, one of the two buildings that make up the QUT Science and Engineering Centre

The Science and Engineering Centre (SEC) is home to the IFE, which occupies three levels in each of the Centre's two buildings, P Block and Y Block. Completed in late 2012, the SEC is the central hub on QUT's Gardens Point campus for research, teaching and community engagement in the fields of STEM (science, technology, engineering and mathematics).

The Centre is a model of sustainable building design, using solar power from rooftop photovoltaic panels and a natural gas tri-generation power system to heat, cool and power the buildings. In 2014, the SEC was awarded a *5 Star Education 'As Built' v1* rating from the Green Building Council of Australia, making it one of the highest-rated 'green' buildings in Brisbane's CBD.

The SEC houses most of the IFE's Central Analytical Research Facility, as well as open-plan office areas, glass-walled project and meeting rooms, and comfortably furnished lounge areas, all designed to encourage interdisciplinary collaboration. Throughout 2014, the SEC's rooms and workspaces for researchers and staff were heavily utilised and close to fully occupied.

Projects

In 2014, the project rooms in the SEC were used for the following types of research and development work:

- **nanotechnology:** materials science projects focusing on developing new solar cell and gas sensor technologies exploiting nanostructures (Professor Nunzio Motta and Dr Mahnaz Shafei)
- **high-performance materials:** development of materials that demonstrate unique electrical and magnetic properties, for application in aerospace, battery technology and other areas (Professors Peter Talbot, Jose Alarco and Ian Mackinnon)
- **greenhouse gas monitoring:** design, development and prototyping of environmental field monitoring equipment for greenhouse gas measurement, using gas chromatography and mass spectrometry (Professor Peter Grace)
- **aquatic robots:** development of autonomous environmental robotic systems for large-scale marine habitats and aquatic greenhouse gas monitoring (Dr Matt Dunbabin); see case study on page 24
- **cyber security:** research into industrial control systems and critical infrastructure security, including control and automation of electricity substations, as well as the design and development of a QUT Supervisory Control and Data Acquisition (SCADA) Security Research Laboratory (Dr Ernest Foo); see case study on page 18

- **serious games:** design and development of software to train and assess the competency of quarantine inspectors and educate 'plant doctors' in plant health diagnostics processes (Bondi Labs; see case study on page 26
- **Airports of the Future:** a collaborative research project focusing on improving airport operations productivity and efficiency as well as airport security screening and surveillance (Associate Professor Clinton Fookes and Professor Prasad Yarlagadda)
- **mobile services:** research into personalising mobile services, applying the principles of interaction design and cognitive science to deliver adaptive and optimised video quality for mobile and emerging technology platforms (Associate Professor Dian Tjondronegoro)
- **mass spectrometry:** research exploring the unique properties of gas phase radical ions and development of new mass spectrometric approaches to surface analysis (Professor Stephen Blanksby).

Staff, students and visitors

As shown in the tables below, the SEC accommodates a diverse group of professional and academic staff, higher degree research (HDR) students, visitors and external collaborators. Core IFE staff include those from the IFE Directorate and the Central Analytical Research Facility, as well as a number of academic staff. The majority of collaborating research staff and students were from QUT's Science and Engineering Faculty. Other researchers were from QUT's Creative Industries Faculty (CIF) and several partner organisations, including a node of National ICT Australia (NICTA), which left in late 2014, and the Queensland Cyber Infrastructure Foundation (QCIF).

	SEC (P and Y Block) occupants at 31 December 2014									
	Core IFE	Creative Industries Faculty	Science and Engineering Faculty Schools*						Partner organisations	TOTAL
			CEBE	CMPE	EEBS	EECS	InfoSys	Maths		
STAFF	68	10	14	23	16	10	49	31	28**	249
STUDENTS		11	2	23	7	14	55	28		140
VISITORS	1	2	1	2	1	1	6	1		15

**Science and Engineering Faculty Schools: Civil Engineering and the Built Environment (CEBE); Chemistry, Physics and Mechanical Engineering (CPME); Earth, Environmental and Biological Sciences (EEBS); Electrical Engineering and Computer Science (EECS); Information Systems (InfoSys); and Mathematical Sciences (Maths)*

*** Staff of National ICT Australia (NICTA) have been included, although they moved to another location in October 2014.*

Central Analytical Research Facility (CARF)

Technician Vincent Chand in CARF's Molecular Genetics Laboratory

The Central Analytical Research Facility (CARF) embodies the IFE's goal of supporting transdisciplinary research on a scale beyond the reach of individual research groups or disciplines. 2014 was the first year of full operation of CARF and represents the culmination of a major co-investment in infrastructure (more than $20M in scientific instrumentation since 2011) and personnel (over 20 academic and professional staff). CARF's mission is to empower researchers to make discoveries through the elucidation of structure and function in molecules and materials. CARF aspires to provide nation-leading facilities and training for the next generation of scientists and engineers.

The Director of CARF, Professor Stephen Blanksby, commenced in February 2014, bringing a strong background in research involving advanced scientific instrumentation (see page 6). Professor Blanksby has now established the mass spectrometry development laboratory within CARF, where his group is modifying commercial instrumentation for new analytical applications in life sciences and materials research.

In parallel, the proteomics and small molecule mass spectrometry lab, led by Dr Pawel Sadowski, was established. This facility is establishing new capabilities to support research in the 'omics' fields (for example, proteomics, metabolomics and lipidomics). Interest in these fields has grown rapidly at QUT and these new facilities, in combination with existing capabilities in molecular genetics, allow CARF to support more research across the life sciences and biomedical disciplines.

Projects and usage

During 2014, the CARF team was strongly engaged with QUT researchers and commercial partners. Usage of CARF infrastructure rose from an average of 1720 instrument hours per month in 2013 to over 3350 instrument hours per month in 2014. There were 401 active users of the facility in 2014 (up from 327 in 2013), including 177 higher degree research students, who received expert training from CARF staff. The CARF team engaged with researchers through a seminar and workshop program that included CARF Showcase Seminars, workshops by instrument vendors and visiting experts, the B^3 (Big Biology and Bioinformatics) Symposium and a Small Angle X-ray Scattering Workshop (see pages 44–46 for more on these events).

QUT researchers partnered with CARF on a range of projects across the suite of analytical capabilities. Highlights included the following:

- Advanced atom-scale microscopy was successfully used to characterise materials with super-capacitance properties that could be used in future battery applications (Project Leader – Professor Nunzio Motta).

- Sensitive mass spectral analysis identified compounds that serve as attractants for the Queensland fruit fly, providing potential new lures for eradication programs (Project Leader – Dr Paul Cunningham).
- The diffusion of fluids through rocks and coal at high pressures was observed using novel X-ray and neutron diffraction techniques. These findings challenge conventional wisdom about how liquids and gases move through rocks deep underground and could significantly influence mining and sequestration practices (Project Leaders – Dr Tomasz Blach and Dr Christof Schrank).
- Over 70 000 air samples collected at sites all over Australia were analysed for greenhouse gas concentrations to build a clearer picture of greenhouse gas emissions from Australian agriculture: visit www.n2o.net.au for more details and data (Project Leader – Professor Peter Grace).

Research articles by CARF staff about new analytical methods were published in leading discipline journals and patenting of new technologies designed and built by CARF are currently being explored by QUT's Bluebox technology transfer group. CARF researchers have received external funding from the Australian Research Council and Geosciences Australia and have presented their research at national and international symposia. Notably, Mr Henry Spratt received the student poster prize for the 'Best X-ray Analysis in Minerals' at the Australian X-ray Analytical Association conference in Perth in February 2014.

In addition to QUT staff, researchers from the University of Queensland (UQ) were attracted to CARF in 2014. A formal framework for reciprocal access was negotiated with UQ's Centre for Microscopy and Microanalysis. At a national level, CARF is involved in a number of collaborations with researchers from the Australian National University, the University of Wollongong and the CSIRO. CARF staff were also involved in international consortia, such as a multi-laboratory reference study measuring cancer-relevant markers in plasma samples. Moreover, CARF supported visits to QUT by experts in electron microprobe analysis (Associate Professor Christopher McFarlane, University of New Brunswick, Canada), mass spectrometry (Dr Philippe Dugourd, French National Center for Scientific Research) and small angle X-ray scattering (Dr Youli Li, University of California, Santa Barbara).

CARF's expert staff were involved with a number of commercial partnerships and consultancies across the mining, exploration, fabrication and laboratory services sectors. Combined, these relationships and commercial services brought in more than $698 000 (up from $516 319 in 2013). Tests and measurements undertaken at CARF are having real-world impact by, for example, improving processes for coal seam gas extraction and waste remediation; providing better characterisation and classification of fertilisers; and enabling asbestos identification for the mining and extractive industries.

Facility upgrades

CARF staff work closely with QUT researchers to identify analytical equipment needs and priorities. In collaboration with the Science and Engineering Faculty, along with QUT's Strategic Major Equipment Program, CARF acquired a range of new equipment in 2014 (valued at over $3M), including:

- a PANanalytical 1kW Wavelength Dispersive X-Ray Fluorescence Spectrometer, which geoscience and materials researchers are using to analyse major and trace metals
- a NextSeq 500 Sequencing System, the latest next generation DNA sequencing technology, which is being used to measure gene expression, transcription and epigenetic factors involved in ecology, plant biotechnology and human disease
- a high resolution Thermo Fisher Scientific Hybrid Orbitrap Mass Spectrometer, which will facilitate the identification and characterisation of new molecules.

Visualisation and eResearch (ViseR)

ViseR Manager Gavin Winter using the touch wall in the Skunkworks lab

The IFE's Visualisation and eResearch (ViseR) team works with QUT researchers and external partners to develop innovative ways of modelling, visualising and interpreting complex information across academic, government and industry sectors. The team uses cutting-edge software platforms, AV and IT facilities and unique equipment (including The Cube) to create prototypes right through to commercially ready products.

Projects and usage

The ViseR team worked concurrently on several major projects in 2014, including the Cube Globe project for the G20 Leaders Summit, Sensing SEC and Skunkworks.

The Cube Globe

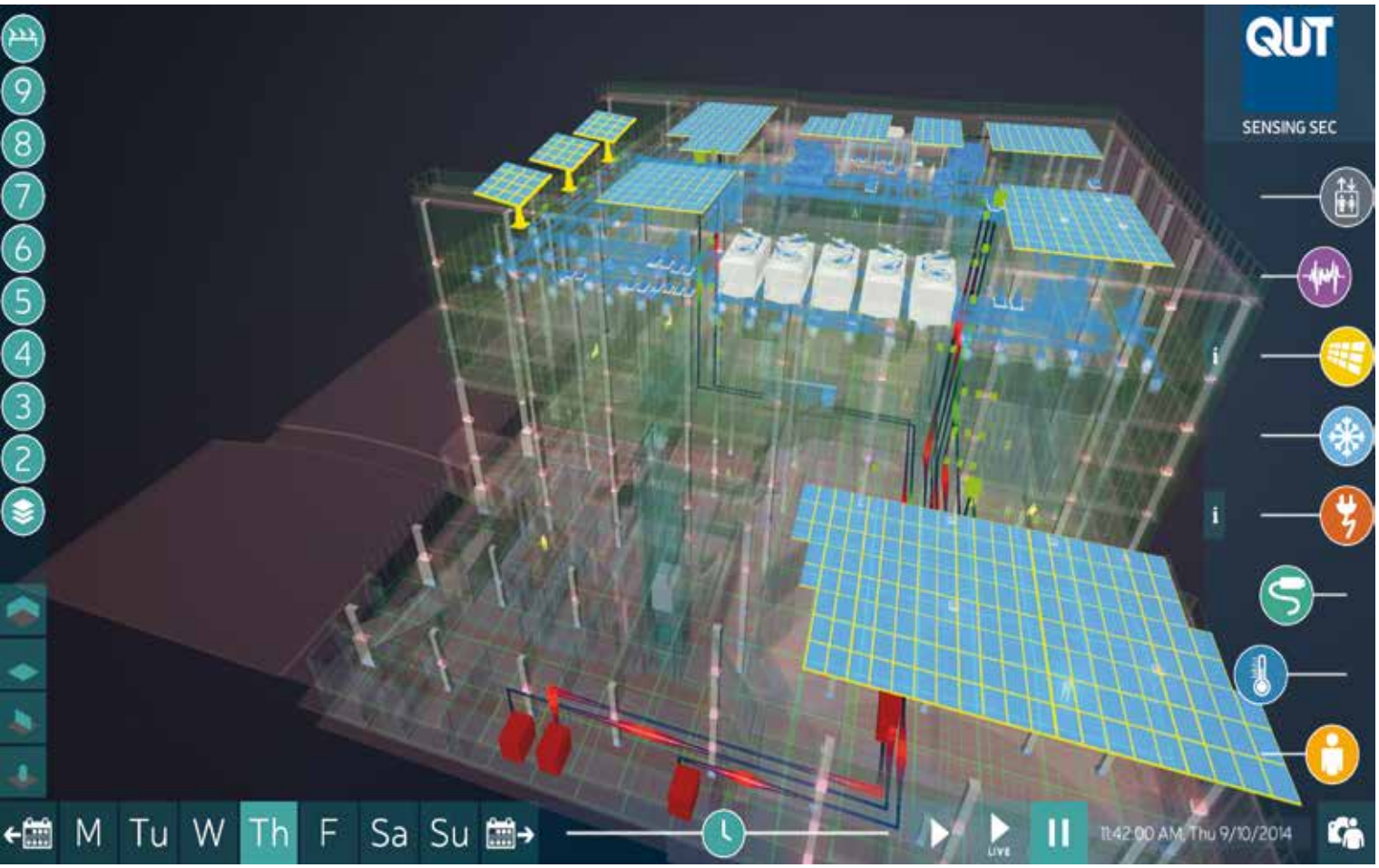
The Team partnered with the Queensland Government to build The Cube Globe, which visualises a vast amount of the State's open datasets and satellite imagery for visitors to explore, discover and share. The world-first spatial platform uses state-of-the-art immersive visualisation, interactive maps, animation and multimedia design to tell compelling stories about Queensland's performance in key economic sectors. This development is the perfect platform for Cube visitors to get a real sense of who we are and what we do in Queensland. See the project case study on page 12 for more details.

Sensing SEC

The QUT Science and Engineering Centre (SEC) is one of the greenest buildings in the Brisbane CBD. The Sensing SEC project will make it one of the smartest. Working with QUT architecture, engineering and IT experts, ViseR is building an open, interactive online platform presenting live and historical data about the operation of the SEC, such as how much energy it generates and consumes. The team is engaged with global experts and is recognised as a leading group meeting the challenges of managing and optimising the convergence of building, AV, IT and energy systems.

Skunkworks lab

During 2014, the ViseR team set up Skunkworks, a visualisation, simulation and interaction research lab in the Science and Engineering Centre. Skunkworks houses a range of advanced IT systems, including a video wall, multi-touch panels, motion capture, stereo projection and spatialised audio systems. It gives the ViseR team and QUT researchers what they need to develop new interactive visualisation tools and applications to solve problems, collaborate with business and government, and build expertise across many disciplines.



A screen shot of the Sensing SEC interface

Samford Ecological Research Facility (SERF)

Isabelle de Haviland, winner of the Dr EN Marks Sustainability Award, holding a baby saw-shelled turtle at SERF

The Samford Ecological Research Facility (SERF) is a 51 hectare property located in the Samford Valley, a 25 minute drive northwest of QUT's Gardens Point Campus. The facility provides QUT with a research, teaching and learning base for a range of ecological, engineering, built environment and educational programs primarily relating to urban development and its impact on ecosystems.

The property was bequeathed to QUT by renowned Queensland entomologist Dr Elizabeth Nesta Marks, whose will instructed the executors of her estate to identify a suitable beneficiary who would use the property for 'ecological purposes'. In accordance with the Deed of Conditions of Gift for the Estate of EN (Patricia) Marks, QUT established a Reference Group to provide an avenue for consultation between QUT, the executors and the community. The five year term of the Reference Group expired in 2014, with the last meeting held in October. Marks family representative Charles Bishop reported to the Marks family that the Reference Group has achieved its primary goal, which was 'to transition the property to a fully functioning ecological research facility'.

Maintaining a high level of community interaction to ensure the sustainable development of the Samford Valley is an important goal for SERF. Community outreach and engagement activities in 2014 included the following:

- The Dr EN Marks Sustainability Award for 2013 was awarded to Isabelle de Haviland, a Bachelor of Applied Science student majoring in Environmental Science, for her project 'The influence of vertical microphone placement on acoustic bird species richness estimates'. Isabelle's project was commended as an important contribution to the environmental monitoring programs at SERF.
- The sixth annual SERF Information Session was held on 23 October 2014, allowing Samford locals to hear from QUT staff and students about the research and educational activities undertaken at SERF (see page 49).
- The extended Marks family held a family reunion at SERF on 21 September 2014. The land now occupied by SERF was purchased by the family in 1879. The family are very happy with the activities being undertaken at SERF under the custodianship of QUT.

Projects and usage

SERF was well used in 2014 for a range of research, teaching and learning activities. Twelve major ongoing research projects were carried out at SERF in 2014.

Several comprehensive environmental (air, water and soil) sensing and monitoring programs were also carried out, including greenhouse gas monitoring, soil moisture and chemistry monitoring, greenhouse gas transfer between soil and air, and development of field sampling techniques using gas sampling and mass spectrometry.

Ecological research topics included determining the abundance of bird species using acoustic sensors and identifying trends in the spatial distribution of arboreal termites in relation to environmental stimuli. The behaviour of insects—particularly the Queensland fruit fly—was studied in the purpose-built insect enclosures at SERF. Other projects involved the use of robots for aerial mapping of vegetation and biomass, 3D mapping of tree density, and testing of sensor and navigation technology in the field.

SERF remains part of the Terrestrial Ecosystem Research Network (TERN), a National Collaborative Research Infrastructure Strategy (NCRIS) initiative, serving as a 'supersite' for studying the impact of peri-urban development on ecosytems. The flux station located in the cleared pasture area at SERF is used for carbon dioxide and water flux measurement, automated greenhouse gas measurement and weather monitoring.

Undergraduate students from the QUT Science and Engineering Faculty made eight field trips to SERF over the year. They were taught experimental design and quantitative research methods, as well as practical skills such as how to capture and release wildlife. The projects they worked on included the design of environmentally sustainable systems for long-term residential development; land resource and soil assessments; surveys of bandicoot activity, monarch butterfly density, herbivore levels and bird density and nest predation; and field entomology studies.

Facility upgrades

In June 2014, a new road crossover with a bitumen surface at the main site entrance from Camp Mountain Road was completed, up to and around the wide bend into the property. This work was required to provide safer access to the site for buses and cars.

The 35 hectares of forest on the property has a significant problem with invasive weeds, including lantana, asparagus vine and ground cover, ochna and Easter wattle, and to a lesser extent, cat's claw creeper, Chinese elm, camphor, privet and corky passionfruit. In late 2014, a specialist contractor began a major weed eradication program on the site in late 2014, spending 700 hours hand cutting and poisoning woody plants and cat's claw creeper.

A heritage-listed 'Slab Hut' is located close to the south-west boundary of the property. Dating from circa 1870, the hut has significant cultural value as one of the first buildings constructed during settlement of the Samford Valley. A local building contractor with previous experience working on the Slab Hut carried out minor maintenance in early 2014, refixing timber palings and covering minor gaps in the walls. All work was in keeping with the conditions of the original heritage report and recommendations.

Banyo Pilot Plant Precinct

PhD student MD Kabir operating the 250 kN hydraulic actuators at Banyo

The Banyo Pilot Plant Precinct, located in the Brisbane suburb of Banyo, is a general-purpose facility for large-scale or scaled-up research in traditional engineering (structural, mechanical or electrical), chemical process engineering and wastewater treatment, and product testing and validation. The projects carried out by higher degree research students and academics at Banyo include the development of pilot-scale equipment and processes for industry partners and the long-term monitoring of industrial products.

One of the primary focuses at Banyo in recent years has been the continuous improvement of workplace health and safety, the layout of research spaces and general environmental hygiene, project approval and management systems and space utilisation.

Projects and usage

As shown in the tables on the next page, 20 projects wereunder way at Banyo during 2014, in areas including mechanical and civil engineering, electrical engineering, water treatment, geology and ecology, and materials characterisation.

Facility upgrades

In 2014, we refurbished and commissioned several parts of the facility for new projects. This included:

- setting up a new soil and plant processing facility and researcher workshop
- establishing a bunded area for testing and assurance of water treatment technologies and development of chemical processing pilot equipment
- commissioning a new walk-in environmental growth chamber for studying concrete curing by controlling temperature and humidity conditions and for testing the corrosion of metals used in building structures
- upgrading the existing gas furnace to enable fire testing of walls to Australian Standard AS1530.4. The furnace measures 3 x 3 metres and its six gas burners can deliver heat up to 1000°C.

Mechanical, civil and electrical engineering projects at the Banyo Pilot Plant Precinct in 2014	
Damage detection in suspension bridges using vibration characteristics (Wasanthi Ramyalatha Wickramasinghe, PhD)	An experimental study of vibration based damage utilising a Story Bridge model (Craig JL Cowled, PhD)
Environmental durability study of CRFP (carbon-fibre-reinforced polymer) strengthened steel tubular structures under four-point bending test (Md Humayun Kabir, PhD)	Behaviour of CFRP strengthened steel tubular structures under axial impact (Chamila Rajeev Batuwitage, PhD)
Profile beam test (Janarthan Balasubramaniam, PhD)	Constant amplitude cyclic load tests of steel batten systems (Dinh Hao Phan, PhD)
Chute experiment to determine the feasibility of a sugar mill retrofit design (Neil Mackenzie)	Low voltage regulator testing for an energy company (Professor Richard Taylor)
High performance materials (Joshua Watts, PhD)	Material characterisation of thin layer mortared masonry (Shahid Nazir, PhD)

Hydrology, geology and ecology projects at the Banyo Pilot Plant Precinct in 2014	
Source characterisation of urban road surface pollutants for enhanced water quality predictions (S Wasanthi Nanayakkara Mummullage, PhD)	Pebble matrix filtration project (Daniel Niruban Subramaniam, PhD)
Risk to urban receiving waters from traffic generated chemical pollutants (Yukun Ma, PhD)	Pilot studies of heavy metal removal from contaminated water sources – 25kL/d plant (Professor Graeme Millar)
Examination of geological core samples from the Walloon Coal Measures (Jessica Sear-Hall, PhD)	Development and manufacturing of automated greenhouse gas measurement systems (Professor Peter Grace)
Australian freshwater crayfish (Lalith Dammannagoda Acharige, PhD)	The fate of above-ground carbon inputs (Elaine Mitchell, PhD, Michelle Gane)
Preparation of thin sections from rock samples for undergraduate teaching and postgraduate research projects	Processing of rock samples for undergraduate courses and postgraduate research projects

Da Vinci Precinct

Researchers Dr Felipe Golzalez (left) and Dr Aaron Mcfadyen (right) with the 'Flamingo' unmanned aerial vehicle in the Da Vinci Precinct; image by Jen Dainer (Industrial Arc Photography)

The Australian Research Centre for Aerospace Automation (ARCAA) facility, located at Brisbane Airport, is an award-winning building that was purpose built to meet the unique needs of ARCAA researchers. The design includes open plan office space, an aircraft simulation and testing laboratory, avionics development area, a general workshop and an indoor flying area.

With more than 40 research academics, engineers, support staff and students, ARCAA conducts research into all aspects of aviation automation. It specifically focuses on developing:

- autonomous technologies to support more efficient and safer use of airspace
- autonomous aircraft and on-board sensor systems for a wide range of commercial applications.

ARCAA transforms leading-edge research concepts into flight-tested reality, greatly accelerating the commercialisation process. The technologies developed at ARCAA are designed to be integrated into civilian manned and unmanned operations and implemented across a variety of sectors, including agriculture; mining and resources; emergency services; building and construction; energy and creative industries. The application of automation technologies will save these sectors significant time and money.

ARCAA's achievements in 2014 were significant:

- Several large-scale collaborative research projects were concluded, and elements of these projects were continued in more targeted R&D projects.
- The awarding of a UAV (Unmanned Aerial Vehicle) Operators Certificate (UOC) has given QUT the unique ability to flight test research concepts and collect valuable data for a multitude of end users.
- Two Queensland Government Science and Innovation Accelerate Fellowships were awarded, addressing issues critical to the routine use of unmanned aircraft for commercial applications.

Projects and usage

As shown in the table below, six projects were under way at ARCAA during 2014, with collaborative partners including the Queensland Government, Boeing, CSIRO, Insitu Pacific Limited, Thales Australia, Plant Biosecurity CRC, CRC for Spatial Information and the Australian Research Council. In addition, the facility supported research by 18 PhD and Masters students.

2014 ARCAA Projects

Project Name	Awarded By/Partners	Scheme	Description
ResQu – Creating a More Resilient Queensland: Unmanned Aircraft for Emergency Response and Biosecurity	Queensland Government Boeing CSIRO QUT Insitu Pacific	Queensland Government Smart Futures Fund	This two year project undertook safety studies and developed automated safety technologies to enable the timely approval of unmanned aircraft for disaster recovery, as well as routinely delivering benefits through surveys for biosecurity and resource management.
P4.31 – Enhanced Flight Assist System (eFAS) for Automated Aerial Survey of Powerline Networks	Cooperative Research Centre for Spatial Information	CRC	The objective of this project was to develop flight-path planning and aircraft guidance and control technology for aerial surveys of powerline networks. Previous research had already demonstrated the essential importance of basic automation technologies in such large-scale inspection tasks. This project developed additional automation mechanisms that improve inspection efficiency, operational flexibility and operational reliability, so that high quality spatial information can be delivered in a timely and cost-effective manner.
PBCRC5055 – UAVs for Plant Biosecurity	Plant Biosecurity Cooperative Research Centre	CRC	The primary objective of this project was to qualitatively evaluate the use of unmanned aerial systems (UAS) for biosecurity applications. The goal was to determine the fundamental factors pertaining to the operation of various UAS that will significantly influence how and where UAS can be effective throughout the plant biosecurity continuum. To this end, UAS regulation and performance attributes were considered in conjunction with the sensor payloads they may carry. The study will help key stakeholders make decisions regarding the use of UAS in the near and short term as part of biosecurity systems.
Scoping Study for UAS Airspace Integration and Enhanced Conflict Management	Thales Australia	Commercial research	This project identified existing unmanned aircraft (UA) airspace integration work being conducted elsewhere in the world, and pinpointed operational concepts specific to the operation of UA in Australia's distinctive environment. Whilst UA are yet to enter civilian airspace on a routine basis, they are becoming more prevalent as they move beyond the military sphere into the realm of government and private sector operators – hence the need to ensure that Australia's air traffic management systems are ready to cater for them.
Developing Novel Concepts for Improved Safety in Aircraft Emergency Situations	Australian Government Scholarships (DIISRTE) – Australian Research Council	Discovery Early Career Researcher Award (DECRA)	The aim of this project is to create an emergency system based on novel detection, control and planning algorithms that can be used in specific cases to improve a pilot's visual situation awareness in emergency forced-landing scenarios. This work will be evaluated in the context of landing site detection and guidance problems, and proven on ARCAA's fleet of manned and unmanned aircraft.
Drone Swarms for Persisent Operations with Human Operator Control	Queensland Government Boeing	Queensland Government Science and Innovation Accelerate Fellowship	This project will investigate control technologies for swarms of UAVs conducting tasks such as surveillance, search and rescue, and fire monitoring. Research partner Boeing Research & Technology – Australia will provide in-kind support to this three year project, whose outputs will seek to address the human resourcing constraints of current commercial operations.

Facility upgrades

ARCAA has unique flight test capabilities. With access to leading edge technology, an indoor flying laboratory, near real-time data feed from The Australian Advanced Air Traffic System (TAAATS), hardware and software-in-the-loop capabilities, unmanned and manned aircraft, QUT researchers have the exclusive ability to translate research concepts from paper to flight-tested reality.

In late 2014, ARCAA was certified by the Civil Aviation Safety Authority (CASA) to conduct commercial unmanned aircraft operations (UOC 1-12E1VR-01). This gives QUT an unmatched capability among Australian universities to conduct research operations anywhere in Australia (>3 nautical miles from a towered aerodrome). Rotary unmanned aircraft are teamed with advanced sensing equipment—including multispectral, hyper-spectral, LiDAR and gas sensors—to provide researchers with a new toolset for biosecurity, precision agriculture, environmental monitoring and infrastructure assessment applications.

In addition, a reconfigurable payload faring was completed on the Airborne Systems Laboratory (ASL), a custom-modified Cessna 172R general aviation aircraft—this enables the easy changing of camera systems including a CM160 multi-sensor gimbal (fitted with electro-optical and infrared imagery systems).

Two new cameras were acquired to augment the existing VICON system for the indoor flying laboratory, and will be commissioned in early 2015. This will enhance the capability for controlled flight-testing for research domains such as collision avoidance, vision-based navigation, path planning and human factors.

Outlook

With the addition of a dedicated research support team to facilitate the UOC, the operations of the Centre have matured to provide the broader QUT community with access to world class assets and capabilities. ARCAA will begin several major new collaborative projects in 2015, including:

- a project with Australia Zoo to evaluate the use of unmanned aircraft equipped with thermal cameras to rapidly assess koala population densities
- a three year Plant Biosecurity CRC project to investigate the sensitivities and capacity of emerging unmanned aerial systems and imaging technologies for biosecurity surveillance in the viticulture, horticultural and grain industries
- a three year Queensland Government Accelerate Fellowship, with collaborative partners Thales Australia and the Civil Aviation Safety Authority (CASA), to investigate how regional airspace can routinely accommodate UAVs operating in regional areas.

Mackay Renewable Biocommodities Pilot Plant

The Mackay Renewable Biocommodities Pilot Plant (MRBPP) is a unique research and development facility located at Mackay Sugar Limited's Racecourse Mill. The facility develops and tests methods of converting waste plant fibre, such as sugarcane bagasse, into ethanol and other high-value biofuels and chemicals, including lignin.

A robust biocommodities industry would have significant economic and environmental benefits for Australia, and the Mackay area is one of several regions of Queensland that are well placed to provide the required inputs and conditions to establish commercial biorefineries. Our Mackay facility is designed to accelerate the development of the Australian biocommodities industry by optimising the processes and minimising the costs of producing ethanol and other bioproducts. The aim is to link innovations in product and process development with the assessment of commercial viability, to enhance the uptake of industrial biotechnology in Australia.

We work with farmers, businesses and other research organisations to find cost-effective ways of turning plant waste into valuable products. The facility can demonstrate and simulate a range of biorefinery processes using various pre-treatment processes and highly flexible downstream processing of different types of biomass feedstock.

Projects and usage

Several projects were conducted at the Mackay Pilot Plant in 2014:

- Novel low cost technologies for biofuels production from sugarcane bagasse (Associate Professor Ian O'Hara, Dr Zhanying Zhang and Professor William Doherty). This project was undertaken within the QUT Syngenta Centre for Sugarcane Biofuels Development with funding from Sugar Research Australia.
- Demonstration of a new process for producing biofuels from sugarcane (Associate Professor Ian O'Hara, Dr Zhanying Zhang, Floren Plaza, Darryn Rackemann and David Moller). Confidential international partner.
- Fungal fermentation to produce bioproducts (Dr Zhanying Zhang, Associate Professor Ian O'Hara and Dr Lalehvash Moghaddam). Molasses is an inexpensive potential feedstock for the propagation of commercially significant fungal organisms. This project aimed to determine the ideal growth conditions for fungal species in molasses solution.

- Testing anaerobically treated bagasse as a dung beetle feedstock. This project aimed to monitor beetle reproductive behaviour in the bagasse compared to reproductive behaviour in cattle dung. The long-term goal is to industrialise the rearing of dung beetles.

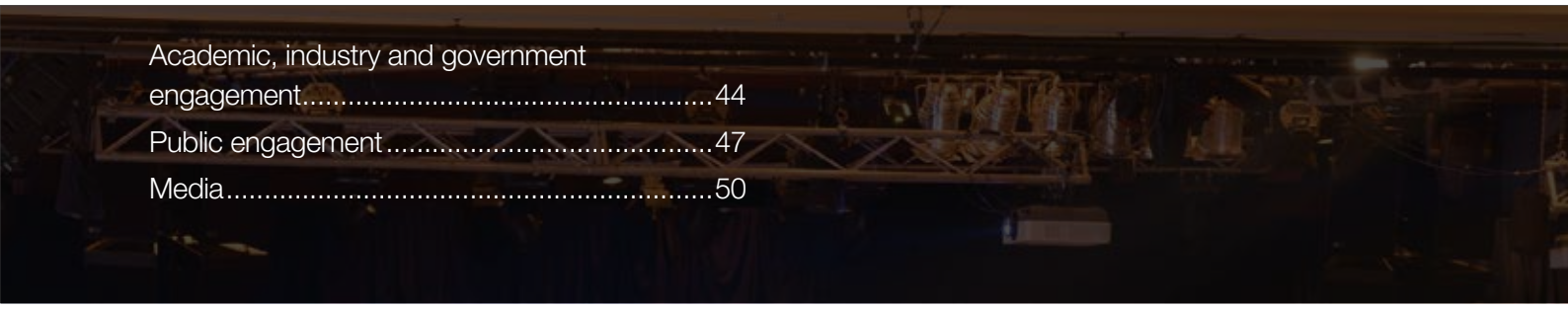
The facility also hosted a very successful Chemical Process Engineering Challenge for high school students (see page 49).

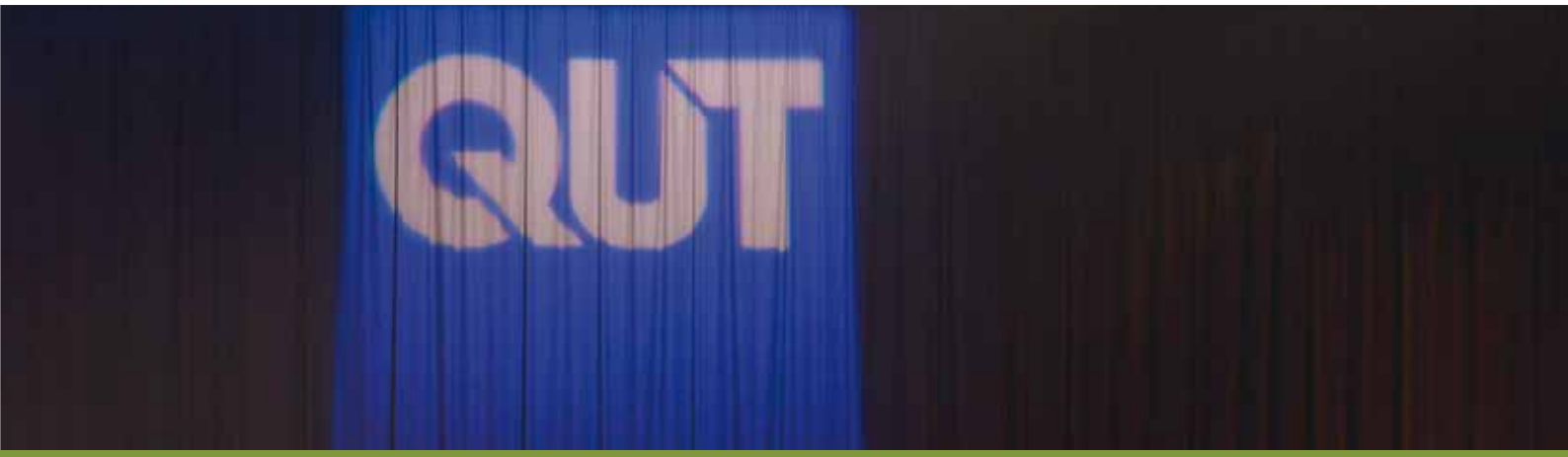
Facility upgrades

A new biochemical analyser was acquired to provide 'real time' bioprocess monitoring of analyte levels in both fermentation and biofuel research. The analyser has three biosensor modules that can measure a range of analytes—including glucose, lactate, ethanol, glycerol, sucrose and lactose—in crude bioprocessing samples. Other upgrades included modifications to improve the efficiency of the boiler, which provides steam for heating in processing equipment, and a refrigerated cool room for storage of temperature sensitive samples.

ENGAGEMENT AND OUTREACH

We engage with industry, government, other research organisations and the general public to share our research discoveries, foster collaborations and understand current challenges.





Academic, industry and government engagement

The B³ Symposium e-poster session, held at The Cube in the QUT Science and Engineering Centre

The IFE ran several very popular symposia, workshops, seminars and showcase events in 2014. These events brought together QUT researchers from different disciplines with researchers from other universities and representatives from industry and government.

Big Biology and Bioinformatics (B³) Symposium

On 24–25 November 2014, the IFE and the Institute for Health and Biomedical Innovation (IHBI) held the second annual QUT Big Biology and Bioinformatics (B³) Symposium. Following the success of the 2013 symposium, attended by 115 QUT staff and students, the 2014 symposium was opened up to researchers from across South East Queensland and 180 people attended. The symposium brings together researchers who study biological systems using advanced bioinformatics and mathematical techniques and 'omics' technologies such as next generation sequencing, mass spectrometry, nuclear magnetic resonance and high-throughput multiplex ELISA systems. Fourteen organisations sponsored the 2014 symposium.

The symposium was the culmination of a year of Big Biology and Bioinformatics events at QUT: seven B³ seminars and seven B³ workshops were held through the year. The seminars and workshops, attended by QUT research staff and students, explored the latest methods of collecting, analysing and using biological data, especially next generation sequencing (NGS) and proteomics data.

Statistical Modelling and Analysis of Big Data Workshop

Big data is now endemic in business, industry, government, environmental management, medical science, social research and many other fields. One of the challenges is determining how to effectively model and analyse data. On 24 February 2014, the IFE held a workshop that brought together international experts in statistical modelling and analysis of big data to share their experiences, approaches and opinions about future directions in this field. The workshop was attended by 320 people and was supported by the Australian Research Council Centre of Excellence for Mathematical and Statistical Frontiers and the Statistical Society of Australia.

Distinguished Visitor Lectures

The IFE Distinguished Visitor Lecture Series is a forum for senior academics and industry figures visiting QUT to share their perspective on the main trends and challenges in their field. In 2014, we presented ten Distinguished Visitor Lectures (see table below), which were attended by 50 people on average and more than 100 in some cases.

Lecture title	Speaker
The Genetic Revolution: How Genetics Could Transform Healthcare	Professor Peter Donnelly (University of Oxford and QUT)
Printed Electronics: Challenges and Opportunities	Eitan Zeira (OneSun Solar and Santa Clara University)
Near Real-Time In-Memory Processing of Big Data and its Applications in Science, Engineering and Business	Dr Jeffrey Word (SAP)
How Far and How Fast Can Biofuels Go?	Winthrop Professor Dongke Zhang (The University of Western Australia)
Making Sure Software Stays Insecure	Research Professor Daniel J. Bernstein (University of Illinois at Chicago and Technische Universiteit Eindhoven)
Redefining the Limits of Low-cost Organic Photovoltaic Devices	Dr Almantas Pivrikas (The University of Queensland)
Reactive Intermediates and Unusual Molecules	Professor Curt Wentrup FAA (The University of Queensland)
Action-FRET Coupled to Ion Mobility: A New Dimension to Mass Spectrometry	Dr Philippe Dugourd (French National Center for Scientific Research and the University of Lyon)
Light Management for Photovoltaics Using Nanostructures	Dr Paolo Prosposito (Università di Roma Tor Vergata and QUT)
Geological Research from the Russian Academy of Sciences	Professor Valery Vernikovsky (Novosibirsk State University)

CARF Showcase Seminars

The CARF Showcase Seminars, which are open to QUT staff, students and research partners, explore the equipment, capabilities and research applications of the IFE's Central Analytical Research Facility. In 2014, we presented four seminars in the series (see table below).

Seminar title	Speakers
LCMS Triple Quad – Applications in the -omics world	Dr Paul Wynne (Shimadzu) and Dr Pawel Sadowski (QUT)
Electron Probe Microanalysis (EPMA)	Dr David Steele (QUT) and Vitaly Lozbin (JEOL Australasia)
Electrochemical Characterisation with Bio-Logic	Jaroslaw Syzdek (Bio-Logic USA)
Gas Chromatography Mass Spectrometry (GCMS)	Dr Paul Wynne (Shimadzu Australasia) and Dr Paul Cunningham (QUT)

Microbiology at QUT and Beyond: A Workshop for Researchers and Industry

Microbiology is a fundamental scientific field that influences a range of research disciplines and industry sectors, from engineering and agriculture to human health and medicine. The IFE held a workshop on 29 October 2014 to help build a strong and active microbiology community linking QUT researchers and industry. Eighty people attended the workshop, at which academics, researchers, industry representatives and students showcased their work and capabilities through presentations and a one hour e-poster session at The Cube.

Small-Angle X-Ray Scattering (SAXS) Workshop

Small angle X-ray scattering (SAXS), along with small angle neutron scattering (SANS), provides fundamental information on the scale of nanometres to microns. It is a scientific field that influences a range of research disciplines and industry sectors that involve materials. SAXS analysis has the potential to provide information not available using other techniques and to confirm information derived by techniques based on different physical principles. On 18 November 2014, the IFE held a workshop for 80 people that included a series of talks on SAXS and its applications.

Mathematics in Industry Study Group (MISG)

From 2013 to 2015 QUT is the host of MISG, one of the world's longest running mathematics think tanks. Each year, teams of academics work for a week on real industry problems and produce reports summarising their findings and recommendations. In 2014, more than 100 applied mathematicians, statisticians and physical scientists worked for a week on the following projects (the names of the organisations that put forward the problems are in brackets):

- Using seaweed to enhance ethanol production (Venus Shell Systems Pty Ltd)
- Optimisation of the thermal and structural performance of an integrated patio door (Centor Design Pty Ltd)
- The flow of non-Newtonian fluids in open channels (Bechtel Australia Pty Ltd)
- Transport mode and cluster separation in road traffic network travel times (Queensland Government – Department of Transport and Main Roads)
- Determining the porosity of energy materials (CSIRO – Energy Technology)
- Determining optimal cheese brining times (Fonterra Co-operative Group Limited).

Agricultural Research Showcase

On 21 February 2014, the IFE ran a half-day Agricultural Research Showcase, attended by 100 QUT staff and students, about the funding opportunities available through the Australian Centre for International Agricultural Research (ACIAR) and the fifteen Rural Research and Development Corporations (RDCs). Speakers from ACIAR and several RDCs spoke about their funding programs and QUT researchers presented more than 50 posters displaying QUT's interdisciplinary agricultural research experience and capabilities.

ACIAR and the RDCs fund research in many areas that are a focus for QUT staff, such as biotechnology, engineering, business and marketing, landscape and ecology, climate and greenhouse gases, soil, water and agricultural production. The showcase was a great chance for IFE researchers from a wide range of disciplines to learn about funding priorities and opportunities and discuss overlaps and links between their research interests and projects.

Power, Energy and Clean Technologies (PECT) Seminars

Throughout 2014 the IFE continued running its popular PECT seminar series, which explores the latest developments in energy and power technologies and systems. The ten seminars held in 2014, listed in the table below, were each attended by between 30 and 70 people, including many from the energy industry.

Seminar title	Speakers
Advancing Energy Storage	Professor Gerard Ledwich (QUT)
Cool Roofs	Dr Wendy Miller (QUT) and Mr Glenn Crompton (QUT)
Aging Equipment	Dr Ghavameddin Nourbakhsh (QUT)
Energy and Population Policies in Australia	Professor Doug Hargreaves (QUT)
Renewable Energies in Australia: The Challenges of Numerical Modelling for Geothermal Energy	Dr Emilie Sauret (QUT)
German/Australian Renewable Fuel Research Collaboration: Queensland/ Karlsruhe Institutes of Technology – Focus on Biodiesel from Native Plants and Biomass Residues	Associate Professsor Richard Brown (QUT) and Mr Jahirul Islam (QUT PhD student)
Perovskite Solar Cells: A Revolutionary Change in Low-Cost, High-Efficiency Solar Cells	Associate Professor Hongxia Wang (QUT)
Batteries and Energy Storage: What's the Latest?	Professor Peter Talbot (QUT)
Safety of Green Refurbishment and Retrofitting Works	Dr Carol Hon (QUT)
Energy Showcase: QUT and Batteries	Professor Peter Talbot (QUT), Dr Michael Wishart (Ergon Energy), Ms Fanny Boulaire (QUT) and Associate Professor Robert Perrons (QUT)

Public engagement

Professor Michael Rosemann delivering his Grand Challenge Lecture on innovation systems

The IFE ran a series of very well attended and well received public events in 2014 that showcased science, technology, engineering and maths (STEM) research and explored some of the major challenges of the 21st century.

Grand Challenge Lecture Series

The IFE continued its popular Grand Challenge Public Lecture Series in 2014 with eleven more lectures by eminent researchers about the grand challenges confronting humanity in the 21st century (see table below). Each lecture was attended by between 75 and 170 people and streamed live to an average of 35 people. The audience for the lectures included many people from industry, government, other universities and the general public, as well as QUT staff and students from every faculty, institute and division. Videos of the lectures were added to the Grand Challenge Lecture Series playlist on QUT's YouTube channel (www.youtube.com/user/TheQUTube) and have been watched in most cases by several hundred people.

Lecture title	Speaker
Our Global Future: A New Direction or Business as Usual?	Professor Ian Mackinnon (QUT)
What Does it Take to Change the World?	Professor Peter Andrews (former Queensland Chief Scientist)
The Energy Transition and the Key Role of Plastics	Professor Reinhold Lang (Johannes Kepler University of Linz)
Science and a Rational Worldview: Humanity's Salvation?	Dr Paul Willis (RiAus Director)
Environmental Management in the Anthropocene	Professor David Schlosberg (University of Sydney) and a QUT panel of Professor Laurie Buys, Dr Cheryl Desha and Dr Jodi Frawley
Air Quality Reports on Our Mobiles: Do We Care?	Professor Lidia Morowska (QUT)
Biofabrication: The Future of Regenerative Medicine?	Associate Professor Mia Woodruff (QUT)
Rapid Evolution in Introduced Species: Will Weeds Become Our Future Natives?	Professor Angela Moles (University of NSW)
Future Crops: The Challenge to Feed the Next Generation	Professor Sagadevan G. Mundree (QUT)
Innovation Systems: How to Develop a Digital Mind	Professor Michael Rosemann (QUT)
Robots to the Rescue: The Unmanned Airborne Vehicle (UAV) Challenge	Professor Jonathan Roberts (QUT)

Dr Michio Kaku in Brisbane

The IFE helped organise the visit of world-renowned physicist, author and broadcaster Dr Michio Kaku to Brisbane on 5 June 2014. Dr Kaku presented his first major Australian public show, *An Evening with Dr Michio Kaku*, at the Brisbane Convention and Exhibition Centre. Compered by award-winning science writer and ABC TV regular Bernie Hobbs, *An Evening with Dr Michio Kaku* took the audience of more than 1500 people on an exciting journey into the future, exploring how our lives will be transformed in the coming decades by scientific and technological marvels, from accessing the internet through wallpaper to sharing real emotions on social media and storing our memories on a disk. Attendees also visited QUT's foyer exhibitions, which included quantum levitation demonstrations, a 3D printing machine and 3D printed giveaways, Lego robots and an unmanned aerial vehicle. Earlier in the day, Dr Kaku visited the QUT Gardens Point campus to explore the Cube, visit a high school workshop and address the media. His visit to QUT and his Brisbane show were covered extensively in traditional and social media. As the major sponsor of the evening event, QUT reinforced its position as a leading Australian university for STEM research and study.

Dr Michio Kaku being shown The Cube by IFE Executive Director Professor Ian Mackinnon

The full house at the Brisbane Convention and Exhibition Centre for An Evening with Dr Michio Kaku

National Science Week

The IFE played a major role in coordinating and organising QUT events for National Science Week on 16–24 August 2014. In particular, the IFE helped run a series of three well-attended and well-received events on 15 August to mark the start of the week: a Grand Challenge Lecture on biofabrication by Associate Professor Mia Woodruff; the launch of Chem World, a new display on The Cube; and Future Shapers: Rising Stars of Science Research, a public and industry engagement event at which three young QUT researchers, Dr Michael Milford, Dr Willa Huston and Dr Jennifer Firn, spoke about how their research will shape the world.

Associate Professor Mia Woodruff delivering her Grand Challenge Lecture on biofabrication

The 'Future Shapers' – Professor Bronwyn Harch, who compered the event, with Dr Jennifer Firn, Dr Willa Huston and Dr Michael Milford

QUT Nikon Small World Image Competition

From November 2013 through to March 2014, the IFE ran a light microscope image competition, sponsored by Nikon, for QUT staff and students. Thirty people entered the competition, submitting a total of 69 images, and 308 people voted for the 'People's Choice Award'. An awards ceremony and exhibition of the ten finalist images was held on 28 March at The Cube and was attended by 120 people. The ten finalist images have been displayed in various formats and forums since the competition closed—including on the display screens in the Science and Engineering Centre and at a QUT booth at the 2014 Royal Queensland Show.

The finalist exhibition and awards ceremony for the QUT Nikon Small World Image Competition

Competition winner Dr Luke Nothdurft in front of his winning image of a live coral branch in seawater

High school engagement program

The IFE played a key supporting role in the STEM (science, technology, engineering and maths) school engagement program run by the QUT Marketing and Communication Department.

From 7 to 11 July 2014, the inaugural Chemical Process Engineering Challenge was held at the IFE's Mackay Renewable Biocommodities Pilot Plant. The Challenge was developed and run by QUT's STEM Teacher in Residence, Anne Brant, in collaboration with the School of Chemistry, Physics and Mechanical Engineering and the Queensland Minerals and Energy Academy. Year 11 and 12 students from Mackay, Rockhampton, Townsville, Moura and Ipswich worked alongside IFE/SEF researchers and engineers, investigating various biochemical processes and designing and carrying out experiments to create biofuels. The Challenge was covered widely in the local media, including the *Mackay Daily Mercury* and the *Rockhampton Morning Bulletin*.

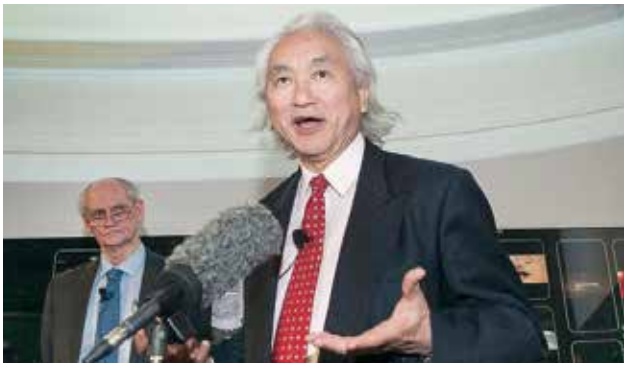
The IFE also supported the 2014 Vice-Chancellor's STEM Camp, which ran from 29 September to 3 October at the Gardens Point campus. During the camp, around 160 Year 11 students from across Queensland worked on a variety of STEM projects, several of them developed and run by IFE researchers in IFE facilities.

Samford Ecological Research Facility (SERF) Annual Information Session

On 23 October 2014, we held the sixth annual SERF Information Session, which was attended by around 40 people, including Samford residents, Marks family members and the local councillor for the Moreton Bay Regional Council, who is a strong supporter of SERF. The session gives the local community a chance to meet QUT staff and students and find out more about how QUT is using SERF. Several QUT researchers and staff gave presentations about our activities at SERF, including research projects, student field trips and property maintenance and upgrades.

Media

Professor James Dale, whose research into provitamin-A-enriched bananas made news in 2014



Dr Michio Kaku talking to the media and QUT staff and students at The Cube during his visit to Brisbane

Traditional media

Our researchers, projects and events were covered widely in a variety of local, national and international media outlets in 2014. Some of the highlights are summarised below.

Super bananas

The IFE's Centre for Tropical Crops and Biocommodities (CTCB) researchers had a significant breakthrough with the world's first human trial of pro-vitamin A-enriched bananas. The genetically modified bananas have elevated levels of betacarotene to help African children avoid the potentially fatal conditions associated with vitamin A deficiency. The project's leader, Distinguished Professor James Dale, who is the Director of the CTCB, was interviewed by a variety of media outlets including nine newspapers, six radio stations and three television stations.

Bees battle to the death

A study by QUT behavioural ecologist Dr Paul Cunningham and University of Queensland molecular biologist Dr James Hereward has revealed that two types of Sugarbag stingless bees are engaging in inter-species warfare and fighting to the death. The study, published in *American Naturalist*, was covered extensively by local, national and international media outlets, including Radio National, ABC North Queensland, 4BC Brisbane and 666 ABC Canberra in Australia and the BBC, *Science, National Geographic, Scientific American* and Discovery News overseas.

An Evening with Dr Michio Kaku

World-renowned physicist, futurist and science communicator Dr Michio Kaku visited QUT in June 2014, sharing his predictions on how technology will revolutionise our world. Following a presentation at The Cube, Dr Kaku took to the stage at the Brisbane Convention and Exhibition Centre for the first leg of his inaugural Australian tour, *An Evening with Dr Michio Kaku*. Dr Kaku's visit to QUT and Brisbane show were covered widely by a number of media outlets, including *The Courier Mail* (Brisbane), *The Daily Telegraph* (Sydney), 612 ABC (radio), and North West Star (Mount Isa).

The table on the next page lists other significant media stories about IFE researchers and research in 2014. (The QUT researcher is named in brackets.)

Newspaper articles	
'New phases for banana trials' (Professor James Dale)	*Australian Bananas*, 1 January
'Warning system a boost for drones' (Professor Duncan Campbell)	*The Australian*, 7 February
'Grass gene may save rice crops' (Professor Sagadevan Mundree)	*North West Star* (Mt Isa), 17 March
'Robot man seeks path to future' (Professor Peter Corke)	*Courier Mail* (Brisbane), 2 May
'QUT research aims at hardier mungbean' (Professor Sagadevan Mundree)	*Queensland Country Life* (Brisbane), 5 June
'Bananas set to save African lives' (Professor James Dale)	*Burnie Advocate* (Tasmania), 17 June
'Experts discuss robotic farming' (Professor Tristan Perez)	*Weekly Times* (Melbourne), 30 September
'Robot boat beats Singapore heat' (Dr Matthew Dunbabin)	*Queensland Times* (Ipswich), 31 October
'Robots doing the heavy lifting' (Professor Peter Corke)	*Weekend Australian*, 15 November
'QUT leads way in 3D printing' (Associate Professor Mia Woodruff)	*Courier Mail* (Brisbane), 22 December
Television programs	
Interview with Ms Anne Brant and Associate Professor Robert Speight on the Chemical Process Engineering Challenge	*WIN Mackay*, 8 July
Interview with Professor Mia Woodruff on 3D printing technology at QUT	*SBS Two*, 17 September
Indian Prime Minister, Narendra Modi, visits the Cube	*Channel 7* (Brisbane), 14 November
Interview with Dr Michael Milford on Alzheimer's research in rats	*ABC News 24* (Sydney), 9 December
Radio programs	
Interview with Dr Paul Cunningham about research into two competing stingless native bee species	*Radio National* (Canberra), 28 October
Interview with Professor Tim Foresman about wearable technology	*612 ABC Brisbane*, 19 November

Digital and social media

The IFE website, which is part of the QUT corporate website, contains detailed information about the IFE's themes, programs, centres, facilities and events. Traffic to the site has grown steeply over the past two years. The site was visited by 16526 unique visitors in 2014, up from 10404 in 2013 (an increase of 59 per cent).

The IFE has a playlist within QUT's YouTube channel, the QUTube, containing videos of the IFE Grand Challenge Lectures. This has significantly expanded the reach and impact of these popular lectures. The Grand Challenge Lectures added to our playlist by the end of 2014 had been watched 220 times each on average; some had been watched more than 500 times.

Our Flickr page, set up in 2013, contains a growing library of images of IFE staff, facilities and events. In 2014, we added photos of the Central Analytical Research Facility, the Banyo Pilot Plant Precinct, the Visualisation and eResearch team and facilities, the Big Biology and Bioinformatics Symposium and our National Science Week events.

The IFE set up a Twitter account in February 2014. By December 2014, there were 257 followers, including a range of organisations, researchers and members of the general public. We tweeted at least once a day, sharing news of research project activities and achievements, upcoming events, new equipment and interesting articles and blogs relevant to the IFE's research areas.

GOVERNANCE

The IFE's Executive Committee, Leadership Team and Health and Safety Committee oversee the direction, performance, policies and safety of the IFE.

Executive Committee and Leadership Team

The IFE is governed by an Executive Committee of senior QUT staff who meet quarterly to assess the performance, progress and plans of the IFE. In 2014, the committee consisted of:

- Professor Arun Sharma – Deputy Vice-Chancellor, Research and Commercialisation (Committee Chair)
- Professor Carol Dickenson – Senior Deputy Vice-Chancellor
- Professor Gordon Wyeth – Executive Dean, Science and Engineering Faculty
- Professor Mandy Thomas – Executive Dean, Creative Industries Faculty
- Professor Ian Mackinnon – Executive Director, IFE
- Professor Bronwyn Harch – Deputy Executive Director (Research), IFE; Assistant Dean (Research), Science and Engineering Faculty
- Mr Stephen Pincus – Executive Director, Finance and Resource Planning
- Ms Carol Richter – Executive Officer to the Deputy Vice-Chancellor, Research and Commercialisation
- Mr Jim Reeves – General Manager
- Ms Melanie Gunn – Resources and Administration Services Manager
- Ms Therese Ferlin – Program Support Officer / Executive Support Officer (Committee Secretary)

Day-to-day management of the operations of the IFE is the responsibility of the IFE Leadership Team, which in 2014 included:

- Professor Ian Mackinnon – Executive Director
- Professor Bronwyn Harch – Deputy Executive Director (Research), IFE; Assistant Dean (Research), Science and Engineering Faculty
- Mr Jim Reeves – General Manager
- Ms Melanie Gunn – Resources and Administration Services Manager
- Dr Kymberley Vickery – Director, Partnerships and Commercial Programs
- Dr Juan Cooper – Distributed Sites and Infrastructure Manager
- Professor Stephen Blanksby – Director, Central Analytical Research Facility

Health, safety and environment

The IFE Health and Safety Committee met quarterly in 2014 to review all areas of workplace safety and design measures to ensure that the IFE complies with all relevant HSE regulations and that all IFE sites are safe working environments. Members of the committee also represent the IFE on the Science and Engineering Faculty Safety Committee, the central Department of Health, Safety and Environment's Professionals Group and the university-wide Health and Safety Network.

Expressions of interest were called in 2014 for Health and Safety Representatives (HSR) on the IFE Health and Safety Committee. As a result, workers based at the Gardens Point campus and workers based at other sites each have a nominated HSR who has completed HSR training. We also welcomed a new Health and Safety Advisor in the Australian Research Centre for Aerospace Automation (ARCAA) facility.

IFE staff reported a small number of minor injuries and incidents in 2014, most related to chemical releases, trips, falls, cuts or abrasions. Our staff are regularly reminded of the importance of following safety protocols and wearing protective equipment.

The induction process for staff and students accessing the Central Analytical Research Facility was standardised in 2014, with all new users required to complete a general laboratory safety induction followed by lab-specific inductions given by laboratory technical managers.

The IFE also developed and implemented a new project management framework in 2014. All activity at the IFE's 'distributed sites' (the Samford Ecological Research Facility, the Da Vinci Precinct and the pilot plants at Banyo and Mackay) is governed by the IFE Operations Group. Requests for access must be accompanied by a project proposal and risk assessment. Proposals are vetted by technical managers and approved by IFE management before work can commence.

Research ethics

Any research activity that involves working with animals must comply with the Australian Code for the Care and Use of Animals for Scientific Purposes. In accordance with the code, QUT has a University Animal Ethics Committee (UAEC) that is responsible for monitoring the acquisition, transportation, production, housing, care, use and fate of animals. The code stipulates that all animal housing and laboratory areas must be regularly inspected by members of the UAEC and appropriate records must be maintained.

The IFE has two facilities where research activities may involve the use of animals: the Samford Ecological Research Facility, located in the Samford Valley, and the Banyo Aquaculture Facility, which is part of the Banyo Pilot Plant Precinct. The Banyo Aquaculture Facility, which to date has housed crayfish and silver perch fish, was inspected by the UAEC on 4 September 2014. The UAEC reported no issues with use of animals at the facility and/or the maintenance of records.

Technician Barry Hume at the Banyo Aquaculture Facility

Financial report

The table below provides a summary of transactions on IFE-related accounts for the period 2011–2014. This summary does not include any co-funded or fully funded initiatives by the IFE that are attributed to other University accounts (e.g. a Division, Faculty or School account). Revenue tracks research income administered by the IFE. Research attributed to other University units supported by the IFE (e.g. through support services, research infrastructure provision or collaboration) is not included in the revenue description.

Revenue	2011* $ '000s	2012 $ '000s	2013 $ '000s	2014** $ '000s
Research				
Competitive Grants+	2406	1304	2096	8828
University Distributions	0	59	25	1809
Commercial	0	1609	1748	4803
Philanthropy/Sponsorships/Misc	0	318	484	5291
Sub-total	2406	3290	4353	20731
Operations				
University Distributions	2811	5294	9702	13447
Testing Services/Consultancy	0	775	795	1076
Other	933	5	9	0
Sub-total	3744	6074	10506	14523
Total Revenue	**6150**	**9364**	**14859**	**35254**
Expenditure				
Research				
Employee Costs	2181	1797	1636	8429
Non-Employee Costs	552	1784	937	6740
Sub-total	2733	3581	2573	15170
Operations				
Employee Costs	2882	4294	6800	12158
Non-Employee Costs	334	1206	2837	3912
Sub-total	3216	5500	9638	16070
Total Expenditure	**5949**	**9081**	**12211**	**31239**
Profit/(Loss)	201	283	2648	4015
Capital Acquisitions++	628	391	991	675
Depreciation	17	71	201	1188
Closing Retained Funds***	-410	-37	1858	4527

* Includes Information Security Institute (ISI) and Institute for Sustainable Resources (ISR) accounts
** Includes reporting on the Centre for Tropical Crops and Biocommodities (CTCB)
*** Not carried forward in this reconciliation
\+ Grants to Chief Investigators in Faculties (e.g. ARC Discovery and Linkage Projects) are not included
++ Does not include Major Equipment

Queensland University of Technology
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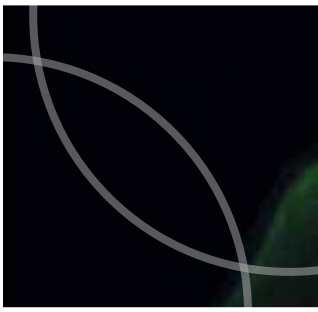

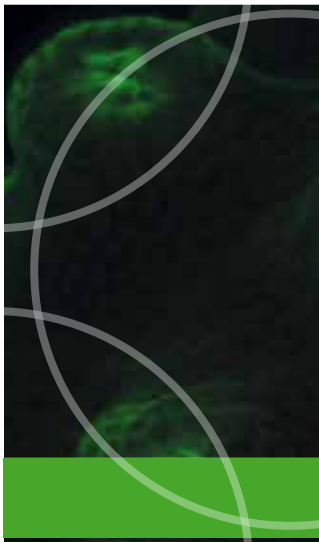

Contact us

Location
Level 6, P Block
QUT Gardens Point campus
2 George Street
Brisbane QLD 4000

Enquiries

Email	ife@qut.edu.au
Web	www.qut.edu.au/ife
Phone	+61 7 3138 9500
Mail	GPO Box 2434, Brisbane QLD 4001
Fax	+61 7 3138 4438

QUT acknowledges the financial support of the Australian and Queensland Governments and Atlantic Philanthropies in the establishment of the Institute for Future Environments and the Science and Engineering Centre.

CRICOS No. 00213J