QUT ife
Institute for Future Environments

ANNUAL REPORT 2015

ABOUT US

The IFE is a transdisciplinary research and innovation institute at Queensland University of Technology (QUT) in Brisbane, Australia. Thousands 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 projects relating to our natural, built and virtual environments.

Our mission

To generate knowledge, technology and practices that make our world more sustainable, secure and resilient.

Our vision

To be renowned as a catalyst for:

- addressing global challenges that build a strong Australia, with a competitive economy
- delivering innovations through transdisciplinary collaboration
- nurturing the entrepreneurial spirit of researchers
- inspiring a generation to recognise STEAM (Science, Technology, Engineering, Arts and Mathematics) as being at the heart of the country's competiveness.

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Participation in the IFE

2600+ participants across 2013–2015 (see p45), including:

- 1624 academic staff
- 42 directorate staff
- 68 technical staff
- 579 higher degree research (HDR) students
- 171 facility users
- 177 affiliates

MESSAGE FROM THE EXECUTIVE DIRECTOR

In the past year, we undertook major changes as the Institute transitioned from start-up mode to consolidation mode and we implemented key transdisciplinary research practices that will prepare us for the future. For example, after extensive consultation within our community, we revised our core research programs into themes and enabling platforms and developed leadership teams and strategic plans for these programs. This evolution was accompanied by a further increase in participation by University staff and students as well as a strong upturn in activities with our external stakeholders.

Our four revised research themes – Growing the Global Bioeconomy, Managing for Resilient Landscapes, Infrastructure for Sustainable Communities, and Harnessing Digital Productivity and Services – are all linked to specific sectors of the economy, namely the agricultural, environmental, infrastructure and ICT sectors. Broadly speaking, the themes are investigating how these sectors can be made more sustainable – economically and environmentally – and more attuned to the changing needs of society. In contrast, our three enabling platforms – IntelliSensing, Manufacturing with Advanced Materials, and Transforming Innovation Systems – are dedicated to developing technologies and systems with applications across many sectors of the economy, such as robots, sensor networks, nanotechnology, new partnership models and innovation pathways.

Leaders of the themes and platforms were appointed in June 2015. In turn, these leaders assembled leadership groups containing a mix of outstanding researchers from many disciplines within QUT's six faculties of Science and Engineering, Creative Industries, Business, Law, Education and Health. These leadership groups have developed broad strategic plans and are fostering a culture in which researchers with allied interests can readily connect and collaborate.

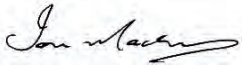
Improving the way that QUT does research and embracing transdisciplinary research, development and deployment (RD&D) is just a means to an end, of course. Our ultimate goal is to make an impact in the real world. Hence, our rationale: transdisciplinary research is essential because the problems faced by our society, our politicians, our industries and our landscapes are blind to disciplinary boundaries.

Working closely with the research leadership groups is our recently consolidated Knowledge to Innovation (K2I) Team, formed over the course of 2015 and led by Dr Mark Gibbs. The K2I Team is dedicated to linking IFE researchers to projects with partners in industry, government and the community sector, to steering IFE projects along the path from discovery to deployment and to connecting these projects with key administrative units in the University.

There are many indicators of strong partnerships within our communities and only twelve are highlighted in this 2015 Annual Report. I encourage you to peruse these case studies to gain insight into the outstanding developments that deliver great outcomes for our society. For example, the Strategic Investment in Farm Robotics (SIFR) program, supported by the Queensland Government, made great progress in 2015. This transdisciplinary research team, which includes experts in robotics, industrial design, computer-human interaction, economics, ecology and plant physiology, conducted very successful field trials of two agricultural robots, AgBot II and Harvey, and are now seeking commercial partners to deploy this technology. It is through such exemplars, and many others, that the IFE builds evidence that transdisciplinary RD&D has a valuable place in our community and our future.

We recognise that many people contribute to the success of this collaborative venture and for that we are grateful. One contributor who has seen the transition from the earlier Institute for Sustainable Resources to the IFE is Jim Reeves, a person of many talents who now serves our community via the Queensland Department of Environment and Heritage Protection. I would like to take this opportunity to thank Jim for his support and advice during his time with the IFE and to wish him well in his stewardship of a large, and priceless, portfolio.

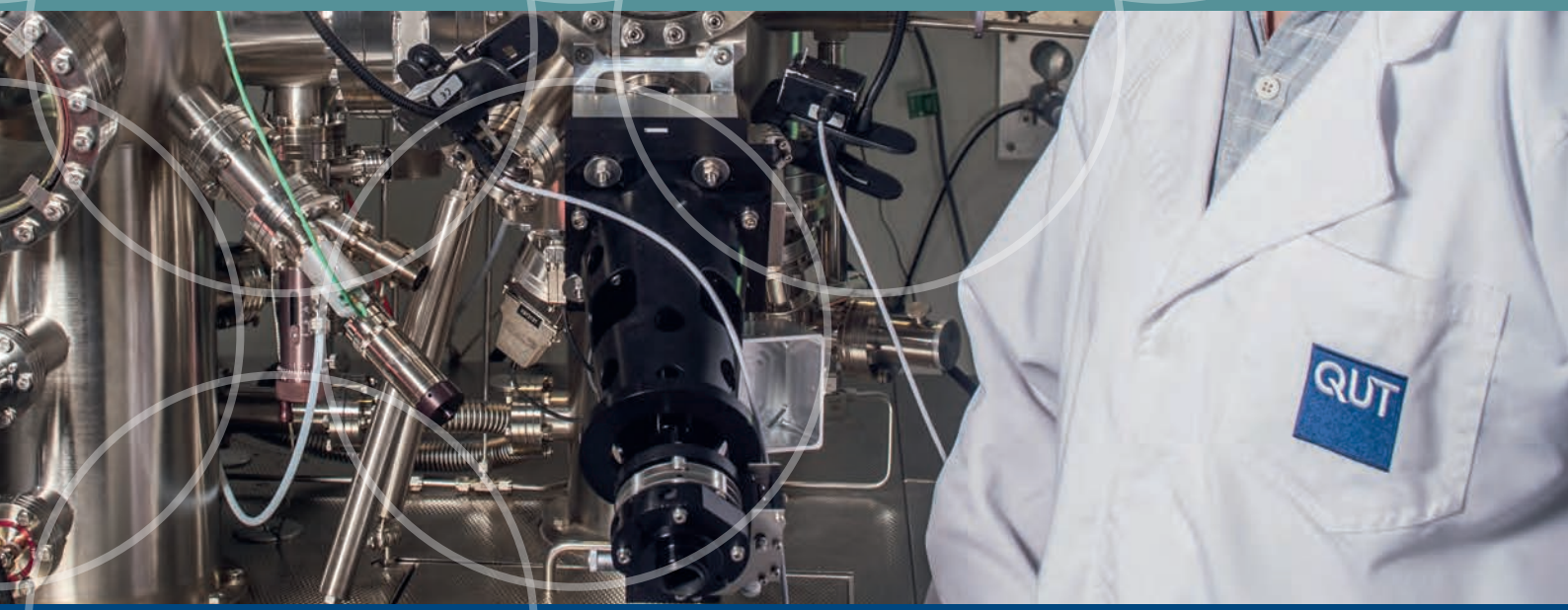
Our participants have delivered a strong performance during 2015 while at the same time transitioning our strategic outlook and practice to meet the challenging times ahead. In the coming years, we look forward to an ongoing, responsive tradition that delivers and deploys quality outcomes and impact to our broader community.



Professor Ian Mackinnon
IFE Executive Director

RESEARCH AND INNOVATION

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



Our research agenda

Transdisciplinary solutions to global problems

The IFE addresses social and economic challenges in a range of key sectors, including agriculture, mining, environmental management, manufacturing, services and information communication and technology. Our mission is to generate knowledge, technology and practices that make our world more sustainable, secure and resilient. We are studying the complex links and interactions between the three environments we live within – the natural, the built and the virtual.

The IFE enables hundreds of researchers and students from across QUT's faculties to collaborate on large-scale projects relating to the IFE's research themes and enabling platforms. It brings together transdisciplinary research teams, manages the research and innovation process and profiles the research(er) outcomes.

The IFE is driving a shift to transdisciplinary research collaboration, coordination and communication at QUT. The grand social, economic and environmental challenges confronting the world do not divide neatly into traditional academic categories, so researchers must go beyond conventional ways of thinking and working.

Deep research and expertise in specific disciplines is as important as ever, but large-scale programs and projects require teams of experts from many disciplines. The IFE draws on QUT's research strengths in specific disciplines of QUT's faculties and schools.

The IFE's research program comprises four research themes and three enabling platforms. Each research theme and enabling platform has an academic theme leader, a leadership team with broad relevant expertise, and a network of research support staff.

*Figure 1: The three converging environments the IFE is studying – **the natural, the built and the virtual***

Research themes

Our research themes are linked to specific societal challenges and sectors of the economy:

- **Growing the Global Bioeconomy** – food for all, better nutrition, valuable bioproducts
- **Managing for resilient landscapes** – monitoring and modelling ecosystems for sustainable development and stewardship
- **Infrastructure for sustainable communities** – planning, designing and building thriving communities
- **Harnessing digital productivity and services** – towards digital transformation, capitalising on strengths and mitigating challenges.

The scope and activities of the four research themes are covered in more details on pages 8–19.

Enabling platforms

Our enabling platforms are technologies, techniques and systems that can solve a wide range of problems for industry and society:

- **IntelliSensing** – transforming data collection, modelling, analytics and decision making
- **Transforming innovation systems** – increasing technology and information flow among people, enterprises and institutions
- **Manufacturing with advanced materials** – discovering and designing new and improved materials for diverse applications.

The scope and activities of the three enabling platforms are covered in more details on pages 20–29.

Allied research centres

The IFE supports a number of local and national research centres that work in areas aligned with our research themes and enabling platforms:

- **Australian Research Council Centre of Excellence for Mathematical & Statistical Frontiers (ACEMS)**– advanced mathematics, statistics, analytics, machine learning data and modelling (aligned to the IntelliSensing enabling platform)
- **Australian Research Council Centre of Excellence for Robotic Vision (ACRV)** – creating robots that can visually sense and understand complex, unstructured environments (aligned to the IntelliSensing enabling platform)
- **Australia-China Centre for Air Quality Science and Management (ACC AQSM)** – developing new technologies and techniques to better monitor, prevent and mitigate air pollution (aligned to the Managing for Resilient Landscapes theme)
- **Australian Research Centre for Aerospace Automation (ARCAA)** – unmanned aerial vehicles, aviation automation, on-board sensor systems (aligned to the IntelliSensing enabling platform)
- **Centre for Emergency and Disaster Management (CEDM)** – understanding and reducing the impacts of emergencies and disasters on health, communities and infrastructure (aligned to the Infrastructure for Sustainable Communities theme)
- **Centre for Tropical Crops and Biocommodities (CTCB)** – plant biotechnology, process engineering, industrial chemistry and commercialisation (aligned to the Growing the Global Bioeconomy theme)
- **Smart Transport Research Centre (STRC)** – supporting smart mobility and innovative transport solutions using new technologies, services and products (aligned to the Infrastructure for Sustainable Communities theme).

Research infrastructure and facilities

The IFE operates state-of-the-art research facilities for monitoring the environment, modelling complex systems, analysing solids, liquids and gases, and developing pilot equipment and processes. Our facilities play a vital role in supporting transdisciplinary research on a scale beyond the reach of individual research groups or disciplines. The technical staff in our facilities work closely with researchers and clients to identify and implement the best solutions to their problems.

Science and Engineering Centre

Houses the IFE Directorate, CARF, ViseR, and several floors of project rooms and open plan office spaces for researchers.

Banyo Pilot Plant Precinct

General purpose facility for large-scale structural, mechanical, electrical and water engineering research, product testing, sample processing and tropical aquaculture.

Visualisation and eResearch (ViseR)

Cutting-edge software platforms and AV and IT equipment, including The Cube, for developing innovative ways of modelling and visualising complex information for QUT, industry and government partners.

Da Vinci Precinct

Home to the Australian Research Centre for Aerospace Automation (ARCAA); includes an aircraft simulation and testing laboratory, an avionics development area, an indoor flying area, a general workshop and an open plan office area.

Central Analytical Research Facility (CARF)

Purpose-built labs for electron and light microscopy, analytical chemistry, molecular genetics, proteomics, small molecule mass spectrometry, X-ray diffraction, physical and mechanical properties.

Samford Ecological Research Facility (SERF)

51 hectare peri-urban field station for ecosystem research, environmental monitoring (soil, water, air and sound), and animal and plant population and behaviour studies.

Mackay Renewable Biocommodities Pilot Plant

A unique R&D facility based on the site of an operating sugar factory that develops technology and processes to convert biomass into biofuels and other bioproducts.

Redlands Research Station

66 hectare crop research station, owned by the Queensland Government, with five glasshouses (PC2 and non-PC2 containment) and field plots for crop trials.

The IFE's headquarters is the Science and Engineering Centre at QUT's Gardens Point campus, but our research facilities are spread around Brisbane and Queensland, as shown in the maps below.

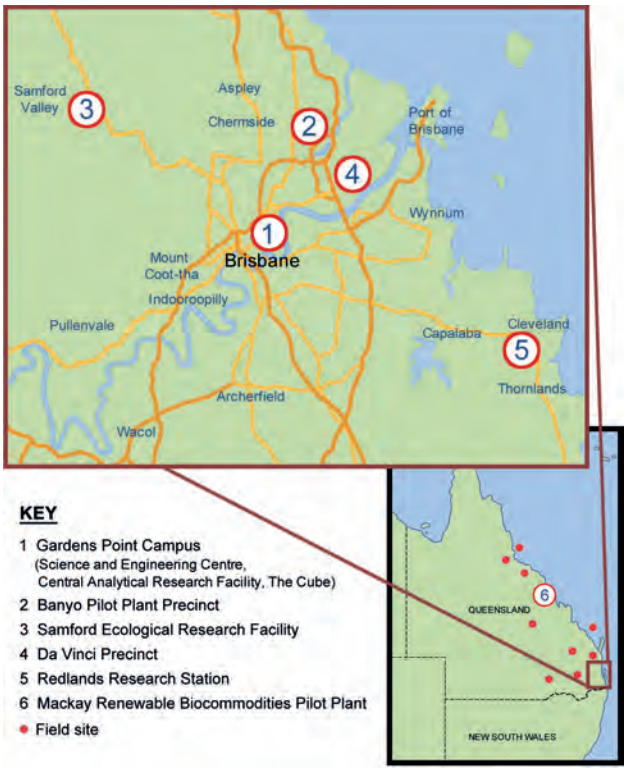


Figure 2: The locations of the IFE's research facilities

Research theme: Growing the Global Bioeconomy

Theme leadership group

L to R: *Dr Paul Cunningham; Dr Peter Prentis; Professor Roger Hellens (Theme Leader); Associate Professor Robert Speight; Dr Susan Theiss.*
Absent: *Associate Professor Caroline Hauxwell*

Real world context	
KEY TRENDS	One in eight people around the world does not have enough food to eat and one in four has nutritional deficiencies. By 2050, global food demand is projected to increase by 70 per cent. Around a third of all food produced for human consumption is lost or wasted, yet little of this waste is converted to valuable byproducts. Society increasingly expects agricultural operations to be environmentally friendly and sustainable, but many people are still resistant to genetically modified agricultural products
GRAND CHALLENGES	• Meeting human needs for food, feed, fibre and fuel as the global population grows • Transforming the bioeconomy to make it more productive, profitable and sustainable • Raising public awareness of the safety and benefits of genetically modified agricultural products

Our research strategy	
IMPACTS	Our research is designed to drive the following changes in the real world: • Bioeconomy industries are profitable. • Bioeconomy inputs are more sustainable. • The health benefits of diets increase.
FOCUSES	We are developing agricultural processes and products that are better for consumers, the environment and the economy. We are investigating how to: • develop crops with improved nutritional value, taste and convenience • reduce reliance on water, nutrients and sprays • add value to commodity crops • turn surplus biomass into sustainable fuels, chemicals and other valuable products.

Case study: Native tobacco plant to transform genetics research

Project or program title	*Nicotiana benthamiana* laboratory and wild isolates characterisation
Research theme or enabling platform	Growing the Global Bioeconomy
QUT project team	Professor Peter Waterhouse; Dr Julia Bally; Dr Hyungtaek Jung
Partner organisations	The University of Sydney; Plant and Food Research; CSIRO
Timeline	2012–ongoing

Why it matters

Nicotiana benthamiana is an ancient Australian tobacco plant, known as Pitjuri to Aboriginal tribes, that geneticists have been using for decades in laboratories around the world for many kinds of research, including testing viruses and vaccines. For a plant so routinely used in research, *Nicotiana benthamiana* itself has been little studied. Knowing more about the plant's history and genetics, and the basis of its unusual properties, could open up many new avenues of research in plant genetics and biotechnology.

Dr Julia Bally and Professor Peter Waterhouse

How the IFE is making an impact

In 2015, IFE researchers tracing the history of the *Nicotiana benthamiana* plant discovered a gene that could speed up plant genetics research and pave the way for growing food in sterile environments such as space stations. By sequencing the plant's genome and studying historical records, Professor Peter Waterhouse and Dr Julia Bally established that the original plant came from the Granites area near the border of Western Australia and the Northern Territory. Using a molecular clock and fossil records, they learned that the plant has survived in its current form in the wild for around 750 000 years.

Further investigation revealed how the plant managed to survive for so many years in such a harsh environment. The researchers discovered that *Nicotiana benthamiana* is the plant equivalent of the nude mouse used in medical research. It has lost its immune system, allowing it to channel its energy into germinating, growing and flowering quickly and setting seed after even a small amount of rainfall. It focused on creating large seeds and on getting these seeds back into the soil in time for the next rain.

This discovery has many potential applications in agricultural and medical research. It shows scientists how they could deactivate the immune systems of other plant species for research purposes. Just as nude mice can be excellent models for cancer research, 'nude' versions of crop plants could speed up agricultural research. Scientists could also use this discovery to investigate other niche or sterile growing environments where plants are protected from disease, including in space. Finally, the fact that the *N. benthamiana* variety from central Australia has doubled its seed size also opens the door for investigations into how the plant could be used commercially as a biofactory, as seeds are an excellent place to make antibodies for pharmaceutical use.

Researchers around the world can access Professor Waterhouse's open source website, **www.benthgenome.qut.edu.au**, which publishes the research team's latest genome and transcriptome assemblies of both laboratory and wild strains of *Nicotiana benthamiana*.

Dr Bally and Professor Waterhouse have lodged a patent on their study (Organisms with Modified Growth Characteristics and Methods of Making Them) and a research paper, "The extremophile *Nicotiana benthamiana* has traded viral defence for early vigour", was published in the journal Nature Plant **www.nature.com/articles/nplants2015165**.

Case study: Biotech research to boost livestock feed quality

Project or program title	Nutritionally enhanced yeast for improved livestock feed
Research theme or enabling platform	Growing the Global Bioeconomy
QUT project team	Associate Professor Robert Speight; Dr Leigh Gebbie
Partner organisations	Ingenza Limited
Timeline	2015–2016

Why it matters

Feeding livestock is a cornerstone of agriculture, and farmers must consider the safety, cost and nutritional value of the feed to ensure the animals receive the maximum benefit. One problem faced by the feed industry is the need to add multiple supplements to livestock feed, including enzymes to help the animals digest the feed and other supplements, such as yeast, that increase protein levels in the animals' diets.

How QUT is making an impact

QUT is leading new genetic research that aims to provide a nutritional boost for livestock and reduce costs for farmers and graziers. Developing an enhanced feed for livestock will improve the profitability of farms, which is particularly important in the drought conditions common in Australia.

In 2015, QUT microbiologist Associate Professor Robert Speight partnered with scientists from Ingenza Limited to demonstrate how a revolutionary gene editing technology called CRISPR-Cas9 could be used to improve livestock feed. Ingenza is a Scottish biotechnology company servicing clients across the chemical, pharmaceutical, food, feed and fuel industries.

Using CRISPR-Cas9 technology, researchers can make precise, targeted changes to the genome of living cells in a fast and accurate way that does not lead to any unwanted changes to the genome or addition of unnecessary foreign DNA.

Associate Professor Robert Speight

Commonly, yeast is added to livestock feed as a source of protein and enzymes are added separately to assist with feed digestion. The goal of this project is to generate a new variety of yeast that combines the required protein and the digestive enzymes. This enhanced yeast could then be fed to livestock to provide them with protein and assist with digestion and nutrient uptake.

In 2015, new yeast strains were constructed using CRISPR-Cas9. As part of this work, genetic elements controlling the production of a specific yeast enzyme with potential for use in animal feed were changed. In 2016, the effect of these genetic changes on enzyme production will be evaluated and the feed applications of the enzyme will be analysed in more detail.

IFE researchers are also investigating developing the enzymes themselves and moving towards lower cost, more fibrous feeds such as sugar cane fibre (bagasse). For bagasse to be used, it needs to be made more digestible so the animals can access the sugars and energy and release more nutrients.

Research theme: Managing for Resilient Landscapes

Theme leadership group

Top row (L to R): *Professor Peter Grace (Theme Leader); Associate Professor Beverley Henry; Professor Les Dawes; Associate Professor Ian O'Hara*

Bottom row (L to R): *Dr Grant Hamilton; Dr Susan Fuller; Dr Erin Peterson; Dr Matthew Dunbabin*

Real world context

KEY TRENDS	Landscapes and ecosystems around the world are under enormous pressure from the growing human population, natural habitat loss, shifting climate zones, changing land use priorities and increasing multinational competition for resources. Our livelihoods and wellbeing depend on the health of our natural, managed and urban environments, which are based on the quality of the soil, water and air and the delivery of high quality ecosystem services.
GRAND CHALLENGES	• Reducing greenhouse gas emissions and adapting to climate change • Sustainably producing 50 per cent more food and fibre by 2030 • Maintaining the health of landscapes and ecosystems around the world and reducing the pressure on finite natural resources

Our research strategy

IMPACTS	Our research is designed to drive the following changes in the real world: • improved resilience and condition of natural and managed ecosystems • increased resource use efficiency, productivity and profitability • increased ecosystem goods and services.
FOCUSES	Landscapes must be resilient and adaptable to retain their structure and functions while absorbing ongoing pressures and disturbances. We are studying how our urban, agricultural and natural landscapes function and how best to manage them. We: • develop management solutions at a variety of spatial and temporal scales, from fields to catchments, from days to decades • use state-of-the-art environmental monitoring, simulation and analytical technologies and techniques to develop new management practices • provide cost-effective sustainable development solutions for land managers to increase the productivity and diversity of our ecosystems • maintain the quality of the air, soil and water and different ecosystems.

Case study: Reducing nitrogen pollution for better agriculture

Project or program title	Increasing nitrogen use efficiency in Australian agriculture
Research theme or enabling platform	Managing for Resilient Landscapes
QUT project team	Professor Peter Grace (project leader); Dr David Rowlings; Dr Clemens Scheer; Dr Massimiliano De Antoni Migliorati
Partner organisations	Several Australian federal and state government departments and funding agencies
Timeline	2012–ongoing

Why it matters

Inefficient use of nitrogen fertilisers is a major source of environmental pollution and a significant barrier to improving Australia's agricultural productivity and profitability. Nitrogen losses from fertilisers cause damage to our natural ecosystems, waterways and reefs, putting agricultural production and global food security at risk. In Australia each year, one million tonnes of nitrogen fertiliser is applied to crops and pastures, and up to half is lost to the environment. The lost nitrogen includes nitrous oxide (N_2O), a potent greenhouse gas, and nitrate (NO_{3^-}), a major water-borne pollutant that contributes to excessive growth of plants and algae in rivers and lakes and represents an economic loss to farmers.

How the IFE is making an impact

The IFE leads Australian research into nitrogen use efficiency on farms. Over the past five years, our researchers have developed a suite of technologies and strategies to help farmers to use nitrogen fertiliser more efficiently and reduce nitrogen pollution while maintaining or improving productivity levels. These include:

- automated greenhouse gas monitoring stations (including stable isotopes) that measure emissions from farms of N_2O, carbon dioxide (CO_2) and methane (CH_4)
- improved modelling tools to allow farmers to manage fertiliser use and predict nitrogen requirements of crops
- new fertiliser management strategies for the effective use of enhanced-efficiency fertilisers and organic soil amendments, such as manures
- de-nitrification bioreactors that help reduce nitrate pollution of our waterways.

The IFE's greenhouse gas monitoring site at Kansas State University, established in 2015

QUT's internationally recognised approach improves soil organic matter content and fertility, reduces greenhouse gas emissions and improves nitrogen and water use efficiency. Elements of this approach are being rolled out in Queensland, New South Wales and the Northern Territory, as well as in India, Chile, USA and Brazil, in collaboration with local farmers.

IFE researchers led by Professor Peter Grace coordinate Australia's N_2O Network **www.n2o.net.au**, which provides the latest scientific data on reducing N_2O soil emissions and provides advice and tools for farmers, agronomists, researchers and policy-makers. QUT also maintains long-term research links with the prestigious Earth Institute in the USA and with organisations throughout North and South Asia and South America.

During 2015, the team established a long-term experimental greenhouse gas monitoring site at Kansas State University (pictured right), and published nine articles in high-ranking peer-reviewed international journals, including "Legume pastures can reduce N_2O emissions intensity in subtropical cereal cropping systems" in *Agriculture Ecosystems and Environment* and "Sampling frequency affects estimates of annual nitrous oxide fluxes" in *Nature Scientific Reports*.

Case study: Measuring ecosystem health through sound

Project or program title	Acoustic monitoring
Research theme or enabling platform	Primary: Managing for Resilient Landscapes. Secondary: IntelliSensing
QUT project team	Mr David Tucker; Dr Susan Fuller; Dr Ian Williamson; Adjunct Professor Stuart Gage; Professor Stuart Parsons; Dr Roger Coles; Dr Erin Peterson
Partner organisations	Michigan State University; Healthy Waterways Limited
Timeline	2012–ongoing

Why it matters

The world's ecosystems are under pressure from population growth, urbanisation and climate change. Governments agree that long term surveillance of our natural systems is needed to resolve the often competing objectives of environmental conservation and economic development. Traditionally, the health or ecological condition of landscapes has been measured using manual surveys, field observations and sound recordings that identify the cover, size and species of vegetation. These methods are very labour intensive and may involve invasive field assessments.

How QUT is making an impact

QUT researchers are looking for more efficient and effective ways to assess the health of ecosystems, using techniques that are non-invasive and allow for remote, automated collection of data. 'Eco-acoustics', or monitoring of the health of ecosystems using sound, is one technique being investigated.

The many sounds that make up the 'soundscape' of an ecosystem can be divided into three broad categories based on their frequency: sounds produced by living things, sounds made by the physical environment (such as wind, rain and thunder) and sounds made by human technology. What does a healthy ecosystem sound like? In simple terms, the more natural the sounds, the healthier the ecosystem.

Acoustic sensing technologies have the potential to give scientists and environmental managers a simple method of checking the health of an ecosystem at a given time or tracking changes in ecosystem health over months or years. Automated sensor systems do not interfere with the behaviour of the observed species and have minimal impact on the environment. They can also collect data 24 hours a day, 7 days a week, greatly reducing the cost and risk of error associated with surveys by humans.

In 2015, PhD researcher David Tucker completed in-depth vegetation condition and landscape assessments, bird surveys and acoustic analysis of ten fragmented forest remnants within South East Queensland. The results of the traditional field methods of measuring condition were then compared to the results of acoustic monitoring. This work scientifically validated the links between the ecological condition and the soundscape of the forests studied, providing further evidence of the effectiveness and potential of bioacoustic monitoring as a tool for measuring ecological condition.

This research builds on the work of bioacoustics pioneer Professor Stuart Gage from Michigan State University, who is an Adjunct Professor at QUT and has visited Brisbane on many occasions to conduct acoustic research at the IFE's Samford Ecological Research Facility (SERF) and other locations. The IFE maintains these strong global links through its ties to Professor Gage and involvement with the International Society of Ecoacoustics.

Acoustic monitoring also has other research applications, such as identifying the presence of particular animal species within a landscape. QUT researchers in computer science, including Professor Paul Roe, have used sound recordings to identify bird species at SERF. These researchers have compared recordings with a comprehensive field census dataset to develop an acoustic environmental workbench, developed computer assisted sampling methods to estimate species richness, and analysis methods for handling 'big data'. A solar-powered acoustic monitoring system is permanently installed at SERF as part of its involvement in the Australian Government's Terrestrial Ecosystem Research Network (TERN). TERN was established to enhance ecosystem research in Australia through systematic national data collection.

QUT researchers are also using acoustic sensors to monitor bats. Honours student Katherine Jeffrey in conjunction with Professor Stuart Parsons, Dr Susan Fuller, Dr Roger Coles and Dr Erin Peterson, and in partnership with Healthy Waterways Limited, is investigating whether bat activity and diversity can be used as an indicator for water quality, and thus stream health. Many species of bat rely on insects emerging from streams for food. Insects can be negatively affected by poor water quality and this in turn may affects bats. Bats are able to be monitored acoustically (by listening for their echolocation calls) over wide spatial and temporal scales relatively cheaply, making them an excellent potential indicator species.

Research theme: Infrastructure for Sustainable Communities

Theme leadership group

Front row (L to R): *Professor Edward Chung; Dr Marc Miska; Professor Laurie Buys (Theme Leader); Dr Tracy Washington; Professor Robin Drogemuller; Associate Professor Geoff Walker.*
Back row (L to R): *Dr Cheryl Desha; Mr Raymond Johnson; Dr Vicky Liu; Professor Marcus Foth; Associate Professor Rosemary Kennedy; Dr Susan Fuller.*
Absent: *Professor Margot Brereton; Dr Lyndall Bryant; Professor Gerard Ledwich.*

Real world context	
KEY TRENDS	The world's population is growing, ageing and urbanising. Global demand for energy, water and resources is rising while finite natural resources are declining. Communities expect that public and private infrastructure – from energy and ICT networks to transport systems and buildings – will be integrated, sustainable and tailored to community needs. New ways of designing, building and managing infrastructure are emerging in the transition from the industrial to the digital age.
GRAND CHALLENGES	• Creating infrastructure that enriches communities while being sustainable, resilient and responsive to climate change • Developing technology and systems that improve the planning, design and operation of infrastructure • Developing policy frameworks, funding systems and business models that deliver sustainable, community-centred infrastructure

Our research strategy	
IMPACTS	Our research is designed to drive the following changes in the real world: • Infrastructure is resilient and provides net benefits to the environment. • Infrastructure supports connected and enriched communities. • Infrastructure models are financially sustainable.
FOCUSES	We are investigating how to: • optimise the construction, performance and security of physical and virtual infrastructure by evaluating how these systems interact, and how future systems should be built and managed • better manage major community infrastructure by developing new methods to understand system behaviour and response • enable faster and safer service delivery, to meet the growing demands of connected consumers, businesses and governments, by developing better ICT network infrastructure.

Case study: Cool paint job saves energy, money and emissions

Project or program title	Guided Innovation Alliance: Cool roofs
Research theme or enabling platform	Infrastructure for Sustainable Communities
QUT project team	Professor John Bell (project leader); Dr Wendy Miller; Dr Tuquabo Tesfamichael
Partner organisations	Ergon Energy; SmartGrid Partners
Timeline	2013–2015

Why it matters

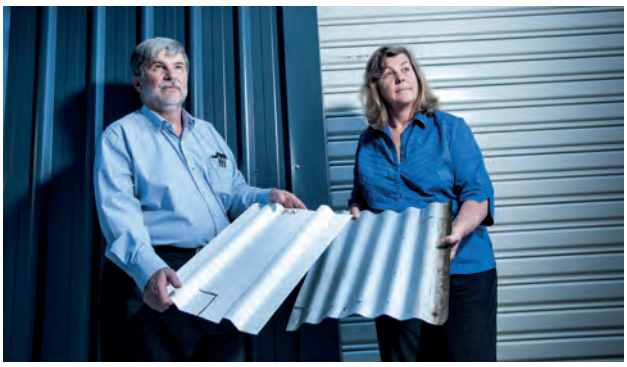
Many Australian households, schools and workplaces use air conditioning to find relief from sweltering summers. Air conditioning is costly to run, increases electricity consumption and peak demand, and indirectly generates CO_2 emissions. Homeowners, governments and industry are all looking for ways to save on energy use, electricity costs and greenhouse gas emissions.

How the IFE is making an impact

QUT researchers have found that a special roof coating can make buildings more energy efficient by improving their thermal performance. Professor John Bell and Dr Wendy Miller (pictured) conducted a two-year study focusing on a sample of houses, schools, offices and retail spaces in Brisbane and Townsville. They discovered that painting roofs with a special reflective paint resulted in a 2°C reduction in the indoor temperature of buildings or rooms without air conditioners.

The specific white paint used in the research reflects 88 per cent of the sun's energy, resulting in a cooler roof and hence cooler inside temperatures. By comparison, a standard light-coloured roof reflects less than 65 per cent of the sun's energy and a dark-coloured roof reflects less than 25 per cent of the sun's energy.

The sixteen buildings studied made significant savings in energy usage and electricity costs. Average energy savings of between 5 and 30 per cent were made, with most buildings reducing energy consumption by more than 15 per cent. The trials indicate the economic benefits of cool roof coatings would be greatest for single storey buildings, buildings with aged, dark- or medium-coloured roofs, buildings with no or low levels of roof insulation, and buildings with high air conditioning use.



Professor John Bell and Dr Wendy Miller

This discovery is good news for home and business owners looking for simple ways of reducing the costs of operating a house, business or school while maintaining a comfortable environment for the building occupants. A cool roof is a passive cooling solution that does not require ongoing investment in the electricity network or in housing. It also helps to reduce peak demand for electricity. QUT supports the inclusion of the cool roof coating in local building regulations, as has been done in California energy code since 2005.

The project was run under the Guided Innovation Alliance, a collaboration between QUT, electricity distributor Ergon Energy and SmartGrid Partners. This alliance sees some of the world's latest innovations in energy-saving technology tested at QUT and throughout Queensland.

> Ergon Energy Emerging Markets Manager Glenn Walden said the research findings could benefit both the business and residential consumers: "Ergon is committed to assisting customers with reducing their power bills. Ergon could use these results on constrained parts of the network where businesses and residents paint their roofs with this reflective white paint and reduce peak demand. Coupled with other strategies, this can defer the need for expensive network augmentation that ultimately would be paid for by all customers."

Case study: Sparking innovation in Australia's senior living industry

Project or program title	Senior Living Innovation
Research theme or enabling platform	Infrastructure for Sustainable Communities
QUT project team	Professor Laurie Buys (project leader), researchers from the faculties of Creative Industries, Science and Engineering, Business, Law, Health and Education
Partner organisations	Senior living industry and related industries
Timeline	2015–2020

Why it matters

Australians are getting older and the way we age is changing. The proportion of people aged over 65 years is projected to more than double by 2054–55, and the 'new senior' expects to lead an active, healthy life, maintaining their social connections and community participation as they age. The retirement living industry estimates that 5.3 per cent of Australians aged over 65 years currently live in a retirement village. Just to maintain that level, 266 000 new dwellings will need to be built by 2040 and existing accommodation will need to be retrofitted as capital assets degrade, functions change and technology advances.

How the IFE is making an impact

The IFE initiated a major new project in 2015 that will reconceptualise the experience of ageing in Australia and transform senior accommodation through innovative models, services and infrastructure. The Senior Living Innovation (SLI) project is designed to foster healthy, active ageing, community connectedness and business innovation. The ultimate goal is to produce great communities and living environments for senior Australians.

SLI is a collaboration between QUT and industry that will inform policy development and decision making in the senior living industry. It will deliver robust evidence, best-practice standards and practical tools for the planning, construction and operation of senior living facilities. Our researchers are developing a virtual platform that brings to life village and private spaces and community infrastructure to allow greater industry innovation and community engagement in the design process.

Professor Laurie Buys

The challenges the project addresses include:

- ensuring services for seniors are interconnected and support thriving communities
- planning and building 'future-proof' accommodation that reflects the expectations and requirements of the 'new senior'
- managing the life cycle of senior living infrastructure and creating innovative facilities through urban infill models and retrofitting of existing accommodation.

SLI will make a practical, commercially focused contribution towards retirement living industry transformation. It will help industry to reduce its costs and increase the quality and personalisation of its services using new digital technologies.

In August 2015, QUT hosted a Senior Living Innovation Workshop that brought together industry representatives and QUT researchers from a range of fields to discuss the future of the senior living industry. Participants explored the ways in which cutting-edge research and emerging technologies – from robotics and virtual reality to information services and design-led innovation – could transform the business models of retirement villages.

Research theme: Harnessing Digital Productivity and Services

Theme leadership group

Top row (L to R): *Associate Professor Alexander Dreiling (Theme Leader); Professor Marek Kowalkiewicz; Professor Larry Neale; Professor Uwe Dulleck*

Bottom row (L to R): *Dr Debra Polson; Professor Axel Bruns; Dr Mandy Lupton; Professor Nicholas Graves*

Real world context

KEY TRENDS	Digital transformation of businesses and societies is one of the most significant drivers of global wealth redistribution. Data is now recognised as an asset and value driver everywhere in the economy, in every sector and every organisation. Technologies including mobile devices, the Internet of Things, spatial information and big data analytics are having a significant impact on business productivity and processes. New opportunities and industries are emerging, and with them come new challenges and risks relating to privacy, access, security, crime and intellectual property.
GRAND CHALLENGES	• Identifying and capitalising on the commercial and social potential of emerging digital technologies • Positioning Australia to export digital services to the expanding Asian middle class • Developing vibrant tech start-up communities in Australia that can seize the opportunities presented by collaborative consumption and the sharing economy

Our research strategy

IMPACTS	Our research is designed to drive the following changes in the real world: • The digital age fosters strong, resilient and inclusive communities. • The value of tech businesses and digitally transformed businesses based in Australia increases. • Individuals benefit from digital transformation through reduced costs of living, access to new services and a higher quality of life.
FOCUSES	We are investigating how to: • improve business productivity and profitability by helping organisations to better understand their business, customers and competitors • predict and manage the impacts of emerging digital technologies on individuals, businesses and societies by focusing on legislation, sustainability and privacy • define new business strategies based on digital transformation of products and services.

Case study: Digital technology takes off at Brisbane Airport

Project or program	Digital Departure Card
Research theme	Primary: Harnessing Digital Productivity and Services Secondary: Infrastructure for Sustainable Communities
QUT team	Dr Debra Polson; Dr Tim Donnet; Associate Professor Alexander Dreiling
Partner organisations	Brisbane Airport Corporation; Australian Customs Service; Department of Immigration and Border Protection; Kernhard Pty Ltd
Timeline	2013–2015

Why it matters

The airport experience is a journey within a journey. Passengers pass through a series of formal stages – check in, baggage drop, security and so forth – on their way to the plane. They talk to staff, pass through checkpoints, buy food and souvenirs, fill out forms and present documents. Innovative airports are exploring ways in which digital technologies can make the passenger experience – and their own business processes – as smooth, seamless and simple as possible.

How the IFE is making an impact

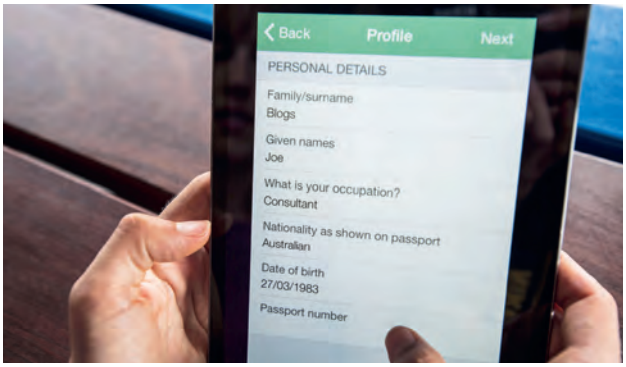
QUT has a long-standing research and development relationship with Brisbane Airport Corporation (BAC), the operator of Brisbane Airport, which is consistently recognised as a leading airport nationally and internationally. In 2012, Associate Professor Alexander Dreiling took over the role of BAC Airport Innovation Chair, with the goal of developing a cohesive digital strategy for the airport and investigating how social media, mobile apps, websites and other digital assets and services could contribute to the business. In 2015, several connected projects led by Associate Professor Alexander Dreiling came to fruition.

Creating a first-rate airport app for mobile phones and tablets was one of the key priorities in the digital strategy for BAC. Associate Professor Dreiling drove the effort to select a vendor to develop the app and enlist a QUT Masters student to gain insights into what features users would find the most beneficial and engaging.

The Brisbane Airport App, first released in 2013 and updated in 2014 and 2015, allows passengers to look up information on departures and arrivals, parking and security, shopping and dining, and what to do and see in Brisbane. It also includes terminal maps and the 'My Trip' function, through which passengers can track the status of their flights, be notified of schedule changes and record where they parked their car.

The app has received significant acclaim and global recognition, being chosen as the best aviation app worldwide for both airlines and airports in a 2015 Moodie APPraisal report and receiving a 'Best in Class' International Media Award in the airline category. In September 2015, the app was adapted to make it compatible with the Apple Watch, furthering its potential use.

One major new feature added to the Brisbane Airport App in 2015 is a world-first Digital Departure Card (pictured on page 19) for international passengers. QUT research into the customer experience at Brisbane Airport had found that some passengers, particularly those who did not speak or read English or were infrequent travellers, struggled with filling out paper arrival and departure cards. The Digital Departure Card was designed to make the process simpler, easier and quicker for outgoing passengers.



Left photo (L to R): *Stephan Clemens (Kerhard), The Honourable Ian Macfarlane MP, Vice-Chancellor Professor Peter Coaldrake (QUT), Associate Professor Alexander Dreiling (QUT) and Roel Hellemons (BAC) at the launch of the Digital Departure Card*
Right photo: *A screen shot of the Digital Departure Card*

To use the new Digital Departure Card, passengers with the Brisbane Airport App on their mobile device enter and save their details before arriving at the airport. This information is converted into a QR code that is scanned and printed at bespoke departure card kiosks located in the International Terminal. The kiosk prints personalised cards, which are signed by the passenger and collected by Customs officers during the normal departure process. Passengers can choose to save their profiles (as well as the profiles of family members with their permission) within the app so that they do not have to fill in their personal information every time they travel internationally from Brisbane.

QUT students from the faculties of Creative Industries, Business and Science and Engineering worked with academic staff to build business cases, marketing plans and technical prototypes to present to BAC, which produced the final product and incorporated it into the Brisbane Airport App. As it is the first of its kind in Australia, the Digital Departure Card initiative is now a prototype that allows performance measurement and design refinements for future large-scale releases.

The QUT team also incubated the idea of the departure card kiosk – a global first – at which passengers can print their departure cards to give to Customs staff. Brisbane-based entrepreneur, software architect and developer Stephan Clemens of Kernhard Pty Ltd created a smart, production-ready kiosk and the first kiosk went live at Brisbane Airport in March 2015.

> Julieanne Alroe, Brisbane Airport Corporation (BAC) CEO and Managing Director, said “We are fortunate to have a long association with Queensland University of Technology (QUT) and it was a team of QUT Interactive and Visual Design students who came up with the initial idea of digitalising the Departure Card process as part of a practical assessment…The result is an Australian if not a world first digital solution that will save time, streamline processing and help reduce anxiety associated with departure formalities, especially for non-English speaking travellers.”

Enabling platform: IntelliSensing

Theme leadership group

Top row (L to R): *Professor Tristan Perez (Enabling Platform Leader); Dr Matthew Dunbabin; Associate Professor Dian Tjondronegoro; Professor Duncan Campbell; Dr Erin Peterson; Dr Grant Hamilton; Professor Ian Turner.*
Bottom row (L to R): *Professor Kerrie Mengersen; Professor Jonathan Roberts; Mr Raymond Johnson; Associate Professor Tomasz Bednarz; Professor Troy Farrell; Professor Paul Hyland.*

Real world context	
KEY TRENDS	Governments, businesses and individuals often suffer from data overload and yet lack the critical information they need to make sound decisions and address management problems. Society is also on the cusp of a revolution in the way we sense and interact with the world. Technological advances in robotics, autonomous systems, sensor networks, and mobile and wearable devices are generating extraordinary volumes of data and giving us unprecedented power to extract key information that helps us understand and manage natural and built environments. This revolution will transform a wide range of industries and sectors as well as the policy-making processes of governments.
GRAND CHALLENGES	• Developing technologies and methods for collecting and analysing large amounts of data to increase situational awareness and gain new insights • Harnessing key information to make our natural and built environments more resilient, secure and sustainable (socially, economically and environmentally) • Designing sensing and data analysis infrastructure with economies of scale for solving management problems and making critical decisions • Addressing society's concerns about policy and law governing robotic and sensing technologies.

Our research strategy	
IMPACTS	Our research is designed to drive the following changes in the real world: • Many industries increase their productivity through IntelliSensing. • IntelliSensing enhances decision making for triple-bottom-line sustainability. • New digital–physical markets and businesses are formed.
FOCUSES	We are investigating how to: • create robots and autonomous systems that augment our capacity to perceive, think and act by sensing and responding to their environments; • design innovative sensing and visualisation tools that allow governments, businesses and individuals to easily access and digest large volumes of data; • develop mathematical models, analytics tools and control strategies that facilitate the rapid integration, dissemination and interpretation of large and complex data sets and improve decision-making; • overcome barriers to the adoption of intellisensing technologies by addressing concerns relating to privacy, security and trust.

Case study: Saving the Reef from the crown-of-thorns starfish

Project or program	COTSbot: a prototype Autonomous Underwater Vehicle (AUV) to detect and manage Crown-of-Thorns Starfish (COTS) populations
Research theme	Primary: IntelliSensing Secondary: Managing for Resilient Landscapes
QUT team	Dr Matthew Dunbabin (project leader); Dr Feras Dayoub; Professor Peter Corke
Partner organisations	qutbluebox
Timeline	2015–2016

Why it matters

The World Heritage-listed Great Barrier Reef, stretching along the Queensland coast for 2300 kilometres, is one of the most complex, biodiverse and beautiful ecosystems on the planet. Home to 600 species of hard and soft coral, 1600 fish species and hundreds of other types of marine creatures and birds, it is visited by more than two million tourists from around the world each year. The reef is under significant threat, not only from climate change, pollution and illegal fishing, but also from one of its own residents, the crown-of-thorns starfish *(Acanthaster planci)*. An estimated 40 per cent of the reef's total decline in coral cover was caused by outbreaks of this coral-eating starfish.

How the IFE is making an impact

QUT roboticists Dr Matthew Dunbabin and Dr Feras Dayoub have created the world's first underwater robot designed to control crown-of-thorns starfish (COTS) numbers. Nicknamed the COTSbot, it promises to be a powerful tool in the fight to protect the reef from COTS outbreaks, complementing and greatly extending the work of human divers.

The advantage of the COTSbot is that multiple robots can work day and night and in any weather. Each robot is designed to search the reef for up to eight hours at a time, and can carry up to 200 lethal shots before refilling. Dr Dunbabin believes the best control strategy could be for groups of COTSbots to be deployed into an area to control the bulk of the COTS, with human divers following at a later time to hit any remaining COTS.

The COTSbot is equipped with stereoscopic cameras to give it depth perception, five thrusters to maintain stability, GPS and pitch-and-roll sensors, and a unique pneumatic injection arm to deliver a fatal dose of bile salt. It also has a state-of-the-art computer vision and machine learning system, and is designed to learn from its experiences in the field. If it is unsure that something is actually a COTS, it takes a photo of the object to be later verified by a human, and that human feedback is incorporated into the robot's memory bank.

COTSbot being trialled on the Great Barrier Reef

The project team spent six months in 2015 developing and training the robot to recognise COTS among coral, using thousands of photos and videos of the reef. Then from September to November 2015, the COTSbot successfully completed its first trials on the Great Barrier Reef, where it was tested with living targets. In the trials on the reef, a human verified each COTS identification the robot made before the robot was allowed to inject it. The robot was able to identify and track all the visible COTS it swam over, ready for human verification, and provided the world's first robotic injection of COTS in the field.

In February 2016, the COTSbot is returning to the reef for further trials, this time operating autonomously, both for navigation and COTS detection and injection. This will be the first time such robotic capabilities have been demonstrated. QUT is in discussions with a potential commercial partner about scaling up the manufacturing and deployment of the COTSbot and hopes to sign an agreement in 2016.

Case study: Agricultural robotics: the future of farming technology

Project or program	Strategic Investment in Farm Robotics (SIFR) research program
Research theme	IntelliSensing
QUT team	Professor Tristan Perez (Project Leader and Lead – Dynamics and Control); Mr Ray Russell (Lead – Mechanical Design); Mr Owen Bawden (Lead –Industrial Design); Dr Jason Kulk (Lead – Software Design); Dr Christopher McCool (Lead – Robotic Vision); Dr Christopher Lehnert (Lead – Manipulation); Dr Inkyu Sa (Lead – Visual Servoing); Dr Feras Dayoub (Robotic Vision), Dr Andrew English (Engineering Support); Associate Professor Ben Upcroft (Robotic Vision); Dr Tanya Scharaschkin (Plant Physiology); Professor Margot Brereton (Computer-Human Interaction); Professor Paul Hyland (Business and Economics); Associate Professor Jennifer Firn (Ecology); Ms Victoria Sullivan (Administrative Support)
Partner organisations	Queensland Department of Agriculture and Fisheries (DAF); ARC Centre of Excellence in Robotic Vision (ACRV)
Timeline	2013–2016

Why it matters

Robots and autonomous systems have the potential to transform agriculture and make the farms of the future more efficient, profitable, sustainable and safe. Agricultural robots will play a vital role in helping farmers manage the daily operation of farms in the coming decades, by autonomously weeding, fertilising and controlling pests and diseases, while also collecting vast amounts of data to inform management decisions.

Australian farmers are seeking more efficient methods of delivering high-quality produce and ensuring the long-term sustainability of their businesses in a globally competitive sector.

How the IFE is making an impact

The IFE is at the forefront of research and innovation in agricultural robotics, integrating deep agricultural knowledge and systems science with powerful digital technologies – from robots and autonomous systems to big data analytics, economic modelling and decision science.

The Queensland Government, through the Department of Agriculture and Fisheries (DAF), is currently co-funding QUT's program on Strategic Investment in Farm Robotics (SIFR). This three-year program, conducted at QUT under the ARC Centre of Excellence for Robotic Vision with the support of IFE, aims to develop and fast-track farm robotic technology that will reinvigorate agricultural productivity by increasing production and reducing costs. The SIFR program takes an integrated approach and focuses not only on technology, but also on key enabling factors for its adoption, including economics and business; risk, regulation and policy; and social aspects such as workforce education and training.

Agbot II: Weed detection, classification and elimination

AgBot II is an innovative agricultural robot prototype fully designed and fabricated by QUT researchers and engineers, with support from the Queensland Government. Part of a new generation of crop and weed management machinery, AgBot II is designed to work in autonomous groups in both broadacre and horticultural crop management applications.

The robot's cameras, sensors, software and other electronics enable it to navigate through a field, apply fertiliser, detect and classify weeds, and kill weeds either mechanically or chemically. AgBot II takes information on the geometry of paddock, sets its path and follows it, covering the area for weed control and crop nutrient management. This technology promises to reduce the cost of weeding operations by approximately 90 per cent, which could save the Australian agricultural sector A$1.3 billion per annum.

Agbot II and project team members (L to R) Mr Simon Thomas; Mr Andrew English; Dr Inkyu Sa; Dr Christopher McCool; Professor Tristan Perez; Mrs Victoria Sullivan; Ms Tyaka Ringrose; Mr Owen Bawden; Mr Raymond Russell; Dr Jason Kulk; Dr Christopher Lehnert

In June 2015, trials of the AgBot II prototype were carried out at the Queensland Government's Redlands Research Station, with outstanding results. In these field trials, AgBot II achieved an overall success rate in weed detection and classification above 90 per cent. Its highest performance was with cotton (97.8%) and wild oats (97.3%), its lowest performance with sowthistle (82.0%). The trials also demonstrated the success of spot-spraying selected weed species and using a robotic hoe to mechanically remove weeds from the soil.

QUT is now seeking commercial partners both in Australia and overseas to move the AgBot II prototype into real world applications.

Harvey: Robotic harvesting of capsicums

The SIFR team, led by Professor Tristan Perez, has also developed a new agricultural robot prototype – nicknamed 'Harvey' – designed to harvest capsicums (sweet peppers). In November 2015, the team conducted the first trials of the robot at a Queensland Government protected cropping facility in North Queensland (pictured). Tasked with identifying and picking red capsicums, Harvey performed significantly better than any capsicum-harvesting robot ever has.

Despite significant efforts by the worldwide horticultural research industry, progress in creating robots to harvest capsicums has been modest to date. In late 2014, worldwide literature indicated a success rate of only 6 per cent in testing scenarios similar to those used for Harvey, and up to 30 per cent when the crop is modified and leaves are removed.

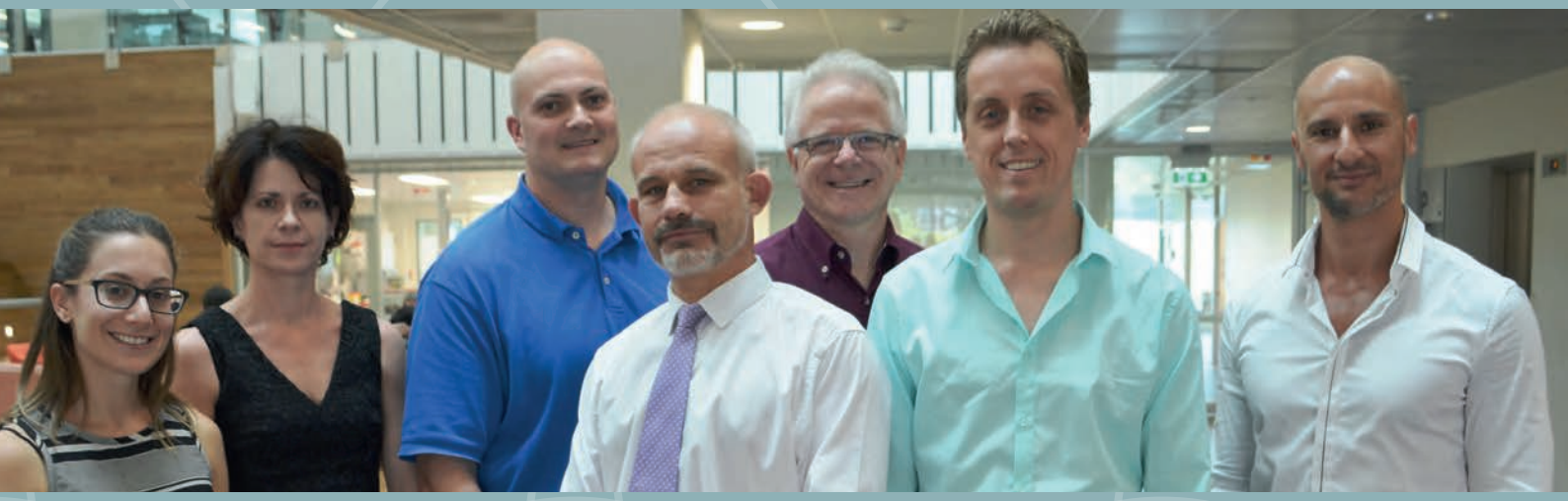
Harvey achieved a harvesting success rate of 65 per cent with unmodified crops (that is, with no leaves removed or fruit moved before harvesting). In 2016, the research team will fine-tune Harvey's performance and conduct further trials, and they believe only minor modifications will be required to achieve an overall success rate exceeding 90 per cent.

How does it work? Harvey's robotic arm has a camera and a unique cutting tool attached to it. Using data from the camera, the robot creates a 3D model of each fruit and its surroundings and plans and controls the robotic arm and cutting tool as they locate and detach the fruit. The combination of state-of-the-art robotic-vision software and novel crop-manipulation tools enables the successful harvesting of the crop and promises significant benefits for horticulture growers.

As with AgBot II, QUT is now seeking partners both in Australia and overseas to commercialise this technology. In the future, our researchers also plan to investigate how automated harvesting technologies can be used for other crops, such as mangoes, strawberries and avocados.

Harvey the capsicum-picking robot being tested at a Queensland Government protected cropping facility in November 2015

Enabling platform: Transforming Innovation Systems



Theme leadership group

Left to Right: *Ms Kylie Pappalardo; Professor Rachel Parker; Associate Professor Robert Perrons (Enabling Platform Leader); Professor Neil King; Distinguished Professor Stuart Cunningham; Dr Henri Burgers; Dr Ozgur Dedehayir*

Real world context	
KEY TRENDS	The innovation system – the path from discovery to deployment – is not working as well as it could in Australia. Many businesses and organisations do not have ready access to the knowledge and skills they need to be innovators. Asset-intensive industries, such as the energy and resources industries, are not well served by innovation research or practice, but are eager to be more innovative and increase their rate of technological change. Despite the myriad electronic collaboration tools available, distance still often stifles the innovation process within Australia and between Australia and the rest of the world.
GRAND CHALLENGES	• Developing the capacity of Australian businesses and organisations to change and innovate faster, so that they remain competitive in a rapidly changing world • Streamlining the innovation system so that research efforts are not wasted and research breakthroughs benefit society more quickly • Increasing engagement between industry and the research sector in Australia

Our research strategy	
IMPACTS	Our research is designed to drive the following changes in the real world: • Australian industries have more resilient revenue streams. • Australia focuses its R&D resources on the projects that matter. • Distance is no longer an impediment to connected innovation.
FOCUSES	We are investigating how to: • initiate, conduct and deliver research more effectively so that innovations can be evaluated and adopted more easily by industry, governments, and the public • develop university–industry relationships that generate new research opportunities and innovation pathways • help businesses and organisations to develop sustainable revenue streams while still experimenting, adapting and exploiting opportunities • change business processes, business models, industry structures, and regulatory frameworks to support innovation • develop innovation management methods that more tightly link research programs to the needs of governments, markets and society.

Case study: Australia Post – Innovating for a digital future

Project or program	Ignite Australia
Research theme or enabling platform	Transforming Innovation Systems
QUT team	Professor Michael Rosemann (project leader); Dr Willem Mertens; Professor Marek Kowalkiewicz; Professor Michael Rosemann; Associate Professor Robert Perrons; Ms Monica Bradley
Partner organisations	Australia Post
Timeline	2015–2017

Why it matters

Australian businesses and organisations need to adapt and innovate faster, so that they remain competitive in a rapidly changing world. As the global digital economy emerges and expands, it is critical that Australian enterprises identify and exploit the opportunities presented by digital delivery of products and services.

How QUT is making an impact

Australia Post is a commercially run, government-owned enterprise that provides postal, retail, financial and travel services to all Australians. Australia Post delivers more than 60 million items every week and acts as an agent for more than 750 businesses and government entities, including over 70 financial institutions. With the sharp increase in online commerce and communication and the corresponding decline of physical mail, Australia Post is seeking to re-evaluate its services and business models. In 2015, Australia Post partnered with QUT and the PwC Chair in Digital Economy to investigate how Australia Post can play an expanded role in the digital economy and help customers and local communities to participate and thrive in the digital economy too.

The PwC Chair in Digital Economy, established at QUT in early 2015, positions Queensland to take advantage of digital transformation in the global economy and explores new opportunities for collaboration between academia, industry and government. The role is sponsored by PricewaterhouseCoopers, QUT, Brisbane Marketing and the Queensland Government's Department of Science, IT and Innovation. Professor Marek Kowalkiewicz was appointed to the role in August 2015, after Associate Professor Robert Perrons acted in the role during the inception and formation of the PwC Chair in Digital Economy team.

L to R: Greg Sutherland, Australia Post Chief Marketing Officer; Professor Michael Rosemann, QUT Information Systems; Tracey Gosling, National Director of State Government Sector & QLD/TAS; Christine Corbett, Executive General Manager for Postal & Retail Services; Ian Jones, former General Manager Enterprise Corporate and Government Sales; Professor Rowena Barrett, QUT School of Management and Ewen Stafford, Chief Operating Officer

Over the course of 2015, through workshops, interviews, design jams, presentations and a conceptual paper, the PwC Chair in Digital Economy explored ideas for how Australia Post can best use its existing assets and resources – including its network of more than 4000 post offices – facilitate e-commerce and build its revenue resilience. It has also explored new digital identity models with multiple organisations during these workshops.

> Australia Post's Group Chief Operating Officer, Ewen Stafford, said the partnership aims to ignite digital and disruptive thinking, enabling their staff to innovate and provide better outcomes for their customers: "Australia Post is at the forefront of the digital revolution, with over $2 billion invested in our IT and broader business in the past four years. We have the platforms and capability, and we now need to further grow our digital mindset and QUT have agreed to help us do that. QUT's team has a wealth of expertise and we will be working with them on three streams over the coming year."

Case study: A digital revolution in public utilities

Project or program	The affordances of smart meters: Opportunities for Queensland Urban Utilities and its ecosystem
Research theme or enabling platform	Transforming Innovation Systems
QUT team	Professor Marek Kowalkiewicz (project leader); Professor Michael Rosemann; Associate Professor Robert Perrons
Partner organisations	Queensland Urban Utilities
Timeline	2015–2017

Why it matters

By continuing to innovate, utilities and other large public service organisations can increase operational efficiency, improve safety standards, enhance customer experiences and improve workplace cultures. They can leverage existing data and emerging digital platforms to transform their service delivery systems and practices.

How the IFE is making an impact

In 2015, Queensland Urban Utilities (QUU) partnered with the PwC Chair in Digital Economy to investigate how the organisation can develop more innovative approaches to service delivery. QUU is one of the largest water distributor-retailers in Australia, supplying drinking water, recycled water and sewerage services to more than 1.4 million people in South East Queensland via a $5 billion infrastructure network.

This multi-staged project will review how QUU currently uses digital information, and how new digital technologies, smart meters and the Internet of Things might transform the management and delivery of public utilities in the short and long term. By identifying opportunities for QUU to better use its existing data and information, the project team will help QUT to improve its operations and customer experiences and explore new market models that take advantage of emerging network-wide intelligence.

Professor Mark Kowalkiewicz leads industry workshop with Queensland Urban Utilities executives

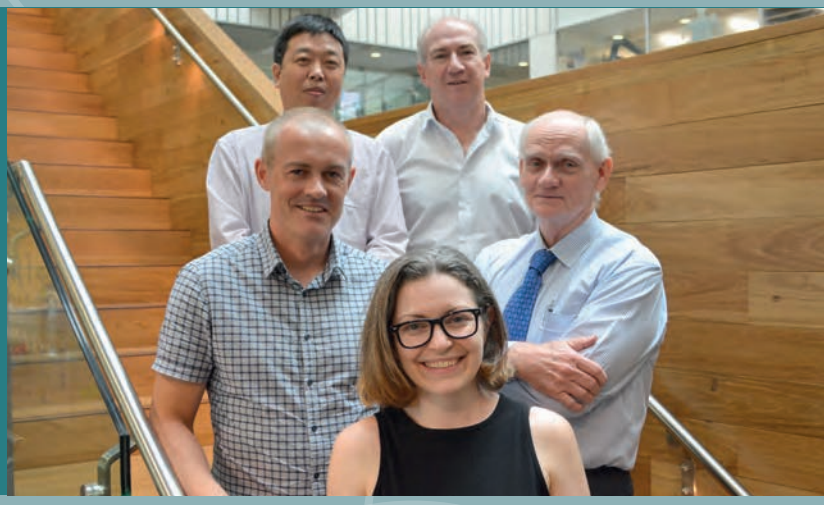
During 2015, project activities included:

- a workshop to create an opportunity statement on the ‘digital utility of the future’
- a design jam with students, customers and QUU staff to generate and shortlist ideas
- development of the shortlisted ideas to prototype stage, including an assessment of the business model, technological readiness and first customer insights
- in-house seminars with QUU executives.

Enabling platform: Manufacturing with Advanced Materials

Theme leadership group

Clockwise from bottom: *Dr Jennifer Macleod; Associate Professor Anthony O'Mullane; Professor YuanTong Gu; Professor Peter Talbot; Professor Ian Mackinnon*
Absent: *Associate Professor Prashant Sonar; Dr James Blinco; Associate Professor Mia Woodruff; Dr Tim Dargaville*



Real world context	
KEY TRENDS	Past societies depended on stone or bronze or iron. Today, silicon and polymers are supporting and transforming the world. Materials science and engineering are integrating concepts and techniques from many disciplines, including chemistry, biology, physics, engineering, information sciences and mathematics. Computer modelling is combining with highly specialised lab equipment to allow precise design of advanced materials for specific purposes.
GRAND CHALLENGES	• Minimising the social and environmental impacts of material sourcing, manufacturing, use, recycling and disposal • Developing high-performance materials with diverse applications across many industries in the digital age • Catalysing new industries in Australia that capitalise on the country's expertise in materials characterisation and processing

Our research strategy	
IMPACTS	Our research is designed to drive the following changes in the real world: • Global industry uses resources more efficiently. • The life cycles of materials are more environmentally sustainable. • Industry shares the benefits of new materials with communities.
FOCUSES	We are investigating how to: • enhance the performance of materials by changing their electrical, magnetic, thermal and energy-conversion properties • produce higher quality coatings and films to protect or deliver devices, sensors and surfaces • create new industries through materials design, demonstrating feasible industrial materials production and innovative processing and analytical techniques.

Case study: Organic LEDs shining new light on our health

Project title	Next generation biomedical sensors
Enabling platform	Manufacturing with Advanced Materials
QUT project team	Dr Soniya D. Yambem (project leader); Associate Professor Prashant Sonar; Associate Professor Mia Woodruff
Timeline	2015–2018

Why it matters

Organic light emitting diodes (OLEDs), which contain a thin organic layer that emits light when electrified, are transforming screen technology by enabling thinner, lighter, more flexible displays with wider viewing angles and higher colour contrast. OLED displays are already being used commercially in televisions, computers, smart phones and games consoles. Another major potential application for OLEDs is in wearable medical devices, such as fitness trackers and adhesive bandages – but research into how OLEDs could be used to monitor a person's health is still in its infancy.

Dr Soniya Yambem in the new organic electronic device laboratory at QUT

How the IFE is making an impact

In 2015, QUT produced its first OLEDs on campus, after establishing an organic electronic device laboratory within the IFE's Central Analytical Research Facility (CARF). The laboratory gives QUT researchers the tools they need to make and test organic electronic devices, including OLEDs and organic field effect transistors (OFETs), in a controlled atmosphere with very low oxygen and moisture levels.

Dr Soniya Yambem is leading a research project to test whether OLEDs can accurately measure a person's physiological condition. By optically sensing the composition of a person's blood or pulse, OLEDs in wearable medical devices could measure various physiological parameters and present a picture of a person's current physical state and fitness level.

OLEDs are light, flexible and easy to fabricate, which means they could be shaped to the human body for specific applications. Moreover, OLEDs can be easily programmed or tuned, so it might be possible to customise and print devices for each patient or patient group.

Monitoring a person's health using a wearable sensor offers a range of possibilities. In hospitals, adhesive bandages or pads containing OLEDs could be applied to infants in intensive care, avoiding the need for multiple wired sensors, which can be distressing for the patients and their families. OLEDs could also be used in fitness wristbands to help people track their own health day by day.

The first stage of Dr Yambem's project, completed in 2015, was to establish the facility for fabrication and testing of OLEDs at QUT. Over the next two years, Dr Yambem will trial the use of OLEDs in biomedical devices, in collaboration with researchers at QUT's Institute for Health and Biomedical Innovation. By 2018, Dr Yambem aims to demonstrate the feasibility of optical sensing using OLEDs, a platform technology with many potential applications in medicine and beyond.

Case study: Smart sensors contributing to a greener environment

Project title	Development of nanomaterials for gas sensing applications
Enabling platform	Manufacturing with Advanced Materials
QUT project team	Dr Mahnaz Shafiei; Professor Nunzio Motta; Mr Carlo Piloto
Timeline	Ongoing

Why it matters

Mobile gas sensors are increasingly being used for applications including health and environmental monitoring, robotics and security. Gas sensors can monitor air quality by detecting environmental pollutants and gases to help improve human, animal, plant and environmental health, and increase energy efficiency within green buildings.

Nanostructured mobile gas sensors can be embedded in sensor nodes for the Internet-of-Things (IoT) applications or in mobile systems for continuous monitoring of air pollutants and greenhouse gases using smart phones, robots and unmanned vehicles. Due to their low power needs, these sensors can provide long-term, real-time data. Research is continuing to finetune the development of high-performance gas sensors with low fabrication and operational costs.

How the IFE is making an impact

The IFE is currently conducting research focused on developing a new technology for inexpensive, reliable, portable gas sensors with ultra-low power requirements and applications in environmental and air quality monitoring.

In 2012, Dr Mahnaz Shafiei and Professor Nunzio Motta established a world-class Sensor Laboratory at QUT, complementing the advanced equipment in the IFE's Central Analytical Research Facility (CARF). Researchers use this specialist laboratory to investigate new nanomaterials for room temperature gas sensors that feature enhanced performance, high sensitivity and selectivity, and fast response and recovery. Testing of new chemiresistor sensors has shown promising results for room temperature sensing, with outcomes featured in premier journals such as *Journal of Physical Chemistry C and Sensor and Actuators B*.

Dr Mahnaz Shafiei and Professor Nunzio Motta in the Sensor Laboratory at QUT

During 2015, Dr Shafiei completed a six-month Australian Endeavour Research Fellowship funded by the Australian Government's Department of Education at Simon Fraser University in Canada. The Fellowship focused on developing novel electrospun nanofibers for low-power gas sensing applications. On returning to Australia, Dr Shafiei developed similar capabilities in QUT's Sensor Laboratory.

Future research will involve developing a new technology using highly porous hybrid nanofibers as a sensing material, using both organic and inorganic materials and a scalable and low cost electrospinning technique. These electrospun hybrid nanofibers offer outstanding physical and chemical properties due to their large surface area to volume ratios and the high surface activity of the nanofillers. Incorporating these novel nanofibers in sensitive quartz crystal microbalance devices operating at room temperature will significantly enhance the sensing performance.

ENGAGEMENT AND OUTREACH

We engage with industry, government, research organisations and the general public to share our research discoveries and understand the challenges they face.

Events

Grand Challenge Lecture Series

The IFE's successful Grand Challenge Lecture Series explores the major challenges confronting humanity in the 21st century and the possible solutions to them. In 201 5, the IFE presented 11 lectures by eminent speakers on a wide range of topics, from climate change and water security to the search for life on Mars. The lectures were attended by an average of 135 people (including via live stream), a mix of QUT staff and students from every faculty, institute and division, stakeholders from industry and government, researchers from other universities and the general public. Videos of the lectures are published on the Grand Challenge Lecture Series playlist on QUT's YouTube channel **www.youtube.com/user/TheQUTube**, expanding the audience of each lecture several times over.

Grand Challenge Lecture	Speaker
How Technology is Transforming the Research Landscape and What it Means for QUT	Professor Arun Sharma (QUT)
The Man Without a Face: Science, Power and Democracy	David Ritter (CEO, Greenpeace Australia Pacific)
Turning Up the Heat on Our Soil and Water Resources	Professor Peter Grace (QUT)
Balancing the Water Needs of Humans and Nature	Professor Stuart Bunn (Director, Australian Rivers Institute)
Learning by Doing: How Computer Games Can Enhance Education and Training	Jonathan Marshall (Founder, Bondi Labs)
The Search for Signs of Life on Mars: NASA's 2020 Rover and Mars Sample Return	Dr Abigail Allwood (NASA)
Robotic Musicianship and Artificial Creativity	Professor Gil Weinberg (Georgia Tech)
Planetary Saviours or Harbingers of Death? The Ecological Role of Bats	Professor Stuart Parsons (QUT)
The Unwelcome Crows: Hospitality in the Anthropocene	Dr Thom Van Dooren (University of New South Wales)
Knowledge Innovation Communities (KIC) to Address Societal Challenges: The Climate Change Challenge	Professor Mary Ritter (Climate-KIC)
Identifying Risk and Building Resilience into Global Food Systems	Professor Molly Jahn (University of Wisconsin-Madison)

Distinguished Visitor Lecture Series

In 2015 the IFE hosted 29 lectures in its Distinguished Visitor Lecture Series, which gives experts from academia and industry a forum for discussing the key trends, issues and opportunities in their fields. The 2015 lectures, which covered a diverse range of topics connected to the IFE's research themes and enabling platforms, were attended by 44 people on average.

Distinguished Visitor Lecture	Speaker
Nanoscale Electrochemical Imaging	Professor Patrick Unwin (University of Warwick)
Multi-Armed Bandit Experiments in the Online Service Economy	Dr Steven Scott (Google)
Microwave Processing of Ceramics, Composites, and Metallic Materials: An Overview	Professor Dinesh K. Agrawal (Pennsylvania State University)
Materials Processing in Separated E and H Fields at 2.45 GHz Microwave Frequency	Professor Dinesh K. Agrawal (Pennsylvania State University)
A King's Bones Under a Carpark? Evaluating the Genetic and Other Evidence	Professor David Balding (University of Melbourne)
Advanced Functional Nanoporous Materials for Multiple Applications	Professor Ajayan Vinu (University of Queensland)
Nanomaterials for Diverse Energy-Related and Structural Applications: Synthesis and Analysis Using State-of-the-Art in situ Transmission Electron Microscopy	Dmitri Golberg (National Institute for Materials Science, Japan)
A Vision into the Future of Nanoscience	Professor Thomas Nann (University of South Australia)
Co-evolution in Host-pathogen Interactions and its Relevance to Agriculture	Professor Jeremy Burdon (CSIRO)
Spatially Resolved Systems Biology to Identify Novel Salinity Tolerance Mechanisms in Barley Roots	Associate Professor Ute Roessner (University of Melbourne)
Next Generation Precision Agriculture	Professor Bruno Basso (Michigan State University & QUT Adjunct Professor)
The Environmental Data Deluge: Sinking or Swimming?	Professor Marian Scott (University of Glasgow)
Active Suspensions, Particles, and Structures	Professor Michael Shelley (New York University)
Microfluidics: Multiphysics in Microscale	Professor Nam-Trung Nguyen (Griffith University)
Spherical Mesoporous Architectures: Interfacial Assembly from Single-to Multi-Level & Their Applications	Professor Dongyuan Zhao (Fudan University)
Climate Change, Innovation & Technology Policy	Professor Adam Jaffe (Motu Economic and Public Policy Research)
Intergovernmental Panel on Climate Change and Climate Policy	Professor Shunsuke Managi (Kyushu University)
Women Tech Innovators and Investors: Can We Have It All?	Dr Jaleh Daie (Aurora Equity)
Quantifying Smell: Real-time Quantification of Volatile Compounds	Professor Murray McEwan (University of Canterbury & Syft Technologies Ltd)
How the Internet of Things Will Not Become an Unpredictable Mess	Professor Antonio Liotta (Eindhoven University of Technology)
The Computing Universe: Towards the Third Age of Computing	Professor Tony Hey (University of Washington)
Meeting the Global Challenges for Agriculture	Professor Mel Oliver (University of Missouri)
Workspace: Software for Productivity and Commercialisation of Modelling and Simulation	Dr Paul Cleary (CSIRO)
Climate Change and the Role of Industrial Biotechnology in Global Solutions	Thomas Videbæk (Novozymes)
Photochemistry, Spectroscopy and Mass Spectrometry of Aromatic Cations: Taming the Pride of Ions	Associate Professor Adam J. Trevitt (University of Wollongong)
Nanofibers and Nanoparticles Designed for Human Needs	Professor Seeram Ramakrishna (National University of Singapore)
Dutch Treat: Who is Paying the Bill for Making Water Management Climate Proof?	Gert-Jan de Maagd (Dutch Ministry of Infrastructure and the Environment)
Discovering Darkness in the International Year of Light	Fred Watson (Australian Astronomical Observatory)
Managing at the Innovation Frontier: Postcards from the Edge	John Bessant (University of Exeter)

Biofutures Cabinet Committee meeting

In October 2015, QUT hosted a Biofutures Cabinet Committee meeting at the IFE's Renewable Biocommodities Pilot Plant in Mackay. Queensland Premier Anastacia Palaszczuk and other members of the Queensland Government toured the facility and discussed the potential of biorefining in Queensland. Biorefining is the conversion of agricultural waste, or biomass, into biofuels, chemicals, plastics and resins. The biorefining industry is becoming a key growth sector around the world, creating opportunities for additional income streams for farmers and manufacturers. QUT, a pioneer in biorefining research and innovation, will be collaborating with the Queensland Government on the creation of a 10-year roadmap for the establishment of a biorefining industry in the State.

Big Biology and Bioinformatics (B^3) Symposium

On 23 and 24 November 2015, the IFE and the Institute of Health and Biomedical Innovation (IHBI) ran the third annual B^3 Symposium, featuring an interactive e-poster session in The Cube. This year's symposium was attended by approximately 150 researchers from across South East Queensland, who discussed 'omics' data integration and how common principles, techniques, methods and technologies can be applied across transdisciplinary projects. In 2016, B^3 will join forces with the Australian Bioinformatics and Computational Biology Society (ABCBS) to present a joint national symposium at QUT.

Delegates of the 2015 Big Biology and Bioinformatics (B^3) Symposium

20th Australasian Conference on Information Security and Privacy (ACISP)

ACISP is a key annual forum for researchers and industry experts to discuss the latest trends, breakthroughs and challenges in information security and cryptography. The IFE hosted 70 Australian and overseas delegates for a three day conference from 29 June to 1 July 2015. The program included keynote speakers from AustCert, Microsoft Security Center and the Norwegian University of Science and Technology. The conference culminated in a public Cyberattack Hypothetical, supported by the Australian Science Communicators, that attracted 131 people.

Delegates of the 2015 Australasian Conference on Information Security and Privacy

Pivotal Summit

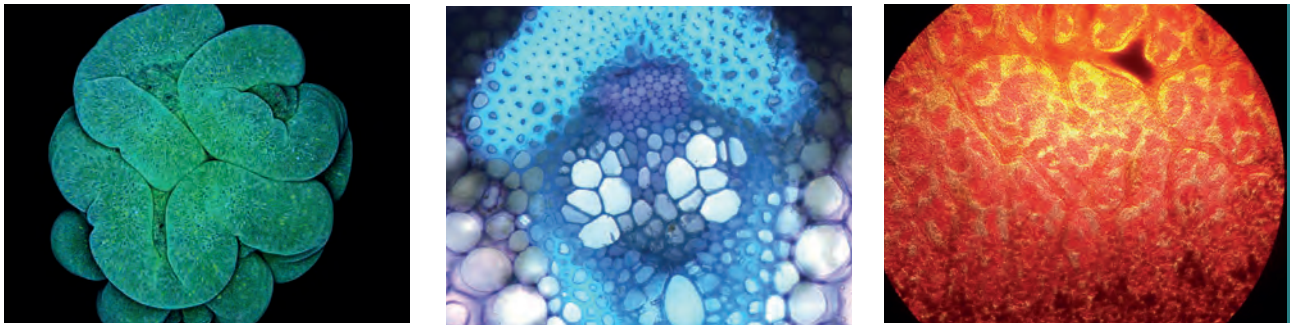
The IFE was a partner and platinum sponsor of the 2015 Pivotal Summit, which explored trends, issues and possibilities in the field of spatial information. Some of the world's leading thinkers from the spatial industry spoke at Pivotal, which was held on 29–30 June at the Brisbane Convention and Exhibition Centre. More than 200 executives, practitioners and researchers and around 100 youth members attended Pivotal. Over the course of the summit they discussed and developed the Pivotal Principles, which outline new ways of sharing data, assessing risk, and planning for a sustainable and prosperous future. Pivotal was hosted by the Spatial Information Business Association (SIBA) in partnership with NASA, the International Society of Digital Earth (ISDE), QUT and the Queensland Government.

Future Shapers Forum

Three of QUT's rising stars described how their research will shape our future environments – natural, built, virtual, social and economic – at a Future Shapers Forum on 25 September 2015. Presentations were given by Dr Henri Burgers (QUT Business School) on corporate entrepreneurship, Dr Cheryl Desha (Science and Engineering Faculty) on building nature-loving cities and Professor Marcus Foth (Creative Industries Faculty) on engaging communities with urban planning and design.

QUT Nikon Small World photomicrography competition

From April to July 2015, the IFE ran a light microscopy image competition for QUT staff and students and Queensland high school students. The 68 entries, which displayed a diverse range of samples including coral, plants, animals, human cells and minerals, showcased the beauty and diversity of the microscopic world. The images were shown on The Cube at a finalist exhibition and awards ceremony on 14 August, attended by 100 people, and are presented in a gallery in the IFE's Flickr page. Jonathon Muller received first prize for his stunning image of a sea anemone mesenteric filament, and the People's Choice Award went to Dr Tanya Scharaschkin with 500 votes for her image of a native iris leaf. Anastasia Surrey from Tullawong State High School won the school category – included the first time in 2015 – for her image of a parasitic worm organ.



The winning images from the QUT Nikon Small World photomicrography competition (L to R): Jonathon Muller's image of a sea anemone mesenteric filament; Dr Tanya Scharaschkin's image of native iris leaf; Anastasia Surrey's image of a parasitic worm organ

Robotronica 2015

On 23 August, around 18000 people visited QUT's Gardens Point campus for Robotronica, an all-day robotics and technology festival featuring demonstrations, workshops, games, tours and talks. The IFE ran guided tours of the Central Analytical Research Facility's high-tech laboratories. The booked-out tours gave the public a chance to see what the world looks like through electron microscopes and many other cutting-edge scientific instruments, and to learn how researchers use these machines to uncover the mysteries of nature and develop new technologies and materials. Demonstrations of agricultural, aerial and aquatic robots – several of them developed by IFE researchers – were also extremely popular, as was our Visualisation and eResearch (ViseR) team's hands-on virtual reality room.

Robotronica 2015: Visitors to QUT looking at microscope displays and ant-nest sculptures (left) and QUT-developed agricultural robot AgBot II (right)

Samford Ecological Research Facility (SERF) Annual Information Session

On 15 October 2015 approximately 30 Samford residents and stakeholders attended the seventh annual Samford Ecological Research Facility (SERF) Information Session, which outlined the research, education and outreach activities conducted at SERF during the year. The speakers included SERF Manager Dr Juan Cooper, Field Technician Marcus Yates, robotics researcher Dr Matthew Dunbabin, and Matthew Keir, winner of the 2014 Dr E.N. Marks Sustainability Award for his study of arboreal termites at SERF.

Übercamp: a masterclass on how to change the world

Twenty of QUT's brightest students and young researchers were chosen from a large pool of applicants from QUT's six faculties to attend the inaugural Übercamp on 29–30 October 2015. Übercamp was developed and run by former Queensland Chief Scientist Peter Andrews and science and innovation policy analyst Fiona Wood, in partnership with the IFE and qutbluebox. The program, based on Peter and Fiona's book *Überpreneurs: How to Create Innovative Global Business and Transform Human Societies*, incorporated workshop sessions, keynotes by successful entrepreneurs and a presentation from qutbluebox. The attendees learned how to define, refine and pitch their big ideas, develop a successful investment proposition and identify the resources they need to reach their goals. The event culminated in each attendee delivering a 90 second pitch to their peers and an expert panel. The winning pitch was delivered by QUT Science and Engineering postgraduate student David Poxon, who convincingly presented his vision for secure global data sharing.

Postgraduate student David Poxon, winner of the pitch competition at Übercamp 2015

STEM high school engagement program

The IFE played a key supporting role in the STEM (science, technology, engineering and maths) High School Engagement program run by the QUT Marketing and Communication Department. In June 2015, the second annual QUT Biofutures Engineering Challenge for high school students was held at the IFE's Mackay Renewable Biocommodities Pilot Plant. The Challenge was developed and run by QUT STEM Teacher in Residence Anne Brant, in collaboration with the IFE, QUT's School of Chemistry, Physics and Mechanical Engineering and the Queensland Minerals and Energy Academy (QMEA). Year 11 and 12 students from Mackay, Gladstone, Townsville, Wavell Heights, Carina and Coorparoo 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 Seven News, WIN News, Mackay Daily Mercury, Rockhampton Morning Bulletin and ABC radio. Representatives from Wilmar Sugar, Mackay Sugar, QMEA and the Queensland Department of Agriculture and Fisheries, all attended the final student presentations.

Left: QUT Biofutures Engineering Challenge attendees; Right: two of the students at the QUT Vice-Chancellor's STEM Camp

The IFE also supported the 2015 QUT Vice-Chancellor's STEM Camp, which gave 160 high-achieving Year 11 students from across Queensland the opportunity to work for a week with QUT staff on research projects addressing some of the grand challenges society faces this century. Several of the projects were developed and run in IFE facilities by IFE researchers, including Professor Sagadevan Mundree, Director of the Centre for Tropical Crops and Biocommodities.

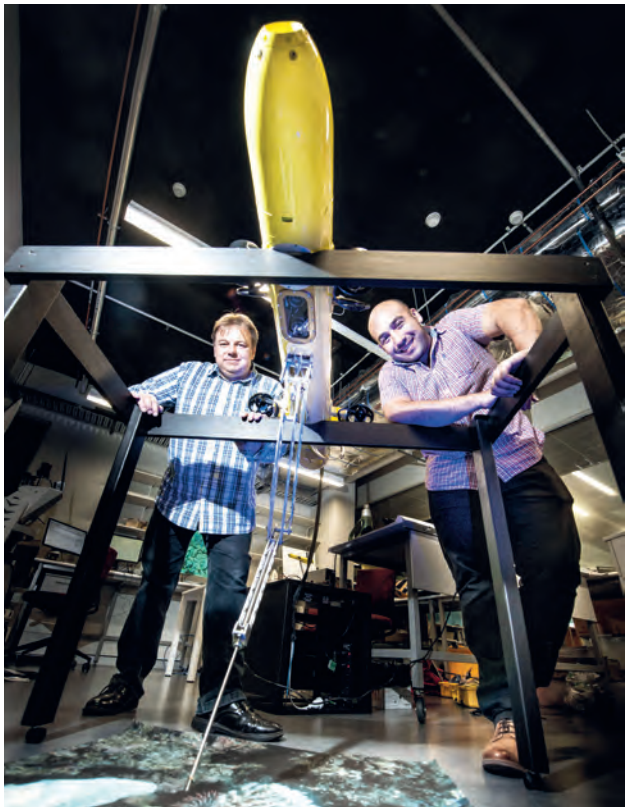
The IFE also worked with the STEM High School Engagement team to introduce a high school category in the 2015 QUT Nikon Small World Competition (see page 35). Senior high school students were invited to enter images taken with a light microscope for a chance to win a $500 science experience prize pack, including scientific equipment and a behind-the-scenes tour of QUT's research institutes and labs.

Media

During 2015, a wide variety of local, national and international media outlets ran more than 200 stories about IFE's researchers, projects and events. Two of the major stories are described below, and some of the other media highlights from 2015 are listed in the table.

Underwater robot to protect reef from crown-of-thorns starfish

The crown-of-thorns starfish (COTS) is responsible for an estimated 40 per cent of the Great Barrier Reef's total decline in coral cover. Sea trials of the world's first autonomous underwater robot designed to seek out and control the COTS, created by QUT roboticists Dr Matthew Dunbabin and Dr Feras Dayoub, resulted in extensive media coverage in Australia and around the world. Hundreds of media outlets covered the story, including ABC News, ABC Radio National, *The Australian, The Age, The Courier-Mail, The Huffington Post*, Mashable, BBC News, *Popular Science, The Guardian* and *The Times of India*. Dr Dunbabin was also featured in The Courier-Mail's QWeekend 50 Best and Brightest in 2015. See page 21 for a case study on the COTSbot project.



Dr Matthew Dunbabin and Dr Feras Dayoub with the COTSbot

IFE scientists unlock secrets of Australian 'resurrection' grass

Scientists from IFE's Centre for Tropical Crops and Biocommodities Professor Sagadevan Mundree and Dr Brett Williams were interviewed extensively about their research into a native Australian grass called Tripogon loliiformis that can survive droughts and extreme environmental stresses. Like other so-called 'resurrection plants', the grass can withstanding desiccation (being dried out) for prolonged periods. Professor Mundree, Dr Williams and their fellow researchers have discovered that sugar manipulation and the controlled sacrifice of cells are keys to the native grass's survival. Their research has implications for global food crops such as chickpea and rice. It could provide genetic keys to help scientists develop more robust crop varieties that can withstand global climate change while still producing maximum yields. The story was covered by ABC News 24, ABC Radio throughout Australia and *The Australian*.

Professor Sagadevan Mundree and Dr Brett Williams

Television, radio and print media highlights

Television	
Interviews with Professor Peter Corke about the next generation of robots being built at the ARC Centre of Excellence for Robotic Vision	ABC Brisbane (9 March); Channel 10 Brisbane (9 March); ABC News (10 March); SBS Sydney (21 April)
Interview with Dr Ernest Foo about the additional leap second being added to clocks in line with the Earth's rotation	Channel 7 Brisbane (28 June); ABC Melbourne (30 June)
Interview with Professor Jonathan Roberts and Dr Matthew Dunbabin about how QUT's Robotronica festival will educate young children about robots	Channel 7 Brisbane (25 July)
Interviews with Dr Ross Brown and Professor Kerrie Mengersen about how they are using virtual reality to ensure the survival of endangered animals	ABC News Brisbane (11 October); ABC News Sydney (12 October)
Launch of Mining Equipment, Technology and Services Growth Centre by Queensland and federal ministers at QUT	ABC News 24 (28 October)
Interview with Professor Peter Waterhouse about a crop that can grow anywhere due to a gene related to an ancient plant species	ABC Perth (3 November); ABC Melbourne (3 November); ABC News 24 (4 November)
Interview with Professor Tim Foresman about changes to climate data, with 100 year weather events now occurring every 10 years	Channel 10 Brisbane (1 December)
Radio	
Interview with Professor Duncan Campbell about using unmanned aircrafts for experiments in wildlife conservation and emergency services	4BC Brisbane (15 February)
Interview with Associate Professor Alexander Dreiling about the new digital departure card kiosk at Brisbane Airport	612 ABC Brisbane (2 April)
Interview with Associate Professor Jennifer Firn about how reducing number of feral pigs in Lake Eyre Basin could save 150 endangered plant and animals species	ABC Eyre Peninsula and West Coast (2 September)
Interviews with ARCAA researchers about possible use of unmanned aerial vehicles (UAVs) to deliver mail in rural areas	612 ABC Brisbane (2 November); ABC Rockhampton (2 November); ABC Townsville (4 November)
Print	
Interview with Associate Professor Ian O'Hara about transforming agricultural waste into niche green products	*Queensland Country Life*, Brisbane (1 January)
Interview with Professor Nunzio Motta about QUT research developing "supercapacitors" to boost the electric car	*Australasian Science*, National (1 February)
Interview with Professor Peter Corke about Baxter, the robot with basic hand-eye-coordination and the ability to process visual stimuli	AAP Newswire (9 March)
Interview with Professor Duncan Campbell about the use of unmanned aerial vehicles to undertake jobs that would be difficult or dangerous for people to do	*Sunday Mail*, Brisbane (29 March)
Interview with Dr Matthew Dunbabin about how robot boats could save lives in catastrophes by detecting major weather events	*Morning Bulletin*, Rockhampton (28 July)
"Mackay on biofuels global stage" – article on partnership between Asahi Holdings and QUT to develop biofuel based on sugarcane	*Daily Mercury*, Mackay (3 October)

Digital and social media

IFE website

The IFE website **www.qut.edu.au/ife**, which is part of the QUT corporate website, contains detailed information about the IFE's research programs, centres, facilities as well as our events for the general public, staff and industry. The site attracted 7221 unique visitors in 2015.

QUTube

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. By the end of 2015, 24 Grand Challenge Lectures from 2013–2015 had been published on the QUTube, with a total of more than 8000 views and an average of 340 views per lecture. Two lectures had been watched more than 1000 times – QUT Associate Professor Mia Woodruff's 2014 lecture on 'Biofabrication: The Future of Regenerative Medicine?' and University of Salford Professor Arto Kiviniemi's talk on 'Designing the Future: Sustainable Buildings and Infrastructure'.

Flickr

Established in 2013, our Flickr page now has over 700 images of IFE staff, facilities and events. In 2015, we added to the growing library of images by profiling our researchers, facilities (including the Samford Ecological Research Facility and Banyo Pilot Plant Precinct) and several major events (Australasian Conference for Information Security and Privacy, QUT Nikon Small World Competition, Übercamp and Big Biology and Bioinformatics Symposium).

Twitter

By December 2015, the IFE's Twitter account (@IFE_QUT) had 480 followers, an increase of 86 per cent December 2014. 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.

Awards and scholarships

Awards received by the IFE

Australian Financial Review Higher Education Award

QUT's Science and Engineering Centre, headquarters of the IFE, won the Facilities Innovation category in the inaugural Australian Financial Review Higher Education Awards, announced on 27 October 2015. Completed in 2012, the Centre is a pioneering education and research facility, a vibrant community hub, and a model of sustainable building design. Infused with an ethos of transdisciplinary collaboration and community engagement, the Centre houses cutting-edge research and teaching spaces, a range of food, retail and recreation facilities, and The Cube, a dazzling digital exhibition space that gives students and the public an inspiring, immersive experience of science, technology, engineering and mathematics.

> "Queensland University of Technology's Science and Engineering Centre is all you could wish for in a twenty-first century university building. Its innovative, flexible design actively supports interactive learning and research, increases space efficiency, and, with its 5-star green rating, is a model for sustainable building practices." – Judge from the Australian Financial Review Higher Education Award.

Wharton – QS Stars Reimagine Education Awards

QUT's teaching methods were recognised as among the world's most innovative when it won two prestigious prizes at the international Reimagine Education Awards in 2015. The Cube won first place (Regional Award – Oceania) for being a unique, innovative learning environment, and Professor Peter Corke's Reimagining Robotics program won first place (Engineering and IT Award). The robotics program also placed second in the Teaching Delivery category.

The public exploring the Dino Zoo on The Cube

Awards and scholarships sponsored by the IFE

Dr E.N. Marks Sustainability Award

Matthew Keir

Since 2008, the Institute for Future Environments has presented an annual award to recognise outstanding contributions to sustainability made by QUT students working at the Samford Ecological Research Facility (SERF). The award is named in honour of Dr Elizabeth Nesta (E. N.) Marks AO, a renowned Queensland entomologist who generously bequeathed the SERF property to QUT. The 2014 Dr E.N. Marks Sustainability Award was won by Matthew Keir, a Bachelor of Applied Science graduate who majored in Environmental Science. Matthew had an outstanding undergraduate record and graduated with Honours in 2014. Matthew undertook a field project at SERF titled 'Spatial distribution of the arboreal termite *Microcerotermes turneri* (Infraorder: Isoptera) in a eucalypt forest'. Matthew's ecological study provides important baseline information about an arboreal termite species and serves as an excellent foundation for more detailed studies of these important members of forest ecosystems.

Siganto Foundation Medal

Dr Stephanie Lowry

The Siganto Foundation Medal is awarded each year to an outstanding early career QUT researcher for excellence in engineering research. The Siganto Foundation Medal was established through generous gifts from The Siganto Foundation, led by Dr Bill Siganto AM and Dr Marie Siganto AM, to support distinguished PhD graduates from the QUT Science and Engineering Faculty and foster career progression, knowledge dissemination and global recognition in the field of engineering. In addition to the Medal, the winner receives $10 000 for transdisciplinary professional development and research activities both locally and internationally, funded jointly by The Siganto Foundation and the IFE. In 2015, Dr Stephanie Lowry, an early career robotics researcher with the Australian Centre for Robotic Vision, was awarded the Medal for her research into how robots can navigate more effectively in changing and dynamic environments. She is currently undertaking further postdoctoral research at Örebro University in Sweden.

Sadly, Bill Siganto passed away in September 2015. He will be remembered at QUT for his outstanding commitment to furthering higher education, and his memory will live on through the Siganto Foundation Medal, which will continue to be awarded to talented early career researchers.

Energy Transformation PhD Top-Up Scholarship

Aihong Zou

The IFE awards a three year top-up scholarship to a suitable PhD student – based on academic merit and research experience, potential and relevance – to support research into energy transformation. This scholarship is funded by a gift from generous donors to QUT. In 2015, Ms Aihong Zou was the inaugural recipient of the scholarship, which provides $10 000 per year over three years. Aihong Zou is a member of QUT's Laboratory for Advanced Modelling and Simulation in Engineering and Science (LAMSES) and her PhD research will focus on innovative ways of applying complex mathematical modelling to the workings of radial turbines. Aihong's research has significant potential to contribute to the design of turbines that extract the maximum amount of power from the available energy resource, increasing electricity output and minimising waste.

PEOPLE AND GOVERNANCE

The IFE team catalyses, supports, conducts and profiles research and innovation aligned with its research themes and enabling platforms.

Organisational structure

EXECUTIVE

Professor Ian Mackinnon
Executive Director

Professor Bronwyn Harch
Deputy Executive Director

Mr Jim Reeves
Director – Operations
(until November 2015)

Professor Stephen Blanksby
Director – Central Analytical Research Facility (CARF)

Dr Kymberley Vickery
Director – Commercial Programmes

RESEARCH THEME AND ENABLING PLATFORM LEADERS

Professor Roger Hellens
Growing the Global Bioeconomy

Professsor Peter Grace
Managing for Resilient Landscapes

Professor Laurie Buys
Infrastructure for Sustainable Communities

Associate Professor Alexander Dreiling
Harnessing Digital Productivity and Services

Professor Tristan Perez
IntelliSensing

Associate Professor Robert Perrons
Transforming Innovation Systems

Professor Ian Mackinnon (interim)
Manufacturing with Advanced Materials

RESEARCH FACILITIES

Central Analytical Research Facility (CARF)

Visualisation and eResearch (ViseR)

Samford Ecological Research Facility (SERF)

Da Vinci Precinct

Banyo Pilot Plant Precinct

Mackay Renewable Biocommodities Pilot Plant

Queensland Crop Development Facility (Redlands)

ALLIED/ASSOCIATED CENTRES

Centre for Tropical Crops and Biocommodities (CTCB)

Australian Centre for Aerospace Automation (ARCAA)

ARC Centre of Excellence for Robotic Vision (ACRV)

ARC Centre of Excellence for Mathematical and Statistics Frontiers (ACEMS)

Smart Transport Research Centre (STRC)

Centre for Emergency and Disaster Management (CEDM)

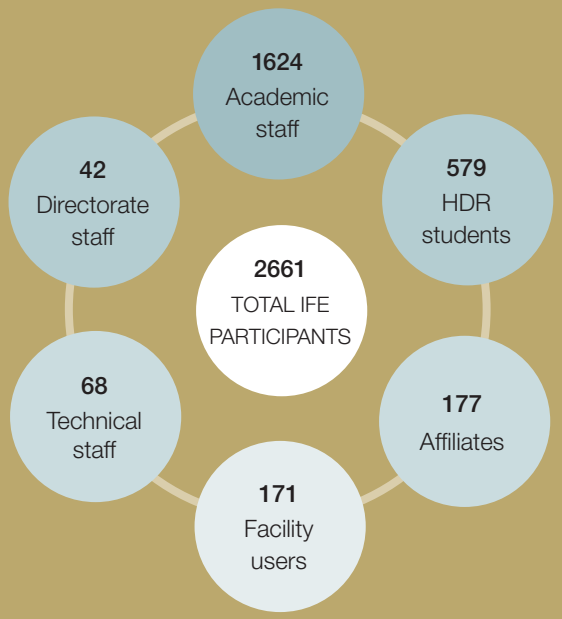
Australia-China Centre for Air Quality Science and Management (ACC - AQSM)

Participation in the IFE

The IFE has staff and participants of several kinds. The diagram below, which shows how many participants of each kind the IFE had across the years 2013–2015, underlines the massive impact the IFE has had on the research culture at QUT.

- **Directorate staff** specialising in finance, communication, knowledge to innovation brokering, visualisation and e-research, governance, human resources and administration
- **Technical staff** in the IFE's research facilities, including the Central Analytical Research Facility, Samford Ecological Research Facility (SERF), Banyo Pilot Plant Precinct and Mackay Renewable Biocommodities Pilot Plant
- **Academic staff**, including:
  - core IFE academic staff – research theme and enabling platform leaders, industry chairs and research fellows
  - collaborating academic staff from QUT's faculties who contribute their deep disciplinary expertise to specific IFE research activities
- **Higher degree research (HDR) students**, including:
  - students supported by IFE scholarships
  - students supervised by academic staff aligned with the IFE's research themes and enabling platforms
- **Facility users**, including:
  - QUT staff and students not captured in the above categories
  - researchers and clients from outside QUT
- **Affiliates** – QUT staff and students not captured in the above categories who are based in the IFE's headquarters, the Science and Engineering Centre, or receive funding from the IFE.

Figure 3: Participation in the IFE, 2013–2015*



**Note: each individual is counted only once in the diagram. Individuals who belonged to multiple categories were counted in their primary category.*

The IFE helps QUT staff and HDR students conducting research aligned with the IFE's mission to strengthen their research quality and impact by offering:

- university-wide transdisciplinary communities of practice
- connections to national and global research networks
- world-class research infrastructure
- funding for seed projects and industry and government co-investment projects
- assistance with developing research and innovation ideas and with links to industry, government and community research needs
- support with project management, project finance, knowledge to innovation brokering, communications and profiling, and event management.

Governance

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

IFE Executive Committee

The IFE is governed by an Executive Committee of senior QUT staff who meet periodically to assess the performance, progress and plans of the IFE. In 2015, 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 (until November 2015)
- Ms Melanie Gunn – Resources and Administration Services Manager (until April 2015).

IFE Senior Leadership Group

Day-to-day management of the operations of the IFE is the responsibility of the IFE Senior Leadership Group, which in 2015 included:

- Professor Ian Mackinnon – Executive Director
- Professor Bronwyn Harch – Deputy Executive Director (Research), IFE; Assistant Dean (Research), Science and Engineering Faculty
- Mr Jim Reeves – Director, Operations (until November 2015)
- Ms Melanie Gunn – Resources and Administration Services Manager (until April 2015)
- Dr Kymberley Vickery – Director, Partnerships and Commercial Programs
- Dr Juan Cooper – Distributed Sites and Infrastructure Manager
- Professor Stephen Blanksby – Director, Central Analytical Research Facility
- Dr Mark Gibbs – Director, Knowledge to Innovation (from September 2015)
- Ms Melissa Burton – Governance and Administrative Services Manager (from September 2015)
- Mr Gavin Winter – Visualisation and eResearch Manager
- Mr Stephen Wimberley – Budget and Finance Coordinator
- Mr Tim Campbell – Research Communications and Outreach Coordinator

Health, Safety and Environment (HSE) Committee

The IFE Health and Safety Committee updated its terms of reference in 2015, incorporating environmental aspects as part of QUT's increased focus on the potential environmental impact of its research and teaching activities. The renamed Health, Safety and Environment (HSE) Committee continued to include representatives from IFE management, Health Safety and Environment Advisors, and Health and Safety Representatives, as well as staff from the IFE's facilities. QUT's Senior Environmental Protection Officer also attended all our HSE Committee meetings, advising on matters of environmental importance.

The HSE Committee met quarterly in 2015, with a fifth meeting convened with the Science and Engineering Faculty (SEF) as an annual joint event promoting HSE collaboration between the IFE and SEF. Regular meetings of IFE and SEF HSE Advisors and Representatives also took place, focusing on the practical application of HSE principles within the institute and faculty.

Our HSE accomplishments in 2015 included:

- the development of a Sample Declaration Form for risk assessment of biological and chemical samples submitted for analysis in the IFE's Central Analytical Research Facility
- IFE Laboratory and Workshop Inspection Week in May
- the "Banyo Bus Tour" environmental assessment at the IFE's Banyo Pilot Plant Precinct as part of the QUT HSE Month in October 2015.

The HSE Management System Gap Analysis Review in 2015 also highlighted the IFE's success in meeting the requirements of QUT's HSE Management System while using SEF's processes and HSE personnel.

IFE staff are actively encouraged to report safety problems, hazards and near misses, so that our HSE Committee can conduct timely investigations of potential HSE risks and develop appropriate controls and procedures before more serious incidents occur. The HSE incidents reported by IFE staff in 2105, which were generally of a minor nature, included 16 near misses, safety problems or hazards; 5 work injury, illness or disease incidents; 1 journey-to-work accident; and 1 environmental impact event. Most of these incidents involved minor chemical spills, poor housekeeping or contact with an object. The 2015 QUT HSE Self-Assessment Review for the IFE highlighted our success in providing staff and students with up-to-date information regarding HSE matters and their responsibilities as well as ensuring broad awareness of and access to of relevant work instructions.

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 research and teaching activities that involve the care and use of animals.

On 7 September 2015, the UAEC members inspected the IFE's Samford Ecological Research Facility (SERF, pictured below), where they were given an overview of the property's history, acquisition, past and current activities and future development plans. Few research or teaching activities involving animals were conducted at SERF in 2015. Approved projects included observational fauna surveys by undergraduate students as part of fields trips to SERF and an investigation of the movement of the giant barred frog, Mixophyes iterates, through riparian corridors.

The UAEC was impressed with the improved design of the pitfall traps used to trap small mammals and amphibians at SERF; the design minimises risks to wildlife and provides security for the animals by including vegetation. The UAEC was also interested in new ecological studies at SERF involving aerial mapping of vegetation using unmanned aerial vehicles (UAVs). IFE will assess all research proposals for projects involving the use of UAVs at SERF and advise on any potential effects on wildlife and birds.

Samford Ecological Research Facility

Financial report

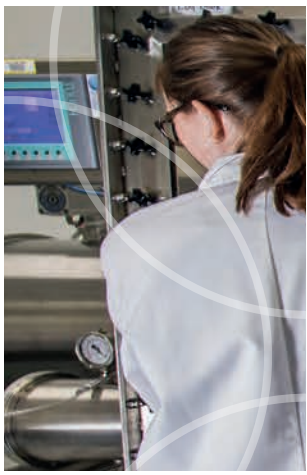
The table below provides a summary of transactions on IFE-related accounts for the period 2012–2015. This summary does not include any co-funded or fully funded initiatives by the IFE that are attributed to other University accounts (e.g. a Division, Faculty or School account). Revenue tracks research 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.

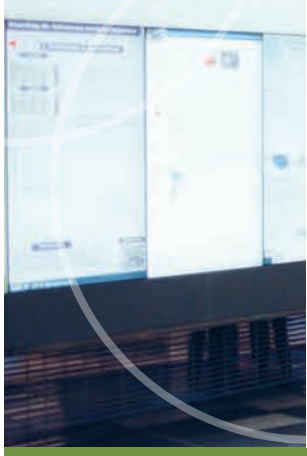
Revenue	2012* $ '000s	2013* $ '000s	2014 $ '000s	2015 $ '000s
Research				
Competitive Grants+	1223	1486	12483	7438
University Distributions	-	-	1784	1843
Commercial	2203	2289	5979	7664
Sub-total	3427	3775	20247	16945
Operations				
University Distributions	5294	10329	13991	15446
Other	780	804	1076	1630
Sub-total	6074	11133	15067	17076
Total Revenue	**9501**	**14908**	**35314**	**34020**

Expenses	$'000's	$'000's	$'000's	$'000's
Research				
Employee Costs	1797	1636	8429	8472
Non-Employee Costs	1730	937	6740	6824
Sub-total	3527	2573	15170	15296
Operations				
Employee Costs	4294	6800	12158	13684
Non-Employee Costs	1206	2837	3912	5208
Sub-total	5500	9638	16070	18892
Total Expenditure	**9027**	**12211**	**31239**	**34188**
Opening Retained Funds	1573	2130	4082	12831
Profit/(Loss)	473	2697	4075	(167)
Retained Funds Transfer	403	45	4162	146
Capital Acquisitions++	391	991	675	1053
Depreciation	71	201	1188	1650
Closing Retained Funds* **	**2130**	**4082**	**12831**	**13407**

* 2012 and 2013 do not include the Centre for Tropical Crops and Biocommodities.
+ Grants to Chief Investigators in Faculties (e.g. ARC Discovery and Linkage projects) are not included.
++ Does not include Major Equipment (SMEP).

Brisbane Australia





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