RESEARCH AT CQU UNIVERSITY
The information contained within this guide is for both domestic and international students. Information specifically for domestic students is titled ‘domestic’ and information specifically for international students is titled ‘international’.

CQU and the Australian Government want international students in Australia to have a safe, enjoyable and rewarding place to study. Australia’s laws promote education and consumer protection for international students. These laws are known as the ESOS framework. For further information please visit www.cqu.edu.au/esos.

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FOREWORD

CQUniversity is emerging as one of Australia’s great universities.

As the only university in Australia with a truly national footprint, we are committed to engaging with communities from Cairns in the north, Melbourne and Adelaide in the south and Perth and Karratha in the west.

Having a physical presence across Australia not only means we can deliver better service to our thousands of distance education students but also means we have a better understanding of these communities and the issues that are important to them. This unique power of place allows us to focus on finding solutions to real challenges.

This is important because at CQUniversity we aim to achieve complete relevance in our research efforts through strong links with industry, government and our community, as well as through tight collaboration with national and international researchers and research networks. Good research, which is relevant, always involves a high level of engagement.

Specifically, we aim to conduct research that explores and emphasises regional development, industry growth, agriculture, environmental management, rural and regional healthcare and education using modern and emerging technologies.

The future of research at CQUniversity looks bright and so does the future of the regions and communities we serve. It’s great to be part of a university that is actively working towards creating sustainable and successful outcomes for regions right across Australia and beyond.
When you think about it, research is all around us. Research is about knowledge, and knowledge changes lives.

Some people devote their entire lives to researching a particular concept, just to improve the lives of others and it’s because of this that we get to enjoy the quality of life we do today.

As a strong regional university, CQU is committed to research that contributes knowledge and innovation through fundamental and applied research in selected priority areas and because of this we are achieving some remarkable feats. A strong engagement agenda also means we are delivering tangible results to individuals, industries and entire communities.

From rail safety and load bearing to precision agricultural tools, mental health, domestic violence and the sweetness of locally-grown fruit, CQU’s applied research is delivering insight and benefits to people on a local and global scale.

As we continue to achieve greatness in our research outputs, increased connectivity and collaboration with community and industry partners will boost our research intensity and give us wider access to facilities and experts across the country.

This is important because, more so than ever before, universities have a crucial role to play in the future of Australia and a specific responsibility to find innovative, sustainable and simple solutions to complex economic, social and environmental challenges.

What’s more, our focus on delivering great research will inform the design of our tertiary and vocational programs and courses. This means CQU graduates will be better prepared for careers in their chosen field – they will be thought leaders and innovators before they even graduate.

CQU is a growing research university and because of this we are contributing to the sustainability, competitiveness and wellbeing of our communities.
A MORE COMPREHENSIVE UNIVERSITY

A new era in education and training has arrived. Renowned as one of the nation’s most inclusive institutions and following a merger with CQ TAFE, CQUniversity Australia is now a more comprehensive university, opening its doors wider, making education even more accessible and applicable to more people.

CQU has one of the largest footprints of any university in Australia, proudly offering a wide variety of education and training options and seamless pathways from short courses, certificates and diplomas, through to undergraduate, postgraduate and research higher degrees.

Choose to study on-campus at one of our many locations or by distance education, full-time or part-time, and benefit from our award winning and experienced teaching and research professionals, as well as our focus on student services and support.

Engaged Research

Our focus is to emphasise research with relevance to the region, involving aspects of regional development, growth in resource industries, environmental management, issues associated with quality health care in rural and regional communities, and education delivery specifically through use of modern technology. Academics and student researchers undertake world-class research at CQUniversity in a number of areas. Our personalised learning support and collaborative partnerships provide pathways for people from all walks of life and different learning styles to achieve, thrive, and succeed.

Research higher degrees

Research higher degrees allow you to undertake research focused on a particular area of interest, resulting in the submission of a thesis. Choose from Masters by Research or Doctor of Philosophy (PhD) options. You may be required to undertake a coursework program or research skills development studies before undertaking a research higher degree.

Regional Universities Network

CQUniversity is a proud member of the Regional Universities Network (RUN). RUN is a network of six universities all with headquarters in regional Australia and a shared commitment to playing a transformative role in their regions.

Through educational and research contributions to regional economic, social, cultural and environmental development, RUN member universities play an important and distinctive role in advancing Australia’s national prosperity, productivity and identity.

For more information visit www.cqu.edu.au/research.
Distance Education Study Centres

CQUniversity’s Distance Education Study Centres in Adelaide, Brisbane, Cairns, Melbourne, Sydney and Townsville are vibrant hubs providing a quiet place to study, away from home and work. These centres enable you to access support, form study groups with fellow students and access resources and technology. You can also visit any of our campuses and access similar facilities.


Please note: International students in Australia on a student visa must study full-time on-campus. International students can only undertake programs by distance education from an overseas location. For more information visit [www.cqu.edu.au/international](http://www.cqu.edu.au/international).

Our Locations

CQUniversity has one of the largest footprints of any university in Australia, with more than 20 locations and plans for more underway.

Distance Education

CQUniversity is one of Australia’s leading providers of distance education. Distance education provides the flexibility to balance study with family and work commitments. It also provides an opportunity for those who live in rural and remote areas, or internationally, to access university study without the need to relocate.

In addition to online materials and regular communication with our research professionals, CQUniversity offers a range of student support services including online orientation, ongoing assistance through the Student Mentor Program, counselling services, support for students with a disability or medical conditions, career planning services and more.

CQUniversity has been awarded five stars for Online/Distance Learning, Inclusiveness and Internationalisation.
CQUnderlinevon University’s contribution to Australia’s research and innovation agenda is led by the activity and excellence of our research centres and institutes.

Research centres and institutes produce the focus, scale and environment that enable researchers to make national and international contributions to their research fields, while supporting the needs of industry and the regions in which CQUnderlinevon University operates. Following are our current research centres and institutes, with additional research centres and institutes to be announced in 2015.

**APPLETON INSTITUTE**
School of Human, Health and Social Sciences
Director – Professor Drew Dawson

The Appleton Institute is a multidisciplinary research hub in Adelaide. Established as part of CQUnderlinevon University in January 2012, the Appleton Institute combines excellence in research, teaching and community engagement across a range of scientific areas including safety science, sleep and biological rhythms, applied psychology, occupational health and safety, human factors, risk management, cultural anthropology and immigration. The Appleton Institute includes a multidisciplinary team of researchers and specialists led by renowned fatigue and human factors expert, Professor Drew Dawson. Appleton’s researchers have a broad range of experience, from investigating how volunteer firefighters respond to sleep loss and heat stress to understanding how horses respond to climate change. The Institute’s research covers a broad range of areas, which can be grouped as sleep and circadian physiology, human factors and safety science, community engagement, animal behaviour and human-animal interaction.

Appleton’s researchers also provide consulting services and regularly advise organisations across a number of industries on issues relating to shiftwork, fatigue, industrial relations, human factors, safety management, worker participation and workplace agreements. The Appleton Institute has worked with over 100 major Australian companies such as Qantas, BHP Billiton, Mobil Industries Australia, The Kimberly-Clark Corporation, Pacific National Rail, Queensland Rail, National Rail and RailCorp.

**INSTITUTE FOR FUTURE FARMING SYSTEMS**
School of Medical and Applied Sciences
Director – Professor Philip Brown

The Institute for Future Farming Systems builds on the strong agricultural research base at CQUnderlinevon University and incorporates strategic partnerships with the Queensland Department of Agriculture, Fisheries and Forestry and other peak industry bodies. CQUnderlinevon University’s research in agricultural science was assessed as ‘well above world class’ in the Excellence in Research for Australia (ERA) 2012 ranking. The University has a unique power of place, allowing researchers to work closely with primary producers in subtropical regions including Bundaberg (Australia’s largest vegetable producing region) and Rockhampton (Australia’s beef capital). The Institute aspires to use its Central Queensland base to become a major contributor to successful agricultural industry development in northern Australia. The Institute’s research activities focus on five agricultural industry areas – sugar cane, cropping, horticulture, beef cattle and poultry. Two industries, horticulture and beef cattle, and two themes, precision technologies and non-invasive plant assessment, form the core activity of the Institute. The Institute for Future Farming Systems builds on long-standing applied industry-focussed research at CQUnderlinevon University in precision livestock management, precision horticulture, and non-invasive assessment in agriculture research, which has improved the productivity, profitability and sustainability of agricultural industries in Central Queensland.
CENTRE FOR INTELLIGENT AND NETWORKED SYSTEMS (CINS)
School of Engineering and Technology
Director – Professor Brijesh Verma

Over the past decade the scope of intelligent systems research has expanded from a focus on individual system behaviour to now addressing issues involved in networked systems behaviour. CQU’s CINS focuses its research on the convergence of three major areas that inform these issues – computational intelligence, networks and pattern recognition.

CINS brings together a group of researchers with international standing and a record of collaboration with leading international researchers and industry. The Centre strives for excellence in research, which is recognised by CQU achieving a ranking of 5 (well above world standard) in the field of mathematical sciences in the last Excellence in Research for Australia (ERA 2012) assessment round. The Centre’s leading researchers, Professor Qing Long Han and Professor Brijesh Verma, provide research leadership to the Centre. This includes securing prestigious Australian Research Council grants over a number of years to support their novel and innovative research. The Centre’s researchers also have an outstanding publication record, publishing in premier international research journals in the field, with outstanding citation rates.

CINS undertakes both basic and applied research. An example of current applied focus is the collaboration with the Department of Main Roads using pattern recognition and computational intelligence techniques, examining the use of vehicle-mounted video systems to capture information about roadside fire risk factors.

CENTRE FOR RAILWAY ENGINEERING (CRE)
School of Engineering and Technology
Director – Professor Colin Cole

The Centre for Railway Engineering is a well-established research centre, housing impressive and extensive infrastructure and expertise built through leadership and participation in three major national Collaborative Research Centres. The Centre has made a major contribution over the past 20 years to initiate, support and champion research of benefit to Australia’s railway industry, and also enjoys an excellent international reputation. The Centre has long-standing and direct relationships with national and international corporations including Aurizon, Pacific National, Australian Rail Track Corporation (ARTC), Faiveley Transport and Bradken.

The CRE engages in applied engineering research of benefit to railway industries including in mechanical, civil and electrical engineering, as well as in areas related to safety and human factors. The Centre enjoys an excellent worldwide reputation in railway research, engagement with industry in both rail owner and rail manufacturer sectors and acknowledged world leadership in applied research in rolling stock dynamics, simulation and conditional monitoring. Core research strengths are in multi-body dynamics, non-linear modelling and simulation. The Centre has engaged in product development for the Australian rail manufacturing sector, establishing a record of original patented research. The CRE is ideally located to continue to provide direct benefits to national and international rail industry through its membership of the current Rail Manufacturing Cooperative Research Centre (CRC) and its core position as one of only three universities invited to be a member of the Australasian Centre for Rail Innovation.

QUEENSLAND CENTRE FOR DOMESTIC AND FAMILY VIOLENCE RESEARCH (CDFVR)
School of Nursing and Midwifery
Director – Associate Professor Annabel Taylor

The CDFVR, based at CQUniversity Mackay Ooralea, contributes to the prevention of domestic and family violence by informing, promoting and supporting the actions of individuals, communities, services and governments through state-wide leadership in research, professional development, education and community engagement. The Centre’s research function is to initiate, undertake and collaborate on innovative and interdisciplinary research and publications to reduce deficits in domestic and family violence knowledge and literature. CDFVR is also committed to undertaking applied research that supports the development of policy and practice in the field of domestic and family violence prevention with a particular, though not exclusive, focus on issues for Aboriginal and Torres Strait Islander people and rural and regional communities.

CDFVR is funded to contribute to the prevention of domestic and family violence using social planning, policy development and research activities. The service also promotes and supports coordination and network development at a state-wide level and the production, review and customisation of training and training resources to develop an effective skills base within the service system. CDFVR receives funding from the Queensland Department of Communities, Child Safety and Disability Services, as well as grants from a range of other sources.
Step your way to a healthier life. Sounds simple doesn’t it? Nonetheless, that is the reality that the 10,000 Steps project, a physical activity concept, has well and truly proven.

From its humble beginnings in Central Queensland in 2001, the 10,000 Steps project is now recognised as an effective local health promotion activity both nationally and internationally. Its resources and research have been adopted worldwide with similar projects now in countries such as Canada and Belgium. This adoption continues to grow and grow.

Coupling the 10,000 Steps message; taking 10,000 steps every day is good for your health, with Australia’s National Physical Activity Guidelines (which recommend accumulating 150 to 300 minutes of moderate intensity physical activity each week), the effectiveness of the project is evidenced by the ongoing support of different levels of government, as well as the ever increasing number of individuals and communities embracing the concept.

Together these members log 4.3 million steps on the program’s website every day while undertaking an Individual Steps Challenge or participating in a Workplace Steps Challenge.

The concept is indeed a simple one. The aim is to increase the day-to-day activity of individuals by encouraging the use of a step-counting pedometer to accumulate incidental physical activity on a daily basis. These steps can be measured over an entire day or at one or more specific instances. The beauty of the project is that almost anyone can take part without having to commit to strict fitness regimes. While 10 000 steps is the recommended daily minimum amount, individuals can easily perform more or less depending on age and general fitness levels, all the while accumulating their steps and improving their health.

Supported by evidence that physical inactivity in the population was contributing to the growth and social burden of some chronic diseases, such as cardiovascular disease, diabetes, obesity, some cancers and mental health, the initial two-year 10,000 Steps project was funded by Queensland Health in 2001. The project was a collaboration between CQUniversity Australia, University of Queensland, Queensland University of Technology and other partners including Rockhampton City Council and the National Heart Foundation. It became the first physical activity project to demonstrate the effectiveness of a community-wide approach to promoting physical activity, from the individual level through to environmental and policy levels.

The early project was effective in increasing physical activity, setting an example on how to conduct community-based health promotion programs elsewhere. Due to its popularity and success – 10 towns across Australia now identify themselves as 10,000 Steps towns – Queensland Health has continued to invest in 10,000 Steps to ensure its widespread adoption and implementation. This meant that the project had to be reinvented and incorporate a significant service to community component. Both were done successfully and today the project continues to maintain an important research and information dissemination focus.

A key research theme of the project is to examine ways to improve the effectiveness of technology to promote physical activity through the use of technology-based promotion, such as websites and mobile devices. The 10,000 Steps program has a smartphone application (the iSteplog) that has been downloaded more than 36 000 times. This research theme has allowed the project to be leveraged as part of a $913 371 National Health and Medical Research Council Project Grant, which aims to better understand how to use technology to promote health. Outcomes of this project are expected in late 2015.

Since 2005, awareness of the 10,000 Steps program has been measured annually at a state-wide level. The general public’s awareness of the project has grown every year and is now approximately 70 percent. This is higher than most other health promotion projects in Australia and internationally.

While dose-response relationships between physical activity levels and health outcomes are well established, there is an ongoing need for health behaviour research that demonstrates physical activity programs aimed at large groups of inactive people are effective in increasing, and maintaining, physical activity levels. That is why the ongoing research conducted under the banner of the 10,000 Steps project has been, and continues to be, essential.
The project currently has over 280,000 members located around the globe, with an average of 3600 new individual members joining each month.
Just imagine being able to create a safe, realistic and stimulating clinical learning environment without having to leave the classroom or working environment. That’s exactly what the unique and innovative Mask-Ed™ (KRS Simulation) and Pup-Ed (KRS Simulation) techniques offer. Both Mask-Ed™ (KRS Simulation), which was first created in 2008, and Pup-Ed (KRS Simulation) offer unique and innovative approaches to teaching and learning. Both techniques were created at CQUniversity by Professor Kerry Reid-Searl and are now gaining national and international recognition for their value in learning and teaching.

Mask-Ed™ involves the informed educator or teacher wearing silicone props including face masks, hands, feet and body torsos. Wearing these props, the educator transforms into a character or person (the patient) in the context of learning for health care professions. The newly created character also has a carefully created history that enables them to become the platform for teaching. In essence the teacher is hidden but still guides the teaching through the character, and the character becomes the coach for the learner in the simulation experience. The character and the history become a platform for teaching and serve as the learning tool for the educator, who draws on their expertise to guide the learning.

The key concept of Mask-Ed™ is that the simulation device takes training to a new dimension because the work is done on a real person, who is also the educator. Simulation learning facilitates critical thinking, reduces the risk element to actual patients and enables the educator to provide real-time feedback to their students. The technique is guided by a teaching framework and workshop materials including user guides and workshop manuals that have now been developed. Online resources are also being prepared for delivery in 2015. Local, national and international workshops are delivered regularly, with participants from across all health disciplines. Mask-Ed™ (KRS Simulation) has been trademarked and patents exist on some of the silicone props.

Pup-Ed works in similar ways but uses puppets. The informed educator works the puppet and transforms it into a character, creating its own history and platform for teaching. More than 50 puppets are currently being used in hospitals and educational institutions across Australia. The effectiveness of Mask-Ed™ is evident in the number of universities, health care facilities and other organisations that have taken up the approach. The number now exceeds 20 sites throughout Australia, the United States of America, the United Kingdom and New Zealand. Organisations taking up Mask-Ed™ are in the areas of nursing, physiotherapy, occupational health and safety, paramedics, psychology, speech therapy and medicine.

The growing success of these techniques are further evident in the extensive teaching awards, invited keynote addresses and research findings that confirm the positive impact on learners and users. The overwhelming positive evaluations are supported by the extensive awards Professor Kerry Reid-Searl and Mask-Ed™ have received. Mask-Ed™ has also benefitted CQUniversity and the wider community by being used widely in community engagement presentations, school visits, Open Days and presentations to groups such as Probus, Rotary and University of the Third Age.

Certainly, based on the evidence to date, both Mask-Ed™ and Pup-Ed have the potential for continued growth not only in the research, teaching and learning arenas but also in their commercialisation.
A century ago, harvested fruit were graded by human visual inspection and sorted on their perceived quality. A new approach discovered a couple of decades ago from local fruit growers has resulted in the development of technology with worldwide application in the more accurate grading of fruit quality. Non-invasive devices using near infrared spectroscopy (NIRS) have been successfully developed in collaboration with various manufacturers and funding sources to improve the overall quality of fruit. Research undertaken at CQU University Australia has translated the theoretical potential of NIRS to commercial practice and explored related agronomic issues relevant to the production of quality fruit.

The NIRS project began in the mid-1990s following an approach from growers in the local Central Queensland pineapple industry who believed they were producing sweeter fruit than their southern counterparts and needed an objective test to demonstrate this. After exploring some colorimetric options, reports on the potential for NIRS were encountered, appropriate laboratory instrumentation was acquired and the concept was demonstrated to the fruit industry.

However, no appropriate equipment existed for fruit grading, with emergent Japanese technology too expensive and slow for use in western horticulture. An Australian Research Council (ARC) Large and ARC Collaborative grant allowed exploration of appropriate optical geometries (patent taken), instrumentation and chemometric development to allow practical use on packlines. Horticulture Australia Limited (HAL) funding further supported extension of the work into different fruit commodities and development of portable instrumentation that allowed in-field use.

From the late 1990s, the project team from CQU University worked with an Australian fruit grading manufacturer, Colour Vision Systems (CVS), to investigate how to integrate NIRS into a fruit packline. While continuing this collaboration the research team worked with a manufacturer of handheld devices, first Integrated Spectronics Pty Ltd, then, more recently, Felix Instruments Incorporated to produce a handheld NIRS device for use in assessment of fruit on trees.

The worldwide market for such devices is modest, such that the value of the technology is in the value added to fruit production, rather than equipment sales.

To support the uptake of the technology, the research team has worked with growers and supply chain groups focussed on production of quality fruit to use the technology to improve their product. For example, the technology has become integral to the success of the Calypso mango.

The project has not been without its challenges. An early business model collapsed due to the failure of Australian supply chains to provide reward for sweeter fruit and to changes within the world’s largest fruit grading manufacturer. Research has continued with a focus on identification of fruit with defects, i.e. negative features rather than positive features such as sweetness. Pilot commercial installations now exist in several apple pack houses, where sorting for internal browning occurs. Fruit industry groups like Montague also seek commercial advantage with retailers through use of internal defect sorting.

Management of harvest time decisions and ultimate eating quality are related to internal parameters including carbohydrate (sugar) content and defects such as flesh browning. Commercially, learning how to grow sweeter, as opposed to more, fruit has become significant. Interest in sweetness sorting has re-emerged within the citrus industry, which has a growing export market in Japan and Korea – markets that require and reward sweetness.

CQU University has been instrumental in these developments, working in concert with the engineers of CVS, and later French-based MAF Pty Ltd, for inline sorting technology, as well as those of Integrated Spectronics, then Felix Instruments Incorporated, for the handheld unit. The research group has also worked with various agronomic collaborators to develop protocols for the use of the technology within the production system, ultimately creating value in apple, citrus and mango supply chains.

The research that began in the mid-1990s with a local enquiry and in a modest confirmation of the work of Japanese researchers that NIRS could be used to sort high moisture, non-homogenous products such as fruit, has continued and now has global implications. Other non-invasive technologies do exist, e.g. transmission X-ray imaging, magnetic resonance imaging, acoustic frequency methods, although the widespread commercial adoption in fruit sorting is yet to occur using such technologies.
The research group has also worked with various agronomic collaborators to develop protocols for the use of the technology within the production system, ultimately creating value in apple, citrus and mango supply chains.
It is surely a positive when money invested in research results in substantial cost-saving benefits for major industries. That is certainly the case with a recent project funded by Queensland Alumina Limited (QAL) that investigated ways to reduce downtime in its descaling and cleaning operations. Reduced flow efficiency due to scale growth and downtime of equipment can cost about a third of the refining process, hence the significance of finding a solution to the problem.

Scale growth in alumina refineries is a common phenomenon and occurs where supersaturated solutions used in the refining process, known as Bayer liquor, are in contact with solid surfaces. The simultaneous dissolution of impurities such as silica during the bauxite digestion process results in scale formation in many parts of process plants. Scale growth is a serious problem as it causes decreased efficiency of fluid flow systems over time, such as increased drag and blockages, ultimately creating excessive pump wear.

Stemming from the observation that, contrary to conventional wisdom, the rate of scale growth is more in fittings called reducers than in a straight section of pipe, a collaboration was formed between CQUniversity Australia and the Commonwealth Scientific and Industrial Research Organisation (CSIRO). It was with this collaboration that the project came into being. A reducer has a higher velocity that creates higher turbulence and therefore scale growth is expected to be less than in a straight section of pipe. The project was initiated to examine this occurrence and the effect of fluid flow characteristics, for example; flow velocity and turbulence, on scale formation.

The project undertook an experimental study at QAL’s plant in Gladstone, Queensland, and results showed that the scale growth in Bayer liquor is strongly affected by fluid velocity while also influenced by a number of other factors. As observed in Nawrath et al. (2006), it was concluded that the scale growth rate decreases with increasing fluid velocity.

The results suggested that the creation of flow instability within the boundary layer of Bayer liquor flow could be used to inhibit or suppress scale growth in the process equipment of Bayer plants (alumina refineries). It was also suggested that an increased flow disturbance or instability in the boundary layer could be used to enhance the effect of scale inhibition. Production of this instability helped achieve a large-scale suppression effect instead of using high velocity, which is difficult to produce due to operational limitations.

The results and outcomes of this research project provided solid evidence of the effect of fluid velocity. Most of
the previous research and studies on scale growth concentrated on the nucleation and bonding phenomenon with little or no work on the role of fluid flow on scaling. It is for this reason that this project is significant and noteworthy – it has provided new results and validated the significant role of fluid velocity in scaling.

The project’s findings have greatly influenced others to conduct further research to determine the relationship between fluid dynamics and scale formation mechanisms. The outcomes and results have led to a new novel agitator design, Swirl Flow Technology (SFT), which was introduced as an alternative design to the widely used conventional draft tube agitator system to mitigate scale growth.

It is known that QAL has adopted the new SFT design and progressively installed this system, resulting in a reduction in scale growth. This has reduced downtime by about 50 percent, saving a significant amount of money, as well as increasing productivity and returns. While not reported in the public domain, the actual figure of savings is estimated to be large, directly benefitting the industry and, arguably, the state’s economy.

Research works akin to this project have provided valuable clues and information about selecting optimum design and operating parameters to reduce scale. However, further research is necessary to fully understand and determine the effects of these parameters.
...an important aid for keeping our firefighters safe so that they can continue to keep us safe.
There are arguably few communities across the globe unaware of the devastating effects of bushfire. Concerns exist that the severity and frequency of bushfire is on the rise and with hotter weather and more intense fires requiring longer shifts and more frequent deployments there are significant threats to the operational readiness of the volunteers and salaried staff of Australasia’s fire and emergency services. Safeguarding workers’ operational readiness relies, in part, on a robust and relevant evidence base from which to build policies and procedures.

In the past, industry-specific research has been required to assist the fire industry in developing comprehensive policy, best practice guidelines and training and educational materials in order to preserve the health and safety of their firefighters during multi-day bushfire suppression deployments. It was this exact focus that became the main aim of the Operational Readiness project.

Research was conducted jointly by the Appleton Institute and the Centre for Physical Activity and Nutrition at Deakin University. It was funded by the Bushfire Cooperative Research Centre (CRC) in collaboration with the Country Fire Service in South Australia, the Country Fire Authority in Victoria, the Tasmanian Fire Service, the Australian Capital Territory (ACT) Rural Fire Service, NSW Rural Fire Service and ACT Parks and Recreation. Following final sign-off by partners the data collection for the project began in 2012 and was completed in 2013, with the final report delivered in 2014.

A four-day bushfire suppression simulation tour was developed and validated with agency collaborators over a 12 month period in 2011. This provided the opportunity to study the impact of, and interaction between, multiple fireground stressors, i.e. sleep disruption and heat, on firefighters’ physiological responses, as well as physical and cognitive work performance across a simulated four-day bushfire suppression tour. Findings were presented to key fire industry stakeholders to inform the development of comprehensive policy, best practice guidelines and training and educational materials for the preservation of firefighters’ health and safety. These outcomes are now used by more than five fire and emergency services agencies and are an important aid for keeping our firefighters safe so that they can continue to keep us safe.

Prior to undertaking this project, research on the impact of multiple occupational stressors on firefighter performance and health was limited. For example, studies did not use tasks that resembled work on the fireground, the duration of the testing was much shorter than commonly experienced by our rural firefighters – hours compared with several days – and cognitive function was often measured in the absence of physical activity, in contrast to operational activities involving both functions. Further, observational studies in the field made it difficult to know what factors were actually having an effect. The emergency services sector sought information about the actual impacts on physical, cognitive and physiological function under realistic, and controlled, conditions that simulated a strike team on deployment.

The research has proven effective with the incorporation of findings being developed into safe working guidelines at the sector level, as well as agency-level policies and procedures pertaining to health and safety of rural firefighters. The sector-level guidelines have been developed by the Australasian Fire and Emergency Service Authorities Council (AFAC), which is the peak body for fire, land management and emergency services in Australasia, along with 32 member agencies and 13 affiliate agencies. AFAC guidelines are now used by agencies throughout Australasia as best practice, grounded in industry-led research.

This significant research project was driven by the industry need for evidence on impacts of exposure to multiple occupational stressors simultaneously on firefighter health and performance markers. Previous research was largely piecemeal, addressing only one element of physical performance or cognitive function or physiology, rather than taking a holistic perspective of the firefighter’s performance. Today, the research team continues to be heavily involved with the emergency services sector to ensure ongoing improvements and updates to relevant best-practice guidelines, policies and procedures.
Is there a way to improve the yield of solar power systems on buildings that are often subject to shadowing from the building itself or adjacent buildings or trees? Researchers at CQUniversity have successfully patented a distributed maximum power tracking technology that greatly increases the yield of solar arrays subject to shadowing.

The initial underpinning research studied the problem of maximum power tracking at the solar cell level. Solar cells are assembled into modules that contain typically 30 to 100 cells. These modules are then assembled into arrays that may have tens or hundreds of modules. Maximum power tracking at the cell level represents the extreme boundary of distributed maximum power point tracking (MPPT) technology.

Maximum power tracking technology works to improve the energy yield. Even in favourable installation conditions arrays can experience 10 to 20 percent increases. In very poor conditions yields can increase by 50 percent or more. The effect is so profound that buildings where solar installations were previously unviable because of shadowing are now viable with this new technology.

It was while managing CQUniversity’s solar car team that Professor Peter Wolfs first identified the opportunity to develop and distribute MPPT technology. Distributed power tracking imparts a benefit on a curved solar array – as found on solar cars, such cars also use arrays that are hand-built from single cells. In this instance the maximum power tracking was even more extreme with a MPPT being applied to the single cells. In this extreme case, where the distribution of many MPPTs were required, there needed to be a focus on methods that resulted in very low MPPT distribution costs and high energy conversion efficiency.

In order to examine the possible benefits of extending the range of electric vehicles, subsequent funding was provided by the Queensland Government from 2004 to 2006. This work resulted in Australian and the United States of America patents, with the Australian patent publication date being 12 July 2005. This significant piece of work appeared in key international conferences from 2005 to 2007.

After becoming aware of the technology, Tigo Energy, a privately held Silicon Valley company with venture capital inputs from matrix partners, OVP venture partners and Generation Investment management, was established in 2007 to develop MPPT products for building integrated Photovoltaic (PV) arrays. The technology that was developed used a distributed maximum power tracking system, based on a technical approach that had been patented by Professor Wolfs. As a distributed MPPT solution, the features of low cost and high efficiency that were pioneered during Professor Wolfs’ solar car project became essential.

Tigo Energy subsequently purchased the rights to the CQUniversity patents in 2010. Today, the Australian and United States of America patents continue to be the central core of their distributed MPPT technology. For instance, the technology has been adopted by Tigo to produce their flagship product, the smart module, which allows module-by-module-based maximum power tracking within building-integrated and rooftop solar arrays.

In 2010 independent testing by Photon Laboratory GmbH showed the Tigo distributed tracking system increased the yield in a range of shadowing situations by 20 to 36 percent. Even for unshadowed arrays, which are considered to have very little loss due to mismatches, a three percent yield could be achieved. These results have enabled Tigo Energy to substantiate and demonstrate clear advantages in energy production.

The research, that forms the basis of the technology still being used today, revealed that highly economic MPPT structures could be developed using capacitive storage and switching power devices. In the conventional approach inductors are included to produce a continuous output current, however the work at CQUniversity between 2004 and 2006 proved this was not strictly necessary. The Tigo Energy Smart module regulators that were subsequently developed from 2007 onwards continue to exploit and leverage this significant innovation.
Maximum power tracking technology works to improve the energy yield. Even in favourable installation conditions arrays can experience 10 to 20 percent increases. In very poor conditions yields can increase by 50 percent or more.
THE ECONOMICS OF IMPROVING WATER QUALITY INTO THE GREAT BARRIER REEF

Chief Investigator: Professor John Rolfe

Prior to this project being conducted, little economic analysis was available to review or guide policy and investment decisions dealing with the declining health of the Great Barrier Reef. Substantial scientific investments were made in relation to monitoring and understanding the ecology of the Great Barrier Reef, as well as the water quality draining from adjacent catchments. Evidence of continuing decline in the health of the reef led to calls for additional protection measures to be undertaken.

Led by the School of Business and Law’s Professor John Rolfe at CQUniversity Australia, this particular program of research used cost-benefit analysis to evaluate the benefits and costs of additional investments in protection for the Great Barrier Reef. Ultimately this would enable more cost effective proposals to be prioritised and available public funding to be used to maximise environmental protection. Within this overarching goal, the economic research project has addressed concerns in four key ways.

First, it has demonstrated that there is a strong economic case for further protection of the Great Barrier Reef, particularly when comparing the community willingness to pay for additional protection against the potential costs of achieving this. This is the first time that this type of analysis has been provided. While demonstrating that the case for public funding is not open-ended, this work has been used within government agencies to help justify the continuation of funding for the Reef Rescue program, with a further $200 million committed by the Australian Government in 2013.

Second, the program of economic research has demonstrated that the costs to landholders of making management changes can vary greatly, both across and within enterprises. The analysis shows why it is not cost effective to achieve universal practice change and why generic programs that treat landholders and enterprises as homogenous units are far too simplistic. For example, it can be profitable for some enterprises to reduce fertiliser inputs or stocking rates but only to a certain level and in combination with other management changes. In addition, the research has identified why the costs of making changes vary with different enterprise, natural resource and climate characteristics, providing a guide to where lower cost management changes can be achieved.

The results of this type of analysis have provided government agencies and the natural resource management groups with better understanding about both the potential and limitations to management change. This has been one of the contributing factors that has resulted in an increased focus on adoption rates of better management practices, as demonstrated in the Great Barrier Reef report cards.

Third, the work with individual agricultural producers has identified reasons why some management changes and government initiatives may be more attractive than others. Many management changes have low or negative benefits to producers. In these cases change may only be attractive through the payment of financial incentives. Even when change may offer financial benefits to producers, gaps in information, high transaction costs, risky outcomes or the complexity of making changes are all key reasons why landholders may be slow to adopt some practices. Results have shown that the cost effectiveness of public funding can be more than doubled when there is better understanding of economic trade-offs and prioritisation of project selection. This analysis provided policy makers and natural resource management groups with insights into how engagement initiatives and incentive programs can be better designed to improve the effectiveness of public funding.

Fourth, the work with natural resource management groups and government agencies on project cost effectiveness and project selection has demonstrated the large efficiencies to be gained from better targeting of project funds and more effective selection methods. The School of Business and Law research team has worked with several agencies and groups to trial different water quality auctions, assessment metrics and evaluation criteria including the Fitzroy Basin Association, reef catchments, Burnett Mary Regional Group, Burdekin Dry Tropics, Growcomm, CSIRO and the Queensland Department of Agriculture, Food and Fisheries. Almost all research activities have involved different partners and field experiments with landholders and communities. This has helped to improve understanding and prioritisation of project selection and funding initiatives.

In short, knowledge gained through assessing the costs of making changes in land management practices across different agricultural sectors and catchments has helped government agencies and catchment groups to better allocate funds. This project has identified the large variations in costs that exist, mapped the dynamic relationships between the profitability of enterprise and pollutant reductions, identified the factors that influence landholder take-up of better management practices and identified the most cost-effective priorities for investment in changing management practices. Significantly, this economic research project has provided policy makers and natural resource management groups with better information about strategic priorities and has fostered the adoption of more competitive selection processes focused on project outputs.
Knowledge gained through assessing the costs of making changes in land management practices across different agricultural sectors and catchments has helped government agencies and catchment groups to better allocate funds.
DON’T FAID AWAY

A BIOMATHEMATICAL MODEL OF HUMAN FATIGUE AS A RISK MANAGEMENT TOOL IN INDUSTRIES THAT EMPLOY SHIFTWORKERS

Chief Investigator: Professor Drew Dawson

Technological innovations, changes in customer demands and community expectations, and the emergence of global competition now require many industries to operate 24 hours a day, seven days a week. In many developed countries, fatigue is recognised in occupational, health and safety (OHS) legislation as an identifiable workplace hazard that must be managed to minimise the risk to employees.

A key component of any hazard management system is the ability to both identify and assess hazards. This presents organisations that employ shiftworkers with a substantial challenge as it is difficult to quantify, and therefore manage, the fatigue risk associated with systems of work. Researchers at CU|University Australia’s Appleton Institute have responded to this challenge by developing a biomathematical model to quantify the impact of shiftwork schedules on employees’ levels of sleepiness, alertness and performance. Research conducted over the last 15 years in laboratory, simulator and field-based settings related to the impact of various sleep/wake and work/rest schedules on human fatigue levels has resulted in the development of various algorithms to estimate the level of fatigue associated with non-standard (shiftwork) duty schedules. This research has been conducted by Professor Drew Dawson, Associate Professor Greg Roach and Dr David Darwent.

InterDynamics is a South Australian software development company that has successfully incorporated these algorithms into a commercialised stand-alone software application called the Fatigue Audit InterDyne (FAID). FAID has been used by companies based in Australia and overseas.

Historically, fatigue risk has been managed by enforcing prescriptive rules that specify maximum duty and minimum rest limits. Duty schedules that comply with the rules are allowed as they are assumed to have low fatigue risk, while schedules that do not comply are assumed to have high fatigue risk and are thus disallowed. Such rules have been somewhat effective but they are inflexible and can produce perverse outcomes as they do not account for time of day effects. In contrast, FAID estimates the fatigue levels associated with a schedule based on the length of its duty periods and rest periods, as well as the time of day that they occur. Rather than determining whether a schedule is allowable or not, FAID categorises the fatigue level associated with each duty period as being low, moderate, high or extreme. This information can then be used to minimise and/or mitigate fatigue risk.

FAID forms part of an overall fatigue risk management strategy that enables employers to reduce the occurrence of fatigue-related incidents, accidents and fatalities.

Under OHS legislation organisations that employ shiftworkers have a duty of care to minimise the likelihood that their employees will be adversely exposed to fatigue. Many organisations have developed fatigue risk management strategies based on the principles of safety management systems. The basis of traditional fatigue management systems has been to minimise the risk to employees by providing multiple, redundant layers of defence against potential fatigue hazards. Dozens of organisations, such as Union Pacific and easyJet, have incorporated FAID as a layer of defence in their fatigue risk management systems and use it to assess and manage the fatigue risk associated with planned and actual duty schedules.

FAID has produced two measurable economic and safety benefits of significance:

Economic

Since 2001, InterDynamics has received $5 million in revenue from the sales of FAID. FAID licences are currently held by 350 organisations in Australia and overseas. Professor Drew Dawson originally licenced the biomathematical algorithms to InterDynamics in 1999. Since then, InterDynamics has renewed its licence in 2003, 2007 and 2013.

Safety

Union Pacific Railway has used FAID to aid the design of fatigue-friendly rosters since 2001. Since then, the incidence of planned rosters with fatigue exceedances has been reduced by 20 to 30 percent. Prior to the introduction of FAID, Union Pacific Railway averaged five fatigue-related fatalities per year. In the 10 years that the organisation has been using FAID, it has not had a single fatigue-related fatality. It is likely that the development of fatigue-friendly rosters using FAID has contributed, at least in part, to this reduction in fatalities.
Many people enjoy a flutter every now and again. Nonetheless, it is well established that gambling can cause financial, psychological and health-related harms to gamblers, their families and the community due to excessive use and expenditure. In Australia, annual social costs of gambling are estimated to range between $4.7 and $8.4 billion. Of all forms of gambling, poker machines or electronic gambling machines (EGMs) are consistently found to present the most significant risk to individuals, with elevated use of EGMs most strongly associated with the development of gambling problems.

Jackpots enhance the appeal of electronic gambling by giving gamblers the impression that they can achieve an immediate reversal of their losses by virtue of winning the jackpot. Given the ubiquity of this feature of EGMs, knowledge of the potential impact on gamblers in terms of promoting unsafe gambling behaviour is critical. Motivated by a lack of research both in Australia and overseas on the impact of EGM jackpots on player behaviour, Gambling Research Australia, Australia’s main gambling research funding body, commissioned a report by the Experimental Gambling Research Laboratory (EGRL) at CQUniversity in an attempt to answer a number of questions. Such questions included do jackpots and linked jackpots increase the likelihood of risky gambling behaviour and gambling-related harm, and to what extent do jackpots enhance the player experience?

The EGRL undertook its multi-stage $250 000 project involving experimental, survey and in-venue player monitoring methodologies from November 2011 to December 2013. The resulting report provided the first major body of empirical evidence on the impact of EGM jackpots on player behaviour. State and territory governments are now using the report to evaluate jackpot payout mechanisms and sizes, with the ultimate goal of determining the safest products for consumers.

“...the research also explored a novel player protection measure, jackpot expiry, which was devised to address the most evident risk associated with jackpots.

In summary, the impact of the research in providing knowledge of the elevated risks caused by jackpot-enabled EGMs is informing policy makers and regulators in determining the constraints enforced on EGM features in casinos, pubs and clubs. Regulators in Australian states and territories are currently reviewing the structure of EGM payout mechanisms, as well as jackpot sizes, to determine the safest configurations for Australian consumers.
Since the time of Edison, the worlds of commerce and research have generally enjoyed a positive and mutually beneficial relationship. At the time that Edison began swamping the world with more patents than actual inventions being taken to the market, a key lesson was learnt – a challenge to a patent submission can often be an indicator that someone has come up with a good idea. In a similar manner, although now resolved, such was the case with a challenge to the development of an electronic smart brake system for freight trains developed in a research partnership between CQUniversity Australia, Faiveley Transport Pty Ltd and the Queensland Government.

Originating in earlier work at the Centre for Rail Engineering and the Cooperative Research Centre (CRC) for Railway Engineering and Technologies this research was designed to develop electronically controlled train brakes and associated smart devices for freight trains. Freight trains still have the same basic operating principles of air braking that was derived in the late 19th century. Given that the control medium is air pressure, the control signal cannot move along the train any faster than sonic velocity. This leads to the familiar ‘clunk-clunk-clunk’ sound we hear in trains.

While electronic braking has been available in passenger trains for some time, there are difficulties in freight trains due to the train length and the fact that freight wagons have no electric power. The need for electronic brakes has continued to increase as heavy haul trains have become longer. Trains of 2.4 kilometres are common in Australia, with longer trains of up to 4 kilometres currently operating in South Africa and proposed for new projects in Australia.

Freight train electronic braking products started to emerge in the mid-1990s, however uptake was very slow. The principal reason for the slow uptake was the fleet roll-out cost and the massive job of fleet-wide retro-fits. In contrast to the slow uptake, the benefits of electronic brakes can be readily seen in uniform brake application – as signals traverse almost instantaneously – giving significant improvement in train stability and safety during braking. In addition, energy can be saved as braking is more precisely controlled.

The roll-out of electronic brakes also offers a new era in freight train safety and early warning systems. The addition of an electronic brake system adds both electrical power and communication to each wagon. This opportunity means that for the first time each wagon can be monitored for faults or derailment. While this technology might not prevent catastrophic and instantaneous derailments, which often have many different causes, it does allow monitoring of degrading track or wagon conditions. Ultimately this enables remedial action before failure. This type of technology can prevent partial derailment such as a dragging wheel, which has been known to travel up to 20 kilometres, destroying most track sleepers in the section before the train finally derails catastrophically.

The impact and effectiveness of the research can be summed up in its two successes. Firstly, the development of an electronic braking product that can be retrofitted to a large percentage of freight rail fleets in Australia, Europe and the United Kingdom. Secondly, the development of a train health advisory system product that is integrated into the electronic braking product, which again is easily fitted to freight rolling stock and provides the capability of every wagon condition monitoring.

The underlying research enabling these impacts was the development of a robust low power brake control product for operation in the severe on-wagon environment, as well as robust and low-cost condition monitoring technology for each wagon that required a minimum number of transducers. This innovation required development of inverse modelling techniques to achieve useful reporting from simple and robust transducer installations.

“Put simply, a single black box was developed to provide braking control and reporting of wagon and track condition to the locomotive driver and railway maintenance staff.”

The design was modular, configurable and cost effective and required no maintenance. Despite early attempts to derail the commercial end of this worthy project, the research still remains significant and relevant. Today, cost-effective electronic smart brakes for freight trains are very much a reality.
CONSULTANCY
CQUniversity Australia researcher expertise and University facilities can be engaged by industry to provide a range of testing services on a fee-for-service basis. CQUniversity consultants can also be engaged to undertake confidential research activities where the data and results are owned wholly by the commissioning industry party.

CONTRACT OR COLLABORATIVE RESEARCH PROJECTS
Contract or collaborative research projects range from small-scale, short-term projects to major multi-year collaborative projects. Industry partners may fully fund the direct research costs of the projects or partner with CQUniversity to leverage funding from agencies such as the Australian Research Council or state government programs such as the Queensland Government Accelerate Partnerships Program. Ownership of intellectual property arising from the research activities are negotiated on a project-by-project basis.

INDUSTRY SCHOLARSHIPS AND TOP-UP SCHOLARSHIPS
Industry scholarships and top-up scholarships can target dedicated full-time student research projects in particular areas of industry need. Research projects may range from two years (Master by Research) to three to four years (PhD).

Scholarship stipends typically cover living expenses and associated costs for students and range from $25,000 to $30,000 per year and $5000 to $10,000 per year for top-ups. Scholarship awardees may commence at any time during the year.

FUNDED PLACES
Funded places allow industry the opportunity to sponsor nominated students to undertake research higher degrees in specified research areas. The industry sponsor covers the cost of a full fee-paying place for the student, ranging from $20,000 to $25,000 per year. Funded place-holders may commence their studies at any time during the year. Many of these students also enjoy the opportunity to work for the industry partner while undertaking their studies.

For further information about sponsoring research or consultancy at CQUniversity please contact the Office of Research Services. Email research-connect@cqu.edu.au or call +61 7 4970 7330.