

FOCUS

INNOVATE OR PERISH: THAT'S THE MANTRA

WE MUST TURN OUR IDEAS INTO WORLD
PRODUCTS AND SERVICES

CAN AUSTRALIA BE NIMBLE
AND AGILE – AND EMBRACE
THE COMING TSUNAMI
OF CHANGE?



REGISTER NOW AT
www.atse.org.au/agribusiness2030

The Academy's inaugural National Technology Challenges Dialogue is a two-day event in Sydney, at the Sofitel Sydney Wentworth, on 15 and 16 June, 2016.

Agribusiness 2030 is an exciting opportunity to exchange ideas between the nation's most eminent entrepreneurs, decision makers, government officials, researchers, academics and business leaders, who will explore:

- the future of agribusiness in the digital age;
- how this will play-out domestically and globally;
- the opportunities and challenges this offers Australia.

It also incorporates ATSE's Annual Innovation Dinner on 15 June where the Clunies Ross Awards will be presented. These exciting awards bring together Australia's top leaders and innovators from research, industry and government and provide a valuable networking opportunity at the nation's premier annual awards for innovation commercialisation.

Sponsorship Packages are available for both the two-day Agribusiness Dialogue and Innovation Dinner. Visit the website for more details or contact Sue Wickham, Executive Manager Operations and Events sue.wickham@atse.org.au



Contents



3

Getting the best from research: will the NISA make a difference?

By Roger Lumley

5

The future of computing: we're at the forefront

By Michelle Simmons

8

Advanced manufacturing – is there anything we can't make?

By Calum Drummond and Stuart Bateman

11 Where and what will we trade in the future?

14 Food security: global challenge, transdisciplinary approach

16 ATSE supports Science meets Parliament

16 ATSE goes to Korea with KASIC

17 REA metrics effective measure of research engagement

17 ATSE hosts JASIC exchange

18 Changes would help R&D Tax Incentive

19 Infrastructure planning a 'critical issue'

20 STELR'S 500th school signs on

37 ATSE in *Focus*

Front cover photo: Spinal implant produced by RMIT.



ATSE *Focus* is produced to stimulate discussion and public policy initiatives on key topics of interest to the Academy and the nation. Many articles are contributed by ATSE Fellows with expertise in these areas. Opinion articles will be considered for publication. Items between 800 and 1400 words are preferred. Please address comments, suggested topics and article for publication to editor@atse.org.au.

Deadline for the receipt of copy for next edition of *Focus* is 13 May 2016.

COPYRIGHT

This publication contains copyright material. Some of the material is owned by Australian Academy of Technological Sciences and Engineering Ltd ACN 008 520 394 (ATSE) and some material is owned by others. All copyright and other intellectual property rights in the materials remain with the owner. No material in this publication may be copied (except as legally allowed) or further disseminated without the express and written permission of the holder of that copyright, with the exception of copying for educational purposes. Copyright © ATSE 2016

PUBLISHER

Australian Academy of Technology and Engineering™

Address:

Level 1, 1 Bowen Crescent, Melbourne

Postal Address:

GPO Box 4055, Melbourne, Victoria 3001

Telephone: 03 9864 0900

Facsimile: 03 9864 0930

Email: editor@atse.org.au

CEO: Dr Margaret Hartley FTSE

Editor: Bill Mackey

Print Post Publication No 341403/0025

ISSN 1326-8708

Design and production:

Coretext 03 9670 1168 www.coretext.com.au

Enhancing Australia's prosperity through technology and innovation

The Australian Academy of Technology and Engineering (ATSE)

ATSE is made up of some of Australia's leading thinkers in technology and engineering. One of Australia's four Learned Academies, it's an eclectic group, drawn from academia, government, industry and research, with a single objective in mind – to apply technology in smart, strategic ways for our social, environmental and economic benefit.

To achieve that goal, ATSE has formed a variety of expert, independent forums for discussion and action – platforms to move debate and public policy on issues concerning Australia's future. These focus on energy, water, health, education, built environment and innovation – and the international collaboration necessary to ensure that Australia is abreast of world trends.

It's an open, transparent approach – one that government, industry and community leaders can trust for technology-led solutions to national and global challenges. Each year, the Australian Government recognises the importance of the work we do by awarding the Academy an establishment grant to help with:

- Fostering research and scholarship in Australia's technological sciences and engineering;
- Providing and conducting administrative support, workshops, forums and events to enable the Academy and its Fellows to contribute on important national issues;
- Managing the development and execution of our programs; and
- Supporting relationships with international communities.

Level 1, 1 Bowen Crescent
Melbourne, 3004
Victoria, Australia

GPO BOX 4055
Melbourne, 3001
Victoria, Australia

T +613 9864 0900
F +613 9864 0930
E info@atse.org.au

www.atse.org.au

AUSTRALIAN ACADEMY OF
TECHNOLOGY AND ENGINEERING™



BY ROGER LUMLEY
roger@awbell.com.au

Getting the best from research: will the NISA make a difference?

INNOVATE OR PERISH Inventors of a product or process don't always gain success in the marketplace; it is those who take the R&D and turn its outcomes into a competitive and desirable product or service.

T

The short answer to the headline question is simple – the National Innovation and Science Agenda (NISA) *has* to make a difference. There

are exciting times ahead for the science and engineering professions in Australia.

Moving into the future, Australian industry must be prepared to create impact and attain market influence by embracing innovation and the challenges faced are truly unique.

It is imperative that the gap between ideas and the marketplace is bridged, through the synergy between invention, science, engineering, technology and management.

Most importantly, and central to the argument, is the simple yet fundamental lesson that it is not always the developers or inventors of a product or process that gain success in the marketplace – it is those who take the R&D and turn its outcomes into a competitive and desirable product or service who gain success in the marketplace.

It is clear that inextricably linking Australia's innovation system to the industries it serves is central to the success of the NISA. This creates a framework where the health of R&D is directly linked to the health of the industries it serves.

This is all very easy to say in a few paragraphs and we have a lot of work ahead of us to make it happen.

So why do some innovative technologies based on R&D succeed while others fail? How do we pick the winners and get the best from research?

In my experience – as a professional researcher now working in industry – the way



Traditional manufacture – pouring a casting.

in which the process of external (government-funded or university) R&D leading to a successful commercialisation outcome *physically happens* is often poorly understood.

Neither the research provider nor the prospective industry partner necessarily knows how to implement a new technology, pass the 'Valley of Death', and then to make a profit from it. Understanding and managing these risks of technology implementation and 'productionisation' is where so many of the unknowns lie.

The researcher's view is that they have developed, or will develop, a technology that is valuable. The researcher may develop a scope of intellectual property surrounding their work that they wish to protect or license.

Unfortunately, many see this as the end point.

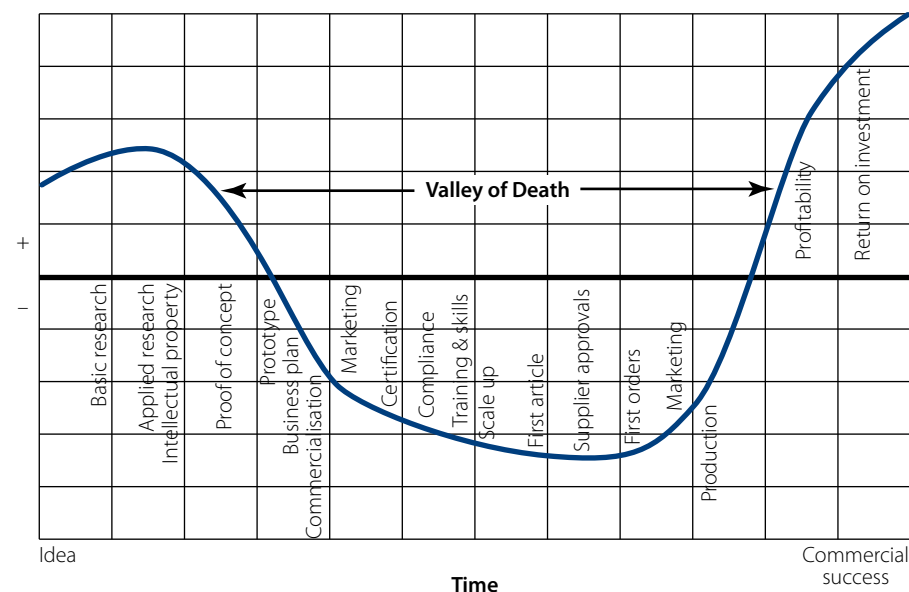
To invest in a new technology, the industry and commercial view will always be that the value proposition has to be sound. Industry needs to be able to understand the return on investment and what physically has to be done to scale up and implement technology, and then to sell products or services profitably. Only then can they actively manage the associated risks.

Recognising this can better help us understand the way that many Australian companies conduct R&D internally (that is, in-house) and collaboratively (business to business).

It is promising that the NISA does recognise this, since Australian innovation

Figure 1 The 'Valley of Death' – between proof of concept and profitability.

Net cash flow



in industry has strategic relevance to the economy. For example, it has been stated by the CEO of a medium-sized Australian manufacturing company that it usually takes the business six months to bring a new product from concept to market.

If we break down what this physically means to this business, the non-recurring costs the company faces in that product-development cycle include: all R&D, methods development, tooling, prototyping, infrastructure, equipment, supply-chain development, limited production runs, process development and refinement, cost reduction and first article inspection – all the while working collaboratively in a project team.

Some of the problems and their solutions that are encountered along the way are extraordinary and, of course, all of this activity needs to be completed within an ambitious project lead time.

It is perhaps also pertinent to consider how commercialisation of new technology or start-ups developed from government-funded or university research might be resourced to fit into the same model and timeframe.

The new Research Engagement for Australia metric (as proposed by ATSE in 2015) is scheduled for implementation. Although there are many of my academic colleagues who will argue otherwise, it is my opinion that the academic system in Australia has not used all of the right metrics when assessing outputs related to research.

Unfortunately, many of our best researchers and universities have been rewarded for producing prestigious journal publications, but not necessarily for producing the technologies and capabilities that provide the fundamental basis for commercial success and prosperity.

Certainly, the NISA attempts to address this balance with a far greater emphasis on industry engagement by the research sector. I am, however, left with the opinion that parts of the Australian research community may be somewhat perplexed by how to achieve the balance between academic excellence and industry engagement.

FUNDAMENTAL CHANGE

The answer may lie with early career researchers. It would not be unreasonable to expect that future professorial appointments in Australia will be considered on both academic excellence together with demonstrated industry engagement and commercialisation of technology. I believe this then should produce a fundamental change in the way our Australian early career researchers are motivated to succeed.

How funding and grant applications are written, assessed and implemented will play a major role in making this happen. It is more than reasonable for all Australian funding bodies to be able to honestly ask the question 'What is the return on investment?' before approving a funding application.

It then also logically follows that those

research leaders and teams who have demonstrated a strong return on investment from successful competitive grant funding will have a proven track record of success hence the capability to attract further funding.

One initiative of the NISA that can have great impact is that associated with the statement "Government as Exemplar". There is an implication here that government and its agencies will be agile, entrepreneurial and innovative – and have an increased capacity to manage risk.

There is also a range of opportunities here for government to really stand out in the procurement and contracts space for major projects. With the initiation of long-term activities within Australia, such as those announced in the Defence White Paper in March 2016, it would be very surprising if there were not a significant effort made to make these a showcase of Australian technical prowess and innovation.

Finally, a common theme that I hear from senior managers throughout Australia (and in fact, those from other first world economies as well) is related to the perceived skills gap.

Many Australian companies see growth hampered by the inability to recruit talented scientists, engineers and technical staff who are employment-ready. The STEM initiatives of the NISA are particularly important, since the fundamental groundwork to prosperity will be created by increasing the flow of good secondary students with strong maths and science backgrounds into tertiary science and engineering courses. These are the people whose task it will be to drive Australian prosperity through the 21st century.

The National Innovation and Science Agenda is a significant step in the right direction towards creating a new prosperity within Australia based on technological prowess. It is now the responsibility of us all to capitalise on the new opportunity, and make the most of it. ☺

Dr Roger Lumley FTSE is Technical Manager with AWB Pty Ltd in Melbourne. He is recognised nationally and internationally as a highly competent scientist, engineer and project manager. A Fellow of the Institute of Engineers Australia, he is an advocate of Australian manufacturing and industry-based research. He also has an outstanding track record in translating research into commercial outcomes and recently led a team that won the AIRG Medal for development and commercialisation of technologies that have been employed in the F35 Joint Strike Fighter.



BY MICHELLE SIMMONS
michelle.simmons@unsw.edu.au

The future of computing: we're at the forefront

INNOVATE OR PERISH The effort to create a working quantum computer at scale is the space race of the 21st century, and Australia is at the very forefront.

T "There is nothing that I can see in the physical laws that says the computer elements cannot be made enormously smaller than they are now. In fact, there may be certain advantages."

So said Nobel Prize-winning physicist Richard Feynman in 1959 in his seminal 'There's Plenty of Room at the Bottom' speech. He also noted, presciently, that computers were very large and that if they could be made smaller "they could be made to be more complicated by several orders of magnitude".

Since that time computers have become smaller and faster every year as they try to keep up with 'Moore's law' – Gordon Moore's observation that the number of components on a silicon chip roughly doubles every 18 months to two years. This law has held true for nearly five decades and dictates the research conducted by semiconductor manufacturing firms.

Trillions of dollars are spent each year to continually miniaturise devices, so that Moore's law has become a self-fulfilling prophecy.

The semiconductor industry is still driven by the demand to make computers faster, smaller and cheaper. A commercial silicon chip today contains over four billion transistors, each of which has to behave reliably for the computer to work. This is one of humankind's greatest achievements, allowing the digital era, where information can be easily communicated, stored and analysed.

But this is only the beginning. As feature sizes shrink over the next decade, eventually the advancement of information technology will require the manipulation of individual atoms. This will mean a fundamental



Dr Joris Keizer conducting an experiment on a scanning tunnelling microscope at UNSW.

departure from the classical world to the world of quantum mechanics.

QUANTUM COMPUTERS

As impressive as classical computing is, there remain many real-world problems that cannot be solved with available computational power. By controlling nature at the smallest length scales, where we deal with quantum states of matter, it is postulated that we will be able to perform calculations in parallel, allowing us to achieve an exponential speed-up in computational power for certain types of problems.

These new computers, called quantum computers, work entirely in the quantum regime. A quantum computer replaces the basic units of classical information, where information is stored and manipulated as charged states (bits), with the quantum states

of either single electrons, ions or photons (quantum bits or qubits). This brings an important advantage: whereas a conventional bit can exist in only two states (either a 0 or a 1), a quantum bit can exist in multiple states (as both a 0 and a 1) at the same time. This enables information to be stored in a huge number of different states in parallel. The ability to do parallel processing all on one chip gives the quantum computer its massive advantage.

Conventional computers struggle when the number of variables in a problem becomes large, or when a computer must search through a large number of different possible solutions. It is in applications like these that a quantum computer would excel: encryption and decryption of information; weather forecasting; economic and financial modelling; scheduling and logistical planning; fast database searches; bioinformatics; and



CLEVER RESOURCEFUL SOLUTIONS

The minerals we help to mine shape the world we live in.

An Australian company with a global footprint, Orica has operations in more than 50 countries and customers in more than 100. On average, we deliver 1,500 blasts every day.

We're focused on developing long-term partnerships with our customers to reduce the total costs of mining, improve productivity and achieve sustainable environmental outcomes.

We combine the progressive thinking of our Global R&D and Technical networks to find solutions for the challenges encountered at every stage of the mining value chain.

To deliver for our customers, we rely on excellence in Science, Technology, Engineering and Mathematics.

We are therefore proud to be the principal Sponsor of ATSE's STELR Project and to have helped more than 400 schools in Australia and beyond become STELR schools.

Blasting Systems | Ground Support | Mining Chemicals

orica.com



simulation of quantum materials. Many of these applications have important national security and economic impacts.

Internationally, there is a fierce race underway to build a scalable, error-corrected quantum computer that fundamentally transcends the limitations of conventional supercomputers. Recently the UK (£270 million), Dutch (€135 million) and US governments – Army Research Office and Intelligence Advanced Research Projects Agencies – along with US laboratories (Sandia, National Institute of Standards and Technology, Hughes Research Laboratories, Zyvex) and leading IT companies (Intel, IBM, Microsoft, Google) have all announced major funding programs for quantum information initiatives.

AUSTRALIAN INDUSTRY

Australia has demonstrated clear international leadership in quantum computation over the past two decades. We have:

- developed internationally unique technologies for engineering electronic devices in silicon at the atomic scale;
- succeeded in fabricating individual transistors at the level of a single atom (about 10 years ahead of industry predictions);
- created the narrowest conducting silicon wires to address these states;
- demonstrated the ability to initialise the spin states of single electrons and single nuclei on these individual atoms;
- achieved the longest-coherence-time qubits in the solid state (greater than 30 seconds) that are much longer than the gate operation times;
- demonstrated the ability to read-out the spin states of single electrons and single nuclei on single atoms; and
- demonstrated the exchange and entanglement of qubits towards a two-qubit gate.

Atomic engineering not only allows exquisite investigations of the quantum world but application of this technology depends on our ability to integrate many of these transistors together in order to develop an atomic-scale or quantum integrated circuit.

In contrast to the semiconductor industry, which is seeking to down-scale devices every year towards the atomic limit, the next innovation in atomic electronics or quantum computing is how to integrate different devices upwards from this limit. Our goal now is to

A BRIEF HISTORY OF COMPUTING

The first transistor was invented at Bell laboratories in 1947 by Bardeen, Brattain and Shockley and consisted of a crystal of germanium with two gold contacts. The voltage on one contact modulated the current flowing through the other, amplifying the input signal up to 100 times. For this discovery, Shockley, Bardeen and Brattain were awarded the Nobel Prize in physics in 1956. However, despite its original use as an amplifier, its most common application today is as an electrical switch for logic gates.

When the transistor was invented, the concept of a stored program digital computer was emerging. Military and aerospace applications demanded computers with complex electronic circuits that were small in size with low weight and power requirements. The synergy between this new component (the transistor) and a new application (the computer) led to the concept of integrating the individual electronic components onto one material.

Yet it took a decade from the invention of the first transistor to the first demonstration of an integrated circuit in 1958, with one transistor, three resistors and one capacitor interconnected *in situ* to form a complete circuit. The subsequent integration of many transistors into a silicon chip brought enormous advantages in cost and performance over manually assembled circuits.

An early application of the integrated circuit was the hand-held calculator. But the most significant benefits were found in digital computing. Intel's first microprocessor, the 4004 with 2300 transistors in the microprocessor, was not released until 1971. The first IBM PC was launched in 1981 with a pricetag of US\$1565. This was a remarkable achievement given that in the 1960s an IBM computer cost as much as US\$9 million and required a quarter of an acre of air-conditioned space with 60 people to keep it loaded with instructions.

increase qubit number to form more and more powerful quantum computers, with the certainty that at some point within the decade classical and quantum technologies will collide.

Globally the mixture of funding is being directed both to fundamental discovery work and to engineering-style development. Consistent with this development, as part of the National Innovation and Science Agenda, the Australian Government, the Commonwealth Bank and Telstra have committed \$45 million to create a commercial entity that can translate past achievements in fundamental quantum computing research to build a 10-qubit prototype in silicon.

By attaching a commercial entity focused upon short-term prototype acceleration to a successful research centre, the Government and commercial partners are hoping to address the challenge Australia has traditionally faced, where long-term, fundamental projects end before commercialisation has taken place, or research is pushed too quickly to commercialisation when it is not ready.

The objective is for research centres to maintain Australia's ongoing fundamental research in silicon, optical and networking platforms, thus supporting essential breakthroughs in error correction, algorithm and architecture development, and scale-up

engineering of large-scale universal computers.

The Government has also recognised that a mechanism for development and commercial exploitation is essential if Australian companies are ultimately to derive a competitive advantage and build a broader ecosystem around quantum computing in the future.

When the Government's National Innovation and Science Agenda was announced by Prime Minister Turnbull in December 2015, he said that "it is an exciting time to be an Australian". I agree wholeheartedly and would update the quote by saying "it is an exciting time to be an Australian quantum scientist and engineer".

The effort to create a working quantum computer at scale is the space race of the 21st century, and Australia is at the very forefront. ☺

Professor Michelle Simmons FAA FTSE is an Australian Research Council Laureate Fellow and Director of the Centre of Excellence for Quantum Computation and Communication Technology (CQC²T) at UNSW. She has pioneered unique technologies internationally to build electronic devices in silicon at the atomic scale. Professor Simmons has twice received a Federation Fellowship; has won both the Pawsey Medal (2006) and Lyle Medal (2015) for outstanding research in physics; was named NSW Scientist of the Year in 2012; was inducted into the American Academy of Arts and Sciences in 2014; and in 2015 was awarded the CSIRO Eureka Prize for Leadership in Science.



BY CALUM DRUMMOND
calum.drummond@rmit.edu.au
and STUART BATEMAN
stuart.bateman@rmit.edu.au

Advanced manufacturing – is there anything we can't make?

INNOVATE OR PERISH Microphones to aircraft components, nappies to personalised medical implants, vaccines to pre-fabricated integrated building units ...

A Although a lot has been said about manufacturing in Australia, its future and our place in an ever-increasing globalised economy, we continue to design, manufacture and deliver a vast range of innovative goods and services that meet and exceed expectations.

Manufacturing adds enormous value to Australia – in fact, around \$100 billion to GDP annually – by employing approximately 900,000 Australians and contributing more than 25 per cent of business expenditure on research and development.

But in a tough, often volatile and increasingly globalised marketplace the capacity of our local manufacturers to compete and win relies not only on the quality of their workmanship but increasingly on:

- how connected and nimble their business is;
- having an IT-savvy workforce with skills that are adaptable and transferable; and
- having a management team that fosters a culture of innovation, collaboration and continuous improvement.

The image of manufacturing is rapidly changing, with a wave of 'new' digital manufacturing processes, an expanding industrial internet and advancements in cobiotics (a new class of diet supplements) upon us.

These advancements will undoubtedly reshape how we design, build and certify, and how we monitor, service and repair our manufactured products. It deserves a rethink of how we train operators and technicians, in the suitability of our design and engineering courses, and our manufacturing research priorities, and poses implications across

primary, secondary, vocational and tertiary education more broadly.

RAPID PROTOTYPING

Additive manufacturing epitomises the changing face of manufacturing. With its roots in the 1960s, and commercialisation of sterolithography in the 1980s, additive manufacturing was originally used for rapid prototyping.

The technology then produced unique fit-for-form (not function), often mechanically weak models directly from computer-aided drawing (CAD) files. It shortened the product development cycle time and hence lowered the cost of introducing new product designs.

Since the 1990s revenue from additive-manufacturing-related products and services has shown almost exponential growth, with some market analysts expecting it to exceed \$20 billion by 2020 from a base of \$3 billion in 2013.

Although not quite Star Trek's 'Replicator', the direct digital-physical link that additive manufacturing delivers provides almost endless design possibilities. Products produced by the technique nowadays are flying on aircraft, implanted as personalised prosthetics conforming to a patient's anatomy, worn as unique jewellery, and of course emerge as a leading process to manufacture in space.

One of additive manufacturing's many attractive features is that it represents a flexible manufacturing platform to produce customised, integrated and – if required – complex articles designed for function rather than to be manufacturable by a particular conventional process.

Parts for different applications and

industry segments can be produced on the same machine, providing endless diversification options. Other benefits include high materials utilisation rates that result in low waste. By understanding the load-bearing/structural requirements, products can often be light-weighted through the use of lattice structures or by placing material where it is structurally required to provide additional environmental and cost benefits.

Contract manufacturing via service bureaus also provides new business models whereby files can be sent anywhere in the world, parts manufactured and returned or forwarded on for additional processing.

However, nothing is perfect and the cost of production-quality additive-manufacturing equipment and materials remains high, build size and material options limited, and the manufacturing speed relatively slow. This makes it more suitable for one-offs or small production runs.

There are also design constraints necessitating the need for support structures within the build, consideration of part anisotropy (the property of being directionally dependent, as opposed to isotropy, which implies identical properties in all directions) due to the layer-by-layer deposition method and often post-processing requirements.

In addition there is a lack of 'rules' and modelling technologies to predict part performance, and process and standards to certify compliance, and build integrity – the latter being the subject of extensive work by standards organisations.

Translated, this means that conventional teachings on how to design and make are no longer sufficient. The skills of



Additive manufacturing in action at RMIT's Advanced Manufacturing Precinct.

operators, designers and engineers must also evolve to cater for the manufacturing technique's intricacies where there is a strong interdependency between the parts performance requirements, its design, the build methodology/parameters and inherent materials properties and response to the manufacturing process.

CONNECTEDNESS

Internet-enabled, bureau-based additive manufacturing also exemplifies the connectedness of our future as what 'we' manufacture will increasingly be a global collective as our manufacturers participate in global supply chains – whether for design and engineering services, or for the production of parts or complete products.

A recent example is Ford, which recently announced that it will retain and grow its engineering and design capabilities in Australia after closure of assembly for its world programs for vehicles such as the Ranger.

This also provides opportunities for local suppliers to enter global supply chains through

early participation in the design phase.

Similarly, how we manufacture and what we manufacture will be connected. The industrial internet, ready availability of sensor technologies, and big data analytics allow real-time information about manufacturing processes and the performance characteristics of equipment in-field to be collected, and decisions/responses on that data even automated.

Not only does this have the potential to improve quality and productivity through optimisation but it also unlocks additional benefits in terms of providing evidence of equipment 'health'. It allows maintenance schedules to be adjusted and completed when required, reducing downtime due to over-servicing, and early intervention preventing otherwise unexpected costly break-downs.

That goes also for the products we produce, where new electronically equipped functional packing will connect manufacturers and/or end users, assisting in authenticating origin, integrity and quality of our high-value manufactured products.

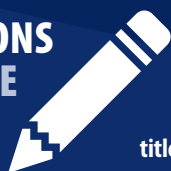
The face of manufacturing is changing from images of a laborious production line to that of flexible, adaptable and connected manufacturing platforms and products.

Our preparedness in terms of skills and capabilities across technical and non-technical fields will undoubtedly be a key determinant in whether we ride the manufacturing technology wave, fall off its back or 'wipe out' trying. ☺

Professor Calum Drummond FTSE is RMIT Deputy Vice Chancellor and Vice President, Research and Innovation. He has a strong interest in the commercialisation of research outcomes. He joined RMIT in 2014 from CSIRO, where he was Group Executive for Manufacturing, Materials and Minerals. Immediately prior to this he was Chief of CSIRO Materials Science and Engineering. In the Group Executive and Chief roles (2006–14) he oversaw one of Australia's largest IP portfolios and the CSIRO SME Engagement Centre. He is a Board Member of the Innovative Manufacturing CRC.

Professor Stuart Bateman is a Professor of Advanced Manufacturing and Materials in the School of Engineering at RMIT and Interim Director of its Advanced Manufacturing Enabling Capability Platform. Prior to joining RMIT he was the Deputy Director of the Future Manufacturing National Research Flagship at CSIRO.

**CONTRIBUTIONS
ARE WELCOME**
FOCUS



Opinion pieces on technology related topics, preferably between 600 and 1400 words, will be considered for publication. They must list the full name of the author, if a Fellow of the Academy. Other contributors should provide their full name, title/role and organisation (if relevant) and email address. Please address to editor@atse.org.au



Our vision is to create sustainability and excellence in Australia's power engineering.

What is the API?

The Australian Power Institute (API) is a not for profit national organisation established by the Australian power industry to boost the quality and numbers of power engineering graduates with the skills and motivation for a career in the energy industry which encompasses:

- Generation, transmission and distribution utilities
- Manufacturers and suppliers to the industry
- Consultants to the industry
- End users of electricity in their operations.

Value Proposition

To deliver a sustainable supply of highly skilled power engineering professionals working effectively to meet the challenges of creating Australia's new energy future, and underpin the technical and commercial success of member companies in the energy sector.

The key objectives of API are to achieve the following:

- Provide a sustainable supply of quality power engineering graduates to industry
- University power engineering teaching and learning provides relevant industry skills
- Value added continuing professional development programs
- A respected organisation leading the national development of power engineering skills.

Further Information

Contact - Mike Griffin (Chief Executive)



0419 643 795



mike.griffin@api.edu.au



www.api.edu.au and www.powerengineering.org.au





BY DOUG SHEARS
dss@icm.com.au

Where and what will we trade in the future?

INNOVATE OR PERISH Imagine you dream of being in charge of an Australian business that wants to take on the world. Where should it head? What sort of company does it have to be to succeed?

The years 2013 and 2014 saw drastic change in Australia's trade. The bottom dropped out of the prices of key commodity exports, especially iron ore and coal. The Australian dollar slipped downwards. Then other exports grew, particularly services and foods.

The result was a surprisingly modest – about three per cent – overall drop in exports in Australian currency terms, according to Austrade.

Short-term changes like these can seem sudden and even violent. But the longer-term trends in Australian trade are much more consistent.

Our export intensity, the ratio of exports to GDP, is low by global standards (as you might expect for an isolated island continent) but has been increasing slowly and steadily. Exports are now about 20 per cent of our GDP, up from 15 per cent 35 years ago.

Exports of services are growing faster than those of goods. They totalled \$65 billion in 2015, of which the biggest parts were education and inbound tourism.

Goods exports were worth \$250 billion in 2015. Of these, foods and beverages amounted to \$39 billion, after varying up and down between \$20 billion and \$25 billion throughout the 2000s and increasing after 2010.

Perhaps the most surprising thing is

that the nine of our top 10 export markets in 2004-05 were still in our top 10 a decade later. Only Thailand dropped out, to be replaced by Malaysia, but this should not disguise growing concentration of our exports on key markets. About 80 per cent of all our merchandise exports now go to Asia, including 28 per cent to China alone, while Europe and North America now each claim less than nine per cent, according to DFAT.

The future direction of Australian exports, then, is going to be mostly to Asia. Services will be increasingly important. Foods and beverages will be important as well. These will

complement our strong business in mineral and energy commodities, which will continue to be our mainstay. Liquefied natural gas is coming up as several large new plants come on-stream, to some degree replacing the lost dollar value of cheaper iron ore and coal.

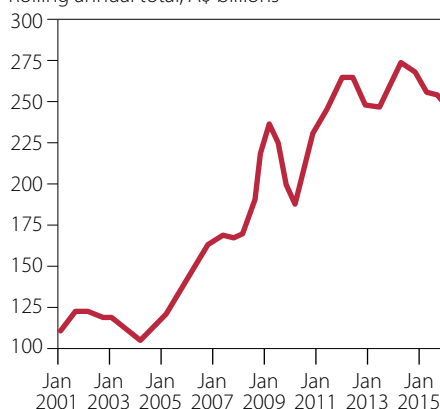
DREAM BUSINESS?

This broad pattern has a great many exceptions. Around the world you can find Cochlear hearing aids, fast catamaran ferries built by Austral in Perth or Incat in Hobart, Paspaley pearls, CSL blood products, Ugg boots, Atlassian's software, Billabong

Figure 1 Export performance: Goods vs. Services.

Total merchandise exports to December 2015

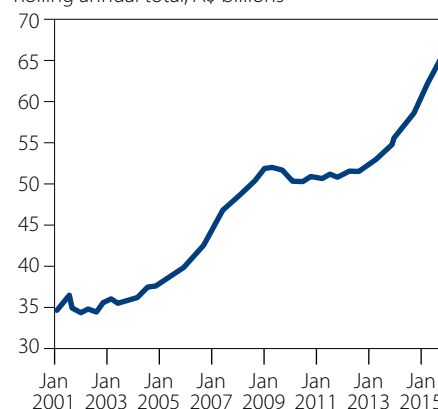
Rolling annual total, A\$ billions



SOURCE: ABS, EXCLUDES CONFIDENTIAL ITEMS

Services exports to December 2015

Rolling annual total, A\$ billions



SOURCE: ABS

LETTERS TO THE
EDITOR
FOCUS



ATSE Focus welcomes letters from readers in response to published article or on technology related topics. Please keep letters brief. Longer letters may be run as contributed articles. Please address to editor@atse.org.au

Figure 2 Top 10 export markets in 2004-05 and 2014-15

TOP 10 EXPORT MARKETS FOR GOODS AND SERVICES 2004-05			
		A\$ bn	SHARE (%)
1	JAPAN	28.2	17.0
2	CHINA	15.9	9.5
3	UNITED STATES	13.9	8.4
4	NEW ZEALAND	12.2	7.3
5	REPUBLIC OF KOREA	11.0	6.6
6	UNITED KINGDOM	9.2	5.5
7	INDIA	7.1	4.3
8	SINGAPORE	5.8	3.5
9	TAIWAN	5.3	3.2
10	THAILAND	4.5	2.7
SUBTOTAL		113.3	68.0
TOTAL ALL COUNTRIES		166.6	100.0
ASEAN 10		20.6	12.4
EU		22.3	13.4

TOP 10 EXPORT MARKETS FOR GOODS AND SERVICES 2014-15			
		A\$ bn	SHARE (%)
1	CHINA	90.3	28.3
2	JAPAN	46.6	14.6
3	UNITED STATES	20.5	6.4
4	REPUBLIC OF KOREA	20.5	6.4
5	INDIA	12.7	4.0
6	NEW ZEALAND	12.3	3.9
7	SINGAPORE	12.0	3.8
8	UNITED KINGDOM	8.6	2.7
9	MALAYSIA	7.9	2.5
10	TAIWAN	7.8	2.4
SUBTOTAL		239.1	75.0
TOTAL ALL COUNTRIES		318.7	100.0
ASEAN 10		40.1	12.6
EU		22.7	7.1

surfwear, Resmed breathing apparatus and many other products of Australian ingenuity.

These are not selling only to Asian markets. You can find them everywhere.

This business we are dreaming about is not a heavyweight in mining or oil and

gas. It is not a bank, nor an inbound tourism business or a university. Let's say it is in foods and beverages, but it could just as well be in any closely defined area of goods or services for consumers or industry.

Where should it go, and what kind

of business does it have to be? Given the background, its home is Australia, a relatively well-off and advanced country of 24 million people occupying a large land mass in the Southern Hemisphere.

It's worth noting that:

- Australia is not close to any large market – this means our situation is very different from that of Denmark, Ireland or even our close cousin, Canada;
- Australia's scale may be large compared with New Zealand but is very small in relation to the big markets of the EU, North America or China;
- our wages are high (the US pays much less at the low end) and the costs of many inputs to the business are correspondingly elevated; and
- the Australian dollar floats on its own – in times of plenty for the big commodity exporters it can go to US\$1.05, as it did recently; in leaner years it can run closer to half this level in US-dollar terms.

Business strategists peddle two main approaches for success, defined as making

SCIENTIFICALLY SPEAKING... CONTENT MATTERS

- ▶ Australia's leading custom publisher for science and innovation
- ▶ Professionally written and produced **publications** and **books**
- ▶ Information products that show R&D at work
- ▶ Print and digital publications crafted to enhance stakeholder and community engagement

FISH, the industry magazine for the Fisheries Research and Development Corporation (FRDC), is now available for iPad. The new digital version of **FISH** makes the entire printed magazine available free of charge including industry analysis, fisher interviews and research news.

FISH magazine is available as an app. Please follow these steps:

- Open Google Play or the App Store on your device
- In the search function type: FRDC FISH Magazine.



CORETEXT
CONTENT MATTERS
www.coretext.com.au



Gourmet Garden stir-in herb pastes.

sustainable returns well above the average. One is to be a low-cost producer compared with competitors. Our miners do this brilliantly, delivering their coal and iron ore to China at a lower cost than anyone else.

The other is to earn higher prices than competitors or substitutes on a sustained basis.

Our dream business has no alternative but to do the latter. It has to go for a premium.

There are two options: promoting a brand and the quality attributes that go with it, or having a product edge and a distinctive technology.

Branding on an international level requires scale. Few Australian companies can do it in the way drinks companies like Diageo (Johnny Walker and many other brands), luxury-good makers like the American firm Tiffany & Co and the French Chanel SA, the American phone and computer maker Apple or the German car maker BMW.

Our surfwear firms, Ugg and a few others have done rather well in this field, but there are not many.

GOURMET GARDEN

What Australia can more often do is develop a business based on technology. An example is Gourmet Garden, based on the Sunshine Coast in Queensland, which makes and sells a range of herbs, either preserved in a gel in tubes or semi-dried in packets. The product will be familiar to anyone who has browsed Australian supermarket shelves in recent years.

Gourmet Garden was developed after investigation of global food trends and consumer preferences. The study found a 'hole' in rich-country food markets. The product was developed through a carefully managed program of R&D, which found a technology that worked and was unique. With some effort and expense, the product was patented.

Gourmet Garden herbs in a tube were

launched in Australia. Soon after, they were trialled in the US, where consumers have fairly similar tastes to Australians. The product went exceptionally well. The semi-dried variant came later: you have to keep investing to freshen your product range and deepen your advantage.

Life is tough in commerce. Australian retailers drive a hard bargain and those in America perhaps even more. Gourmet Garden needed its secure patents or it would soon have been copied in a country with a lower cost base or replaced by a similar range under private label. Attempts were made. None was able to match Gourmet Garden's quality and cost and it came through successfully.

Next came the phase of scale-up. Initially, the low Australian dollar was in Gourmet Garden's favour. Then the dollar shot up during the mining boom. Gourmet Garden found its margins squeezed severely but was able to survive because it was the only competitor in its niche. More lately, a lower dollar has enabled it to offer more attractive terms to expand its presence. The UK and Europe are new markets for it to conquer.

Additional investment and encouragement by Gourmet Garden has stimulated development and increased sophistication of the main input – herbs – by Australian farmers. They may now be the most cost and quality-competitive in their field in the world.

The essence of Gourmet Garden is not 'value adding', which we used to talk about a lot in Australia. It is 'unique value adding', which can't be copied or undercut by lower-cost competitors.

NOT SILICON BILLABONG

All the recent talk about innovation and the speeches by Malcolm Turnbull are most welcome. Unique and distinctive products such as Gourmet Garden's should be a significant part of a trade mix into the future.

However, this does not only mean IT and products based on the internet. We will have

our share: CSIRO developed some of the initial technology for Wi-Fi; Hitwise has been a great success in web measurement; the billion-dollar 'unicorn' Atlassian has been mentioned, and there have been a good many others.

But we are never likely to have significant scale (at least compared with world leader California) in the IT and internet venture-capital market.

We need to innovate *everywhere* where we want to have businesses based on Australian ingenuity, and we need to look for an edge that is capable of patent protection and not easily replicated.

So, what is the future direction of Australian export trade?

- The commodities (minerals, fuels and basic agricultural products such as dairy and grains) will always be the mainstay. Mostly they will focus on Asia to take advantage of lower transport costs than from (say) Brazil or the US. Some commodities, mainly those of high value per unit of weight, will sell on global markets. For these businesses, strategy will be based on producing at low cost. Plenty of innovation will be needed, mainly of a particular kind, to secure the lowest costs per unit in the world.
- Large-scale services, such as tourism and education, will depend on offering quality for cost. They will need to innovate too, to keep their products fresh and competitive. They will need active marketing. They will sell mainly to Asia but to a lesser degree to all other countries.
- Ingenuity businesses, such as Gourmet Garden, will depend absolutely on innovation. Unique and unmatched value-added will be the only way for them to survive. Their market will be global.

There will be businesses that combine more than one of these narratives – wine, for example, or engineering services. But for the most part Australia's future trade will follow these three directions. ☺

Mr Douglas Shears FTSE is Chairman, ICM Australia Pty Ltd, and acknowledged as a leading agribusinessman. His national and international contributions include creating high-profile food brands, initiating Australia's 'clean green' image, creating the first commercial organic food product, enhancing water-use efficiency in agriculture, and refining food flavour and freshness technologies. Mr Shears established ICM Australia, a leading privately owned agricultural and pastoral company, and is a former owner of Uncle Tobys and Berri Fruit Juices. He is also a former Director of CSIRO and Member of the Prime Minister's Science Council.



BY MARY ANN AUGUSTIN
maryann.augustin@csiro
and STEVEN MCINNES
steven.mcinnis@thinkhci.com.au

Food security: global challenge, transdisciplinary approach

INNOVATE OR PERISH Transdisciplinary research has its risks and is demanding, but we have to learn to take intelligent risks and work together across disciplines, while remaining expert in our own discipline.

A

A secure food supply for the world now and into the future is a significant challenge for science and society. Food security exists

when “all people at all times have physical, social and economic access to sufficient, safe and nutritious food”.

Transdisciplinary teams, exploring questions at the intersection of many disciplines, are required to develop integrative solutions for improving food security as it cannot be satisfactorily solved through single discipline perspectives.

Addressing food security requires considering the whole supply chain – including food on-farm production, food distribution, logistics, efficient resource use, food processing, food marketing and consumer preferences – while considering how science solutions relate to societal relevance and values.

Multi-level perspectives drawing on disciplines as diverse as agriculture, climate science, environmental science, nutrition, food science, engineering, informatics, economics and social sciences, are required for developing sustainable food systems that improve food security.

Developing strategies to enhance food security involves an integrative process where researchers, with deep discipline knowledge in their own field, jointly develop a shared conceptual framework and work across disciplines to synthesise content, theory and methods to co-create new models and innovative solutions in a holistic fashion.

This requires an appreciation and acknowledgement of the contributions from other fields, a willingness to debate issues and

resolve differences in opinion in a respectful manner and to bring in other experts when there is insufficient knowledge in the room.

TEAM-BASED APPROACH

In a transdisciplinary team-based approach, each person brings their own deep and unique discipline knowledge and works collaboratively across disciplines with a mutually agreed purpose.

It is critical that attention is paid to choosing team members from disciplines required to address the complex problem being addressed. It is essential to ensure good team dynamics and organisational behaviour. The composition of the team may change through the phases as different lines of inquiry are developed to address emerging issues not previously anticipated.

It is also important to consider culture and strategy to improve the likelihood of successful outcomes of transdisciplinary research. In addition to unique contributions from their disciplines, team members will bring a holistic, open-systems appreciation of the field, coupled with their desire to fully integrate their own speciality into transcendent processes and outcomes and to realise overarching, rather than immediate, goals.

Transdisciplinary research must transcend the discipline boundaries of individual researchers. This is a challenge for many, even those who have developed networks for conducting research to answer questions requiring interdisciplinary approaches where researchers work jointly, through the lens of their individual perspectives, to address a common problem.

Transdisciplinary research requires true

collaboration including trust, mutual respect and, critically, the development of a co-created vision formed in the context of a global – not discipline-shaped – perspective of the challenges and opportunities. Productive transdisciplinary research requires a focus, a framing of the problem and conundrums, as well as management of boundary conditions for the issue being addressed. The vision must be owned by all members of the team.

A plain-language approach needs to be established to promote meaningful information exchange. There is potential for conflict and misunderstanding of positions as individual discipline perspectives are articulated. These require resolution as and when they arise so that research, creative thinking and collective risk-taking can proceed apace.

It is important to create the climate for respectful conversations that allow individuals the opportunity to clarify and question others' viewpoints and discuss the validity of conceptual frameworks from different disciplines, and reciprocally to receive such questions confidently, without feeling threatened or challenged.

Transdisciplinary leaders have to be skilful in promoting collaboration and risk-taking amongst discipline thought leaders, harnessing diverse views and integrating them to create a product or propose strategies to solve problems in ways that would not have been achievable through a single-discipline approach.

In contrast to the traditional mindset of hierarchical science leadership, a new collective leadership mindset is needed for successful transdisciplinary endeavours.

EFFECTIVE FACILITATION

Transdisciplinary strategic research – within experiential learning in high-performing teams, that encourage combinations of analytical, creative and thinking across perspectives and disciplines – benefits from effective facilitation.

The outcomes are shaped by combining creation-of-science connections (informed by each person's science-business network knowledge) and collaborative and networked leadership with the art of effective facilitation that stimulates progressive, creative thinking in a risk-buffered climate.

Facilitation helps team processes and builds collaborative leadership – requisites for various phases of transdisciplinary research. Effective facilitation moves the team to create a shared sense of purpose vision, develop a common language, increase awareness and mindfulness and provide a safe environment for robust discussion, managing conflicts, assisting team learning and promoting transactional compliance for tasks and generating shared understanding and ownership of how goals may be achieved.

This lays the foundation for creative insights and co-identification of opportunities. There is a crossing of the divide between single-discipline perspectives, coming to a rich consensus view through the power of collective presence and knowledge-sharing in a safe and secure environment. This enables team members to work on challenges far greater in scope and significance than they would do working just within their discipline.

While face-to-face communication is critical to the establishment of highly functioning teams, subsequently the sharing of insights and knowledge using various forms of communication, including safe and secure online tools and web conferencing, may be used to facilitate interactions in real time and allow collective distillation of ideas, consolidation of views and the development of innovative solutions to problems and new perspectives, often not previously anticipated.

This constitutes a paradigm shift in how researchers undertake the more complex challenges we face in our more connected and volatile world. The solutions that will emerge cannot be found within one or even two disciplines.

Thus, each person, in such a program will experience what Einstein is reputed to have remarked: "The significant problems we

TRANSDISCIPLINARY RESEARCH

In transdisciplinary research, multiple disciplines and perspectives are brought together in an integrative way to address a problem. Transdisciplinary research progresses through various phases: development, conceptualisation, implementation and translation. There may be a cyclical progression in addition to iterative, recurrent or alternative pathways through the phases. Transdisciplinary research involves a very dynamic team-based process as new questions arise and teams may have to recycle back to different phases.

A transdisciplinary approach is important for addressing complex global challenges. This is necessary for agility to innovate and adapt to respond to complex challenges faced by society, such as those at the nexus of food and nutrition, health, energy, environment and water. Addressing any of the 2015 United Nations 17 Sustainable Development Goals, of critical importance to the world, requires researchers to engage collaboratively across disciplines. Using research aimed at improving food security as an example of work that benefits from a transdisciplinary approach, this article considers some of elements of the team-based approach, hurdles for working across disciplines and the importance of collaborative leadership in guiding transdisciplinary research.



Collaboration is the key.

face cannot be solved by the same level of thinking that created them".

Undertaking transdisciplinary research for impact has its risks and is demanding, but we have to learn to take intelligent risks and work together across disciplines, while remaining expert in our own discipline.

We have to do things differently but it is an adventure that is worth taking for collective discovery beyond disciplines.

Engaging in transdisciplinary research is also important for the future relevance of our own discipline. And in the progressively more turbulent environment of future scientific research, the demand for transdisciplinary science will only grow, forming networks of researchers not just across geographic and organisational divides, but from different disciplines.

To sustain an effective research strategy in more complex structures will demand

higher orders of cultural and leadership capability. This article represents one small step on that journey. ☺

Dr Mary Ann Augustin FTSE is Group Leader, Breakthrough Bioprocessing at CSIRO, where she has held various science leadership roles. She was a Professorial Fellow at Monash University (2005–07). A chemist by training, she has applied her discipline to food research for more than 30 years. Dr Augustin has worked and promoted research within multidisciplinary teams, an essential requirement for success in innovation in the food industry. Her work within teams has involved all stages of the research process from concept to commercialisation.

Mr Steven McInnes is a founding director of Human Capital International, a consultancy that has specialised in helping organisations deliver on their strategic goals, build high-performance cultures and develop their leadership capability for 17 years. Working across sectors, he focuses on assisting individuals and teams who aspire to deliver transformational impact to global challenges. As a program facilitator and coach, he plays a vital role in supporting those who make up the transdisciplinary team.

ATSE IN ACTION

ATSE supports Science meets Parliament

ATSE has again supported the annual Science meets Parliament event in Canberra, staged by Science and Technology Australia.

As a sponsor, ATSE sent Senior Research and Policy Officer Dr Andy Hastings as a delegate and Executive Manager Policy and Projects Dr Matt Wenham attended some parts of the event, which included including a dinner, a Parliamentary Forum and face-to-face meetings between attendees and parliamentarians.

The purpose of Science meets Parliament is to improve the way science is communicated to Australia's decision-makers and policy-shapers.

"Science meets Parliament brings together 200 working scientists for a two-day program of professional development and networking aimed at helping them better communicate their science to the media and parliamentarians," said Mrs Karen Andrews, Assistant Minister for Science.

During the Parliamentary Forum,



Karen Andrews addresses the event.

Mrs Andrews joined a panel of politicians and media personalities to debate the issue of 'Science and Politics: how do they mix?'

SA CAN "SAFELY BENEFIT" FROM NUCLEAR ENGAGEMENT

South Australia has the potential to safely benefit from expanding its participation in the nuclear fuel cycle, according to ATSE.

In its response to the Tentative Findings of the SA Nuclear Fuel Cycle Royal Commission, ATSE agreed community consent was a critical prerequisite for any successful development. Creation of world-class regulatory frameworks and careful consideration of social, environmental, safety and financial risks were also essential, ATSE noted.

ATSE said it broadly supported the tentative findings of the Royal Commission, but noted some potential areas of concern and outlined a number of recommended improvements on the

Tentative Findings. ATSE particularly noted that little attention was paid to the role that the private sector would play in nuclear fuel-cycle activities and recommended that the Royal Commission consider this role and also outlined how government could create an appropriate environment to support industry involvement.

ATSE's response also emphasised that long-term political decision-making, with bipartisan support at both state and federal government levels, would be a prerequisite to achieving progress and that any development would require sophisticated planning and consent-based decision-making, acknowledging the particular interests and experiences of regional, remote and Aboriginal communities.

The ATSE response document is on the ATSE website.

ATSE GOES TO KOREA WITH KASIC

An ATSE delegation, led by Ms Kathryn Fagg FTSE, visited the Republic of Korea in March for a one-day workshop and associated site visits under the Korea Australia Science and Innovation Connect (KASIC) program, which was established to support closer collaboration between research and industry in Australia and Korea.

KASIC is funded through the Department of Industry, Innovation and Science and administered by ATSE.

The workshop, hosted by the Australian Embassy in Seoul, focused on models for successful research–industry collaboration, both at a national and international level.

Korean attendees from the Korea International Trade Association and Small and Medium Business Administration group provided valuable insights into the Korean innovation landscape, and representatives from the industry collaboration divisions at five leading universities outlined their approaches to research–industry collaboration. The National Academy of Engineering (NAEK) and the National Research Foundation (NRF) also provided their insights and programs.

Australian delegates presented on their experiences with industry collaboration from a variety of perspectives including CRCs,

Research Technology Clusters, Innovation Connections and Health Technologies.

The workshop also provided the opportunity to announce an innovative new program of international research–SME priming grants, based on the successful CAESIE program with the European Union. The new program will be open to Korean participation.

The workshop concluded with networking drinks at the Embassy with workshop delegates and additional invited guests. The delegation also undertook site visits to KAIST and Hanyang University for further discussions on models of research–industry linkages and the new Priming Grants program.

Delegates supporting Ms Fagg were: ATSE Director Professor Karen Reynolds FTSE; ATSE CEO and Director Dr Margaret Hartley FTSE; Dr Buzz Palmer, CEO of STC Australia and Director of Entrepreneurship at Monash University; Dr Michael Egan, Director of Business Development (Physical Sciences) at the University of Melbourne; Dr Sanjay Mazumdar, CEO of the Data to Decisions CRC; Dr Mark Bradley ATSE Manager, International Innovation Programs; and Dr Carolyn O'Brien, ATSE Senior International Relations and Policy Officer.

ATSE IN ACTION

REA metrics an effective measure of research engagement

Using external research income as a measure of research engagement and collaboration and as a forward proxy of impact is a feasible approach that makes use of already collected university data, a new ATSE report shows.

The ATSE report provides the details of a pilot study of ATSE's engagement metrics, Research Engagement for Australia (REA), which was conducted in 2015 with universities and state governments in South Australia and Queensland.

Work underpinning the report was stimulated by data showing that Australia ranks last among OECD nations when it comes to collaboration between public and private-sector researchers.

The pilot study built on ATSE's earlier report, *REA: Measuring research engagement between universities and end users*, which proposed a set of metrics based on university research income received from external sources, such as government contracts, industry-sponsored research and partnerships with non-profit and community organisations. The metric compares results

within the same research discipline.

"The pilot report shows that the REA metrics are an effective way of measuring research engagement – collaboration with partners outside of academia – for Australian researchers," said ATSE Interim President and chair of the REA steering committee, Professor Peter Gray FTSE.

"The pilot has also produced a number of refinements to the original REA methodology: the inclusion of small explanatory 'vignettes' for universities to further describe their engagement activities; and the inclusion of additional data, such as Rural R&D Corporation and research extension income."

The Australian Government's National Innovation and Science Agenda recognised the work done on REA as part of its program for introducing measures of research performance other than traditional academic outputs, such as those measured by Excellence in Research Australia.

"ATSE was very pleased to see the announcement by Minister Pyne and Minister Birmingham of the membership of a Steering Committee to provide advice and guidance on the way forward for our national assessment

of research engagement and impact, and we look forward to working with the Committee and the ARC in further developing and applying the ATSE Engagement metrics," Professor Gray said.

"We were particularly pleased to see the strong industry representation on the Committee and the inclusion of Australia's Chief Scientist, Dr Alan Finkel AO FTSE, who was President of ATSE before becoming Chief Scientist," he added.

The ATSE findings featured strongly in *The Australian* (16 March), with a news report and an opinion article.

THE REA IMPLEMENTATION SUMMARY AND PILOT REPORT ARE AVAILABLE ON THE ATSE WEBSITE AT [SUBJECTS>INDUSTRY AND INNOVATION>RESEARCH ENGAGEMENT FOR AUSTRALIA](#)



ATSE HOSTS JASIC EXCHANGE

ATSE recently hosted an exchange program between Australia and Japan under the Japan Australia Science Innovation Connect (JASIC) initiative, which focused on science and technology applications for 'Healthy Ageing for Societal Benefit', a topic of national importance to both economies.

The eight JASIC participants, all senior researchers from leading Japanese research institutions and industry, are focused on the development of their international linkages for research-translation activities. Each JASIC participant had a tailored program, visiting Australian institutions and industry around the country to build on personal, institutional and business-to-researcher linkages.

The JASIC program, administered by ATSE and supported by the Department of Industry, Innovation and Science, aims to promote and strengthen Australia-Japan bilateral ties and increase researcher-to-industry linkages. It builds on other initiatives such as the Australia Japan Emerging Research Leaders Exchange Program (ERLEP).

JASIC was established following negotiations between both countries and a workshop in Tokyo last May, attended by senior Japanese and Australian stakeholders.

PARTICIPANTS WERE:

- Chota Matsumoto, Professor, Department of Ophthalmology, Kinki University Faculty of Medicine;
- Hiroshi Sato, Group Leader, Human Environment Interaction Research Group, Human Informatics Research Institute, National Institute of Advanced Industrial Science and Technology;
- Noritaka Kawashima, Chief, Motor Control Section, Rehabilitation Institute of the National Rehabilitation Centre for Persons with Disabilities;
- Tetsushi Taguchi, Senior Researcher, Biomaterials Unit, National Institute for Materials Science;
- Toshio Fukuda, Professor, Nagoya University / Meijo University/ Beijing Institute of Technology;
- Yoshihide Hayashizaki, Program Director, Preventive Medicine and Diagnosis Innovation Program, RIKEN;
- Yoshio Matsumoto, Team Leader, Robot Innovation Research Centre, AIST; and
- Yoshitaka Kimura, Professor of Obstetrics and Gynaecology, Graduate School of Medicine, Tohoku University.

ATSE IN ACTION

Changes would help R&D Tax Incentive

The R&D Tax Incentive Program should be continued but would benefit from changes, ATSE said in its submission to the recent R&D Tax Incentive Review.

It noted that confidence in the program, an effective measure when used in the spirit intended, was key to its success – but changes were required to ensure it operated more effectively and efficiently to achieve its intended results.

Any changes to the program should encourage the right sort of activities, not reduce program costs. Any money saved should be redirected to other forms of support – such as higher concessional rates for collaborative activities, the CRC Program, or direct incentives such as the Business Research and Innovation Initiative (BRII) pilot announced as part of the National Innovation and Science Agenda (NISA).

Key points in the ATSE submission included:

- the definition of R&D should be tightened to ensure that the Incentive Program targeted additional R&D activities with the

potential for ‘spillovers’;

- there is evidence that business-as-usual activities were being claimed under the Tax Concession;
- the prominence of consultants specialising in assisting companies to claim the R&D Tax Incentive indicated that many companies were using the Incentive to reduce their tax bills after they had made investment decisions likely to have occurred under business-as-usual conditions;
- the disproportionate increase in registrations relative to total R&D expenditure (as shown in Figure 1 in the Issues Paper) is likely to be evidence that the program has not been successful in driving significant additional R&D expenditure;
- the Incentive may encourage multinational companies to conduct R&D in Australia but was unlikely to be the most significant driver of this decision; and
- the Incentive should not apply to R&D that would have occurred anyway due to market forces – rather, it should drive more basic research as it is seen as ‘optional’;

and is financially riskier, more likely to be additional, and has greater potential for spillover effects and societal benefit.

ATSE also noted that R&D which involved collaboration between industry and publicly funded research organisations (PFRs) was more likely to have significant spillover effects than R&D undertaken internally by firms. These channels were essential for allowing the benefits of R&D to flow to society as a whole rather than being contained within business.

To drive greater collaboration, the R&D Tax Incentive should be used to provide incentives to companies to engage in collaborative research expenditure. Such collaborative arrangements would also be more transparent as they would require an external financial transaction rather than an internal allocation of costs.

ATSE said the major focus of the R&D Tax Incentive should be to promote research, development and innovation in the small and medium enterprises (SMEs) that make up the majority of the Australian economy, especially those SMEs with high growth potential.

[THE SUBMISSION IS AVAILABLE ONLINE AT SUBJECTS> PUBLICATIONS>SUBMISSIONS> INDUSTRY AND INNOVATION.](#)

UNCONVENTIONAL GAS RISKS CAN BE MANAGED

The potential social, environmental and health risks associated with unconventional gas mining are not insignificant but can be managed responsibly by a robust legislative and regulatory framework, ATSE says.

In its recent submission to the Senate Select Committee on Unconventional Gas Mining, ATSE says both government and industry need to adopt evidence-based leading practices and be conscious of the need for continuous improvement as new evidence comes to light.

It notes its support for a national approach to the conduct of unconventional gas mining, but says regulations must be able to respond to the different levels of risk in different situations. ATSE says it strongly supports the improvement and harmonisation of Australia's current legislative and regulatory framework.

Any national approach to unconventional gas developments in Australia should have a strong emphasis on the need for a social licence to operate, which requires sustained engagement, recognition of prevailing community values, communication of scientific, technical and socio-economic information by trusted sources, certainty in the regulatory regime and confidence that long-term socio-economic benefits will accrue.

“There are many processes that occur during unconventional gas mining operations which have the potential to impact the environment; however, most if not all of these impacts can be managed.

“Nonetheless, if not adequately managed, the clearing of land to establish drill sites, levelling of the site, and establishment and construction of access roads can result in impacts on soil, increased fire risk, spread of invasive species and fragmentation of patches of native vegetation, habitats and landscape function.

“Other potential environmental impacts on the landscape may include impacts to surface and ground water systems, and ecosystems, and induced seismicity.

“Research into Australia's sedimentary basins and related water resources, landscapes and ecosystems, and how best to monitor them, will be essential to ensure careful management of gas production and minimisation (and avoidance) of potential impacts.

“Provided leading practice is followed and there is comprehensive knowledge of the sub surface, hydraulic fracturing is most unlikely to cause damaging induced seismic events or result in widespread, systemic impacts on drinking-water resources.

“Poor well construction and improperly decommissioned wells are risks to groundwater and it is important to be able to demonstrate lifetime well integrity and remediation responsibility for unconventional gas wells and adopt leading practice for wastewater disposal and management of materials and chemicals.”

ATSE IN ACTION

An Australian infrastructure icon.

Infrastructure planning a 'critical issue'

ATSE says major reforms are needed to improve the way Australia plans, finances, constructs, maintains and operates infrastructure to ensure it can underpin gains in productivity and contribute to economic growth.

It says effective infrastructure planning is a critical issue for Australia – particularly as the nation's population continues to grow – and that infrastructure is vital for driving productivity, underpinning prosperity and maintaining our way of life. Its construction and use impact on all aspects of our society and environment.

The recent announcement by Infrastructure Australia of the nation's first 15-year Infrastructure Plan and a reinvigorated Infrastructure Priority List recognises the importance of infrastructure planning and is an essential step in planning and delivering the Australia's future infrastructure, ATSE says.

A key priority identified in ATSE's submission to the 2015 Australian Infrastructure Audit, which informed the new Infrastructure Plan, was the need to commit to robust long-term infrastructure planning.

"It is pleasing that the Plan incorporates this requirement in the document, which provides a positive reform and investment roadmap for Australia," said Mr David Singleton FTSE, Chair of ATSE's Infrastructure Forum, in response to the release of the 15-year plan.

"Our national aspirations should include infrastructure that is designed to promote social cohesion across demographics and makes best use of land.

"The principles of good infrastructure planning such as clear goals, a pipeline of projects and rolling long-term budgets are often enunciated but rarely applied in practice.

"Better processes for advanced planning are critical to ensure an ongoing pipeline of future projects that will deliver optimum value to the community and earn community trust and ongoing support."

This would allow industry to develop effective delivery plans and better workforce management, particularly in engineering, Mr Singleton said.

"It is important that we find alternate ways to fund infrastructure. This could be through user-pays charges and the sale of existing assets, with the proceeds reinvested into new projects."

All the recommendations outlined in the ATSE Infrastructure Position Statement 'Infrastructure to meet Australia's future needs' also featured as key findings of the Audit, including the need to:

- commit to robust long-term infrastructure planning;
- ensure effective infrastructure development and delivery;
- implement best practice, whole-of-life infrastructure management; and

- use existing infrastructure as effectively as possible.

Infrastructure Australia chairman Mr Mark Birrell said the agency's 15-year plan called on federal, state and territory governments to reform their approaches to regional infrastructure, population studies, productivity schemes, freight networks, funding models and market processes.

"Our plan sets out 78 recommendations for reform and provides a vision and road map to address today's infrastructure gaps and set us up to meet the challenges of tomorrow," Mr Birrell said.

The Infrastructure Plan represented a big step forward in removing the politicisation of infrastructure development, Engineers Australia said. "With over 60,000 engineers employed in infrastructure delivery in this country, long-term planning gives engineering employers the certainty they need to invest in the skills and workforce development the government will need to deliver its nation building agenda."

Mr Peter Watson FTSE is a member of the Infrastructure Australia Board. He has more than 25 years' experience in the engineering, construction and services industries and was CEO of Transfield Services from 1993 to 2009.

■ *Infrastructure Australia is an independent statutory body with a mandate to prioritise and progress nationally significant infrastructure. It provides research and advice to governments and the community on the projects and reforms Australia needs to fill the infrastructure gap.*

ATSE IN ACTION

STELR'S 500th school signs on

Victoria University Secondary College (VUSC), in Melbourne's suburban Deer Park, officially signed on as the 500th school in the national STELR program.

With the support of Orica, VUSC students will now be able to engage fully with STELR – Science and Technology Education Leveraging Relevance – as part of ATSE's national campaign to get Australian secondary students interested in science and technology courses and careers.

VUSC Principal Ms Genevieve Simson received a certificate of appreciation from ATSE CEO Dr Margaret Hartley FTSE and Orica's Group Executive Corp Services and Company Secretary Ms Kirsten Gray to mark the occasion, which was attended by Australia's Chief Scientist Dr Alan Finkel AO FTSE and Victoria's Lead Scientist Dr Leonie Walsh FTSE, as well as Interim ATSE President Professor Peter Gray FTSE.

Guests were able to watch VUSC students using the STELR equipment at the event. This equipment is now in some 20 per cent of Australian high schools – with an estimated 50,000 secondary students and more than 1500 teachers involved each year.

"The duty falls on us to make science exciting, accessible and relevant to students' lives, so they come to the classroom hungry to learn," Dr Finkel said. "Students are under no obligation to society to care. Five hundred STELR schools is an excellent beginning, this is our chance to inspire."

Ms Gray said: "STELR is all about enthusing students and helping lead more young people towards STEM-related careers; careers that are critical to companies like Orica, the world's leading supplier of explosives to the mining industry.

"Our vision to provide Clever Resourceful Solutions can only be realised if we continue to invest in innovative research and development led by our technical experts, our engineers and our scientists.

"As founding and major sponsors we have supported the program generally and been active in bringing STELR to schools in the communities in which we and our customers operate across Australia and into the Asia-Pacific region. This synergy between Orica's commitment to science and technology and our commitment to host communities is perfectly illustrated today at VUSC in Deer

Park, the birthplace of Orica."

Mr Peter Pentland, Executive Manager ATSE School Programs, said the 500th school was a great achievement for the program.

"When we started this journey in 2007 we were aiming for wide adoption of the

STELR principles, designed to respond to the declining participation in STEM subjects in schools and tertiary institutions. We are delighted that, with support of our partners, we have been able to achieve such a dramatic expansion of the program," Mr Pentland said.

With support from state governments, STELR was trialled in 30 schools in 2009. Federal Government funding enabled it to spread to more than 180 schools in 2010. Support from partners has helped STELR penetrate into all states and territories and has brought STEM education to Indigenous, remote and disadvantaged school students.

Orica has been the major partner since 2009 and the Australian Power Institute has provided substantial support since 2010.

Conceived by Dr Finkel, ATSE's immediate past president, STELR has evolved to reflect the new *Australian Curriculum: Science* and the various modules are designed to be taught within the curriculum, making them available to all students in the appropriate year levels (6 to 10) of participating schools.

As well as long-term anchor support from Orica and the Australian Power Institute, substantial support has come from Cochlear, Rio Tinto, MMG, Cigre, Charles Darwin University, University of New England, Deakin University, the University of South Australia, the University of Queensland, Southern Cross University, the University of Wollongong, Rio Tinto, IBM, *Cosmos* magazine and an array of ATSE Fellows and charitable trusts.



The cake says it all.

STEM LEARNING KEY TO VARIED OCCUPATIONS

Tertiary qualifications in STEM must equip Australian graduates with contemporary discipline knowledge and employability skills for a wide range of possible careers and further study, ATSE says.

In its recent submission to the House of Representatives Standing Committee on Education and Employment inquiry into Innovation and Creativity, ATSE says it is widely accepted that STEM skills are not only required in STEM-based occupations, but also prepare graduates for a broad range of occupations, including management.

"STEM graduates typically excel in a range of highly desirable capabilities including active learning, critical thinking, complex problem-solving and creative problem-solving.

"However, industry often questions whether STEM graduates possess satisfactory interpersonal and time-management skills, and knowledge of business practices.

"To address this, all formative STEM degrees should feature relevant interdisciplinary and non-STEM content (for example, ethics, entrepreneurship, project and IP management). Any such changes will require detailed assessments of existing course deficiencies and the needs of the future workforce. Given the changing nature of employment, there is also a strong case for the inclusion of STEM skills, such as data analysis, in non-STEM degrees."

ATSE says Australia's future prosperity and wellbeing will depend on employing more creative and innovative graduates. "Graduates will need to possess postgraduate coursework qualifications and research degrees in the STEM disciplines. Many will be at the forefront of Australia's new and emerging enterprises."

WOMEN IN TECHNOLOGY

DST highlights work of women scientists

The Defence Science and Technology Group marked International Women's Day in March by highlighting the work of two of its leading female scientists.



Deanne Bateman (second from left) with colleagues from DST Group Edinburgh, SA.

Defence Scientist Dr Jie Ding, from Land Division, is a member of the Land Personnel Protection team and Ms Deanne Bateman, from Joint and Operations Analysis Division, is the Director of the Science and Technology Program.

Dr Ding has made important discoveries that may directly impact on the safety and sustainability of the armour provided to the Australian Defence Force. Collaborating with

universities she has developed an innovative approach to the very heart of the battery, creating a new class of electrolytes that harden upon impact.

She grew up in Kunming in China, where she graduated from university with a Bachelor of Chemistry before moving to Australia and completing a PhD in Electrochemistry, Material Science at the University of Wollongong.

Dr Ding has spent 11 years with DST Group, joining the organisation in 2005 as a Research Scientist. In 2007, she undertook a Defence Science Fellowship to the Institute for Soldier Nanotechnologies at the Massachusetts Institute of Technology, where her research focused on the applications of advanced materials for actuators, sensors and superhydrophobic surfaces.

Ms Bateman graduated with a Bachelor of Applied Science (Mathematics and Computing) from the University of South Australia in 1998. On completion of her studies Deanne accepted a graduated position within the Australian Signals Directorate (formally Defence Signals Directorate) in Canberra. In 2005, after eight years in Canberra, she returned to SA, joining

DST Group to take her career in new direction, moving away from the ICT environment and into project management.

She is currently working on a major ICT project to significantly enhance how Defence scientists collaborate and share knowledge.

The Defence Science and Technology Group (DST Group) is Australia's second-largest government-funded science organisation after CSIRO. The agency's name was changed from the Defence Science and Technology Organisation to the Defence Science and Technology Group in July 2015. It is headed by Chief Defence Scientist Dr Alex Zelinksky FTSE.



Jie Ding examines electrolyte material that can function as both battery component and body armour.

GENDER STATISTICS STILL DIVERGING

Statistics continue to diverge over gender lines, according to data released recently by the Australian Bureau of Statistics (ABS).

Ms Lisa Conolly, Director of Family and Community Statistics at the ABS, said the Australian Public Service (APS) was showing a gradual upward trend for women in leadership positions.

"Women held 41 per cent of senior executive roles and just under 48 per cent of executive level roles in the APS in 2015," Ms Conolly said.

"In January 2016, 30.5 per cent of Federal Parliamentarians were women. There is a higher proportion of women in the Senate (38 per cent) than in the House of Representatives (27 per cent)."

In the educational sphere, young Australian men and women were choosing different educational pathways after school.

"In 2015, more young women (18 to 24 years) were studying for a Bachelor Degree or higher qualification (34 per cent compared with 28 per cent of young men), while young men were more likely than young women to study for a Certificate III or IV (9.5 per cent compared to 6.0 per cent)," Ms Conolly said.

However, young women were less likely to be fully engaged in education or work, with just under a quarter of young men (23.4 per cent) and 29.5 per cent of young women aged 20 to 24 either not studying or working at all, or studying or working part-time.

On the health front, Australian men 18 years and over in 2014-15 were more than twice as likely as women to consume alcohol in quantities that present a lifetime risk (24 per cent compared with 9 per cent).

While men were more likely to be overweight or obese (71 per cent compared

with 56 per cent of women), women were less likely to be active, with 69 per cent of women and 61 per cent of men 15 years and over being sedentary or engaging in low levels of exercise.

More women reported high levels of psychological distress than men.

Where working conditions were concerned, men were slightly more likely to have paid leave entitlements (which may indicate a slightly higher level of job security). Looking at employed couples with dependent children, in November 2014 more than one in 10 men and one in 5 women did not have paid leave entitlements. This figure was even higher for employed women who were lone parents, at 26.4 per cent.

Women, on the other hand, were a little more likely to own their own home without a mortgage (28.1 per cent compared with 25 per cent of men in 2013-14).

WOMEN IN TECHNOLOGY

Women step up at ANSTO

Two women scientists have taken senior appointments at the Australian Nuclear Science and Technology Organisation (ANSTO).

Dr Simone Richter has been recruited from Germany to become Group Executive Science and Technology and Landmark Infrastructure.

Dr Richter is founding director of one of Europe's largest research infrastructure projects – the Euro Facility of Antiproton and Ion Research in Germany, which is currently under construction.

At ANSTO she will oversee the research and infrastructure program accessed by hundreds of national and international scientists and industry partners per year. The role will specifically see Dr Richter focus on fostering innovation in research, as well as the development of future science infrastructure and capabilities.

Dr Suzanne Hollins has been appointed Head of Research. Dr Hollins first came to ANSTO in 2001. She is a leading expert in

areas such as groundwater sustainability, connectivity between surface and groundwater, matters that impact on wetlands, and links between hydrological and climate processes.

In her new role she will lead the delivery of world-class applied and translational research programs – driving ideas from research, ultimately, to products.

The appointments follow a year-long review of ANSTO's nuclear science and technology operating model which will in

future sharpen its focus on:

- driving innovation;
- the interconnectedness between research conducted both within and external to ANSTO and its landmark and national research infrastructure; and
- achieving research outcomes to support health, the environment and advances in the nuclear fuel cycle.

"ANSTO contains a large portion of Australia's major science and research infrastructure, where we use the latest nuclear technology to benefit Australia's health, environment and economy," said ANSTO CEO Dr Adi Paterson FTSE.

"Through ANSTO, Australia has a very strong global reputation in the field of nuclear science and technology, but the science world is never static – and there is more we can do.

"These changes will help us to position ANSTO and Australia to take advantage of opportunities in the sciences that will deliver benefits to the people of Australia, and the world."



Simone Richter



Suzanne Hollins

CONCERTED NATIONAL EFFORT NEEDED TO BOOST WOMEN

Assistant Minister for Science Karen Andrews has acknowledged the contribution of Australian women to science, technology, engineering and mathematics (STEM) when marking International Women's Day.

"We have so many talented women working in STEM in Australia and internationally, but as we celebrate their many achievements we also must look to areas where gender equality is still lagging behind.

"We need a concerted, national effort to overcome the cultural and organisational factors that discourage girls and women from studying and working in STEM."

Currently women comprise only 25 per cent of IT graduates and less than one in eight engineering graduates. Women occupy fewer than 20 per cent of senior researcher positions in Australian universities and research institutes, and make up only around 25 per cent of the STEM workforce overall.

"We want to encourage women and girls to embark on and remain in STEM careers," Mrs Andrews said.

"The Government is investing more than \$13 million through the National Innovation and Science Agenda to encourage more women to embark on and remain in, STEM-related careers.

"Australia has come so far in gender equality and there are many more opportunities available to women than in the past. However, we must continue this vital work to create a stronger future for women in STEM."

The Minister for Women, Senator Michaelia Cash, said while Australia had a history of leading the way for women, there was still much work to do.

"We have made great inroads into gender equality and consider ourselves an egalitarian society, but the fact remains is we have inequality between the sexes that we have a responsibility to address."

Delivering the International Women's Day address to the National Press Club in Canberra she said the Government was focused on increasing women's workforce participation and ensuring women are safe at home, on the

streets and online.

"As the Minister for Women and Employment I am particularly excited about and focused on the synergies between the two portfolios and the opportunities that exist to increase participation and financially empower women, instancing policies such as reforming our tax and transfer system, strengthening childcare, improving workplace diversity and flexibility, and supporting more women to innovate, succeed as entrepreneurs and thrive in jobs of the future."

Minister Cash also announced that the Government would commit to increasing the target to 50 per cent women across all Australian Government boards, with a minimum of 40 per cent on each board.

"Our diversity target shows that we're committed to women in leadership and we're prepared to lead the way," Minister Cash said.

"Gender equality is not only essential for Australia's future prosperity, but it is about the kind of society we want for ourselves."

We need science – and plenty of it

If we want bold solutions in this century then we need science – and plenty of it, Chief Scientist Dr Alan Finkel AO FTSE told the National Press Club in his first NPC address, as part of Science meets Parliament.

But science was not enough, he said. “We need to think about interactions, unexpected consequences and the management of risk.

“If we were to build nothing new – before we were absolutely certain we knew the best way to do it – that would be the end of progress.

“And even if we did figure out the quantum world tomorrow – even if we did have a grip on the fantastical complexity of the human brain – even if we did crack nuclear fusion – there would still be questions about the practical ways our knowledge might be applied.”

Dr Finkel instanced self-driving cars.

“There are plenty of benefits: mobility for the elderly, fewer accidents, freedom to talk on your mobile phone ... but is it that simple?

“Say you’re in the city to attend a meeting. Do you pay for the car to park – or do you just send it round and round the block for the duration of your meeting? Congestion would skyrocket.

“Say it’s 8:00am on a school day. Do you carpool – or pack the kids off and wait for the car to return ... again, and again? More congestion!

“But the harder questions for government only proceed from there:

- How do we deter people who think like me from adding to traffic congestion?
- Who do we allow to own or direct these cars?
- What happens to all the people who today drive things like trucks and taxis for a living?
- Who builds, and then who takes responsibility, for the sophisticated networks of sensors to support the cars?
- And given that orderly traffic flow depends on the interconnections between the cars and the traffic management software, what happens when a car hits an internet blackspot? Potential catastrophe?”

These were just a fraction of the issues attached to one technology in the immediately foreseeable future, he said

“To solve them, we need not just science, but *research* – where



Alan Finkel at the National Press Club.

research is the investigatory collaboration between science, technology, sociology, economics and the like.

“In all of the complex challenges that technology will bring, the humanities, arts and social sciences are critical to our research endeavour and we neglect them at our cost. Combine these research elements, and we will reap the benefits. And if you can imagine that self-driving car – then you can also imagine a low-emissions electricity grid supplying electric vehicles ... connected to fantastic arrays of solar panels in the outback ... travelling through an ever more exciting world.

“Perhaps by then we’ve made progress towards bionic eyes for the vision impaired, or launched trips into space for tourists. We could be living in an Electric Planet – a zero-emissions world.

“How much progress could your lifetime contain?

“We decide – and not just by the scope of our ambition but by the breadth of our research, the quality of our planning and the calibre of our leadership.

“With great science we will create great research outcomes. With clever innovation we will turn those research outcomes into societal and economic benefit.

“With great science and clever innovation combined, we can discover how truly remarkable we might be.”

100 YEARS OF SCIENCE

The Australian Government has marked 100 years of involvement in Australian science – a century since former Prime Minister Billy Hughes established the Advisory Council of Science and Industry, the institution that ultimately evolved into CSIRO.

Industry, Innovation and Science Minister Christopher Pyne and Assistant Science Minister Karen Andrews announced the centenary.

“CSIRO is our national science agency. It has advanced Australia with a range of inventions, innovations and knowledge breakthroughs that have changed and improved the lives of people here and around the world,” Mr Pyne said.

“Australia has a strong scientific and research community, which the government has helped build over the course of 100 years, and I look forward to celebrating its many achievements,” Mrs Andrews said.

MASTERS IN SCIENCE POLICY AVAILABLE

Flinders University, Adelaide, is offering an MSc (Science Policy and Communication) degree from 2017.

The degree is aimed at professionals with qualifications and/or experience in STEM (science, technology, engineering or mathematics) disciplines who wish to use their expertise to have a greater impact on the decision-making of governments, industries, communities and individuals.

Flinders University says applicants will require a STEM degree or equivalent and “will develop their ability to translate these existing skills and experience into meaningful change in high-level policy domains”, becoming ‘agents of change’ who will “participate in innovation and the shaping of a constantly evolving society”.



BY JOHN YEAMAN
jyeaman@usc.edu.au

Truck peloton under control of a lead vehicle.



IMAGE: DERWENT BURISCH – POLYWORLD

The innovative road: storing water and generating electricity

From Weipa, trucks could travel to Melbourne in 24 hours, obviating the need for five days of shipping around the east coast – through the Great Barrier Reef.

T There's a transport concept that involves dramatic innovation in road design and construction, water storage, electricity generation and autonomous vehicles that could save up to five days' shipping time and protect the Great Barrier Reef.

Successful conclusion of this proposed concept would give Australia an efficient new resource for transporting goods quickly and efficiently by road, open up large tracts of land to agriculture – creating 'green' townships using energy generated by the roadway – and develop intellectual property that could be marketed to the entire world.

Substantial research would be required to bring its elements together and position the concept for adoption.

CONCEPT AND BENEFITS

Road construction has not seen a major change in design or construction since Julius Caesar, yet new materials and methods enable enormous changes. Today plastics – particularly polyethylene – offer a material as dense as road materials and with stiffness and strength greater than steel. And polyethylene is manufactured entirely in Australia from Australian natural materials.

Water. Australia is a vast continent with a large area, particularly west of the Dividing Range, which is arid for a greater part of the year. Yet monsoonal rains during the wet season are neither harvested nor stored.

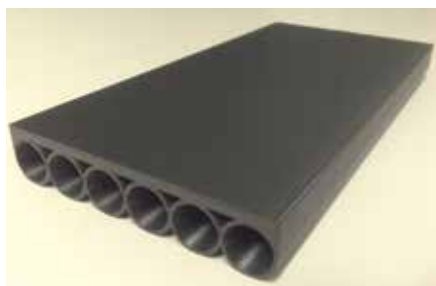
Electricity can be generated by exchanging hot water for cold and by the difference in temperature between a road surface and the substrate.

The **trucking industry** has trucks, axles and tyres that are capable of payloads of 150 tonnes and speeds of 150 kilometres per hour. Our current road conditions and regulations do not permit them to operate at their potential.

Autonomous vehicles will soon be widespread with many resources companies already operating autonomous trucks remotely. These vehicles do not need signs, lines, guard rails or lighting to operate and they know where they are and their relationship to other vehicles at every instant.

The transport concept envisaged is to combine all these attributes into a dedicated, high-speed, east coast road for autonomous trucks. The benefits would include:

- transporting materials and equipment, in heavy payloads and at high speed,



A 1/100th scale 3D printed model of the proposed configuration.



A 3D printed model showing how additional tubes could be added for heat-exchange electricity generation and service conduits.

allowing the trucking industry to use its latent capability;

- providing water for irrigation to the dry inland, opening up the area west of the Great Dividing Range to new agriculture, harnessing water at minimal cost without dams;
- providing sufficient 'green' energy – again at minimum cost – for its own use and to power towns and cities of the inland;
- reducing transport times by replacing a five-day coastal shipping schedule with a one-day transit time from north to south; and
- minimising marine traffic through the Great Barrier Reef.

MAKING IT WORK

It is feasible to construct dedicated truck roads for the transport of goods at high speeds, using pelotons (or platoons) of vehicles linked to one lead vehicle and all operated as an autonomous unit. Such a unit would have distinct advantage over a railroad as vehicles would be able to leave the peloton by switching to manual and then delivering their goods locally.

The simple essentials are:

- each carriageway would be constructed on six 1.2-metre polyethylene tubes to provide a road width of 8 m;
- each tube will be capable of storing one

megalitre of water each kilometre – the tubes would be filled with water during the wet season and used during the dry season for irrigation;

- the configuration could include conduits built into the structure for telephone and internet cabling;
- each section of road would be constructed to create energy from the water in tubes in the road, heated by solar energy and converted to energy using the principles of heat exchange;
- the Stirling Engine principle could be used to generate electricity to power electric fences for stock and animal control; and
- the whole roadway section would be either factory-constructed, with each tube welded together, or printed on a 3D printer and placed directly onto an engineered subgrade.

From a new port of entry into Australia, say Weipa, trucks could travel this road to Melbourne in 24 hours, obviating the need for five days of shipping around the east coast, through the Great Barrier Reef.

MANAGING THE PELOTON

A driver who wanted to join a road-train peloton would enter his/her destination and then be guided by the onboard navigation system to the nearest road-train peloton.

The vehicle would join the rear of the queue and the system would take control of the truck, via wireless radio communication. The peloton would be controlled by the first vehicle, a dedicated control vehicle driven by professional drivers.

As an individual driver approached a depot or other departure point, he/she would switch back to manual operation and take control of the vehicle – then leave the peloton and continue to the depot to unload.

At the depot, large containers would be broken down into smaller containers for transshipment on smaller commercial vehicles, or aircraft, to the end destinations. The truck would then replace offloaded containers with new ones for further transport and the driver could signal that he/she wanted to join a fresh peloton.

Meanwhile the original peloton, now with capacity to accept another vehicle, would have closed the gap created by the departing truck and continued on its journey.

The pelotons would only stop to change drivers and refuel.

NECESSARY RESEARCH

The concept and the benefits need substantial research – 11 key issues need to be resolved.

- 1** Establishing the efficacy of placing 100 to 150-tonne loads on a set of tubes must be evaluated. This will require exhaustive research into the appropriate configuration and analysis of the necessary stiffness of various subgrade reactions.
- 2** Finding the optimum road location for a dedicated route.
- 3** Developing a specialised surfacing material to provide the wearing course on the pavement. The surface must be sacrificial, recyclable and should be built around as much recycled material as possible. Recycled construction aggregates, glass and rubber tyre grindings may be combined with bitumen to provide the binder.
- 4** Establishing specifications and methods for enhancing the subgrade to support the road configuration directly on the natural material.
- 5** Deciding an expedient method for repair. Repair of failed sections of roadway would need to be completed in hours, not days.
- 6** Determining how to move flood water into the tubes, minimising detritus, using a one-way flap on the tubes.
- 7** Clearing the solids settlement from the tubes and recovering valuable resources for fertilisation and other purposes.
- 8** Examining Irrigation and friction issues, which would determine the optimum length of tubing.
- 9** Converting the differential between the top and the underside of the pavement structure to provide energy to power the electric fences for stock control.
- 10** Converting the 'hot' water in the tubes to electrical energy using heat-exchange principles.
- 11** Determining the benefit-to-cost ratio for the suggested construction and operation practices to ensure viability. ☉

Dr John Yeaman FTSE is the endowed TMR Chair of Pavement Engineering at the University of the Sunshine Coast, Queensland. With nearly 60 years' experience specialising in roads and runways, he is passionate about teaching the technology to young engineers. He is currently supervising six PhD candidates and teaches a Master's Degree in the subject in intensive mode. He was elected a Fellow of the Academy in 1997.

NEWS

Bat immunity may help humans

Researchers have uncovered a unique ability in bats that allows them to carry lethal diseases but remain unaffected by them.

Unlike humans, bats keep their immune systems switched on 24/7 and scientists believe this could hold the key to protecting people from deadly diseases such as Ebola.

Bats are a natural host for more than 100 viruses, some of which are lethal to people, including Middle Eastern Respiratory Syndrome (MERS), and the Ebola and Hendra viruses. But bats do not get sick or show signs of disease from these viruses.

Published in the journal *Proceedings of the National Academy of Sciences*, this new research examines the genes and immune system of the Australian black flying fox, with surprising results.

"Whenever our body encounters a foreign organism, like bacteria or a virus, a complicated set of immune responses are set in motion, one of which is the defence mechanism known as innate immunity," said leading bat immunologist at CSIRO's Australian Animal Health Laboratory Dr Michelle Baker.

"We focused on the innate immunity of bats, in particular the role of interferons – which are integral for innate immune responses in mammals – to understand what's special about how bats respond to invading viruses.



Bat immunity under study.

"Interestingly, we have shown that bats only have three interferons, which is only a fraction – about a quarter – of the number of interferons we find in people.

"This is surprising given bats have this unique ability to control viral infections that are lethal in people and yet they can do this with a lower number of interferons."

The team also compared two type 1 interferons – alpha and beta.

The research showed that bats express a heightened innate immune response even when they were not infected with any detectable virus.

"Unlike people and mice, who activate their immune systems only in response to infection, the bats interferon-alpha is constantly 'switched on', acting as a 24/7 front-line defence against diseases," Dr Baker said.

"In other mammalian species, having the immune response constantly switched on is dangerous – for example it's toxic to tissue and cells – whereas the bat immune system operates in harmony.

"If we can redirect other species' immune responses to behave in a similar manner to that of bats, then the high death rate associated with diseases, such as Ebola, could be a thing of the past," Dr Baker said.

This work builds on previous research undertaken by CSIRO and its partners to better understand bat immunity to help protect Australia and its people from exotic and emerging infectious diseases.

■ Led by CSIRO, this international research effort included expertise from CSIRO, Duke-NUS Medical School and the Burnet Institute.

SYNCHROTRON NOW PART OF ANSTO

The Australian Nuclear Science and Technology Organisation (ANSTO) has been announced as the home of the Australian Synchrotron.

Expected to occur in July, with the Federal Government's support, the inclusion of the Australian Synchrotron will cement ANSTO's position as custodian of Australia's most significant landmark and national infrastructure for research.

The Synchrotron is a world-class research facility that uses accelerator technology to produce a powerful source of light a million times brighter than the sun.

ANSTO's science infrastructure made a difference "to people's lives, to the economy, and to our understanding of the world around us," ANSTO said.

This includes making radiopharmaceuticals such as technetium-

99m, used in diagnosis of diseases, and lutetium-177, an effective treatment for cancers such as neuroendocrine tumours.

ANSTO infrastructure and research was also used to study and understand the environment, make the minerals industry more profitable, and irradiate silicon needed in solar farms and hybrid cars.

"ANSTO is the custodian of some of Australia's more significant and formidable science infrastructure, and the Australian Synchrotron will be the next great addition," said ANSTO CEO Dr Adi Paterson FTSE.

"It will now be better placed than it has ever been before to develop its beamline infrastructure, and commit to longer-term research.

"The Synchrotron has delivered essential resources and innovations in the fields as diverse as medicine, agriculture and manufacturing, and now will deliver even more for Australians every day."

CSL links with Bio21 in major expansion

The University of Melbourne's Bio21 Molecular Science and Biotechnology Institute is to be substantially expanded and will in future house the Global Research and Translational Medicine Hub of Australia's largest multinational biopharmaceutical company, CSL.



Malcolm Turnbull at Bio21.

CSL has been a partner in Bio21 since 2007 and expects, over time, to more than double the presence of its research scientists, from 75 to around 150, at the Hub.

The university is embarking on a \$36.4 million, 5000 m² expansion of the Bio21 Institute. The new facility will allow for the expansion of major technology platforms that underpin

personalised medicine and the development of new diagnostics.

Work on the new building will commence in 2016 and the expansion is expected to be completed during 2017.

Prime Minister Malcolm Turnbull made the announcement after touring Bio21 in March.

Bio21 is one of the university's flagship research institutes, and for more than a decade has played an important role in positioning Victoria and Australia as a leading destination for life sciences and biotechnology research. It is also a leading example of a successful academia-industry partnership.

"CSL is committed to fostering excellence in Australian research. R&D is our past and our future. The increased presence at Bio21 will allow CSL to increase its collaborations with university researchers, plus other research institutes and hospitals. It will also provide an expanded base for new national and international collaborations," said Dr Andrew Cuthbertson FTSE, CSL Chief Scientific Officer and R&D Director.

"This expansion makes business sense and is very exciting scientifically. Our research scientists find Bio21 an attractive and intellectually stimulating place to work, and the cross-cultivation of ideas from academia to commercial helps translate science into life-saving medicines.

"This is an important industry-university partnership that will enable greater knowledge and technology transfer, drive innovation and ensure Australian research is translated into positive health outcomes around the world" said University of Melbourne Vice-Chancellor Professor Glyn Davis.

"Bio21 is delivering a world-class research facility for Australia and will play an important part in advancing biomedical research knowledge and the development of new therapies," said Professor Davis. "The co-location of a large multinational with the university is a fundamental aspect to its success and will generate an environment in which other start-ups and small businesses can thrive."

AUSTRALIA "CAN LEAD" STEM-CELL RESEARCH

Some of Australia's brightest young scientists say Australia has the potential to revolutionise medicine and become a world leader in stem-cell research.

A new report, developed with input from world experts, explains recent advancements and presents a roadmap for how Australia can safely and effectively take stem-cell research from the lab bench to the hospital bed, and better regulate rogue stem-cell therapists offering unproven and possibly risky therapies for commercial gain.

The Stem Cell Revolution: Lessons and Imperatives for Australia recommends: clinical trials as the main route to prove the effectiveness of possible new treatments; a national centre to help accelerate the translation of clinical discoveries; and stem-cell banks with relevant clinical and genomics data to help facilitate research.

Co-chair of the report's steering committee Professor Richard Harvey said Australia's stem-cell research needs a national strategic effort to remain globally competitive.

"We can make organs in a dish and correct disease-causing genetic defects in a patient's own cells: it's an exciting time for stem-cell researchers and new breakthroughs are making headlines almost daily. We must continue to strategically support this vital area, and see it as a priority area of research for Australia if we are to reap the benefits for humanity, save on our healthcare bill and continue to be a world leader," Professor Harvey said.

"This report provides a roadmap to encourage innovation by supporting research, facilitate the development of new treatments and provide mechanisms to test them."

The report also addresses the rise of stem-cell tourism and the regulatory environment that allows practitioners to offer unproven therapies.

"One downside of the excitement around stem cells is that public expectations can be falsely raised. Without more clinical trials to test new treatments in Australia, patients may be tempted to seek out unproven therapies, at home or overseas, which can cost anything between \$10,000 and \$60,000 and may not work or even make people even more ill," Professor Harvey said.

The report is based on a think tank convened by the Australian Academy of Science last year with support from the Theo Murphy (Australia) Fund.



BY BILL BURROWS
wburrows@inet.net.au

Is it time to rethink Australia's carbon abatement contracts?

Australia's total net CO₂ emissions are much lower than implied by the National Greenhouse Gas Inventory. Averaged across years, we are highly likely to remain a net sink.

It is often said that Australia is one of the world's leading per capita emitters of carbon dioxide (CO₂). This statement is a consequence of our small population, coupled with an advanced economy and relatively large land area. Crucially, it also resulted from sources and sinks 'arbitrarily' included or excluded from the National Greenhouse Gas Inventory (NGGI) when inputs from the Land Use, Land Use Change and Forestry (LULUC&F) sector were allocated to it.

Therefore, huge areas of native vegetation have not been taken into account when compiling our carbon budgets. This nation has essentially reported CO₂ emissions that are conveniently 'measured' and directly identified with human activities – rather than those that mirror Australia's true input to CO₂ content in the global atmosphere.

A less selective and more meaningful analysis of CO₂ fluxes would report *net* emissions – the resultant when all known sinks (sequestered amounts) of CO₂ are subtracted from all known sources (the amount released to the atmosphere as a result of fossil fuel consumption, cement manufacture, land clearing, plant respiration/decomposition, fires, adjacent ocean outgassing, etc.).

Fortunately, satellite-based spectral sensors now enable net CO₂ emissions to be measured with accuracy and precision. The fact that we are an island continent adds to the integrity of the values reported (compared

with countries in Europe, for example, where a nation's air mass can cross borders at daily – or even shorter – time intervals).

TWO SATELLITES

Two such satellites monitor CO₂ in the atmosphere today – Japan's GOSAT (Greenhouse Gases Observing Satellite) and NASA's OCO-2 (Orbiting Carbon Observatory-2). The former has been in orbit since 2009, while the latter (with a better coverage of the Earth's surface and about four times the precision of GOSAT) became operational in September 2014.

Both sets of satellite sensors record the column-averaged dry air mole fraction of CO₂ (X_{CO₂} - ppmv) from the top of the Earth's atmosphere to its surface. The sensors integrate the net atmospheric contributions from all CO₂ sources and sinks, with no distinction made as to whether the recorded gas is anthropogenic or naturally occurring. Clearly it is the concentration of CO₂ in the atmosphere, rather than its origin, which is of most interest in monitoring it.

Prior to the space-based observations provided by GOSAT and OCO-2, carbon fluxes derived from ground-based measurements were problematic. This notably applied to those observations made for LULUC&F sector. To determine carbon fluxes in vegetation from field data it is necessary to obtain



Native tree/shrub 'thickening' (an increasing carbon sink) over 15 years in eucalypt woodland in Central Queensland in 1984 (top) and in 1999 (bottom).

sequential recordings of carbon stocks in the above-ground and below-ground components of the vegetation, as well as in the soil supporting it.

Sampling problems are immense, particularly in native plant communities, and at any time weather patterns, vegetation age and disturbances, such as clearing, harvesting, fire and grazing, can impact the flux being estimated.

On the other hand only space-based measurements can provide the robustness, spatial coverage and sampling density/frequency, as well as the accuracy and precision necessary to determine the *Australia-wide* flux inversion of column-averaged CO₂.

Results from GOSAT and OCO-2 missions have been slow to be published. But two recent data sets suggest this country would be wise to embrace the technology and its outputs, especially given the significant budget allocations set aside by the Australian Government to buy Carbon Abatement Contracts (CACs).

A **carbon sink** is anything that absorbs more carbon than it releases.

A **carbon source** is anything that releases more carbon than it absorbs. Forests, soils, oceans and the atmosphere all store carbon, which moves between them in a continuous cycle.

CARBON SINK

A large enhanced carbon sink was detected over Australia in GOSAT records from the end of 2010 to early 2012, which amounted annually to some 2800 Mt CO₂-e (equivalent). This contrasted with Australia's reported NGGI emissions for 2011 of some 552 Mt CO₂-e – less than one-fifth of the land sink that was mostly excluded from that inventory year's calculations.

The vast CO₂ sink observed in 2011 has been attributed to the La Niña rainfall pattern experienced then, together with CO₂ fertilisation impacts on vegetation and perhaps reduced fire incidence.

This has led some to caution that Australia would not necessarily be a sink in years of below-average rainfall (such as El Niño years). This may be true, although a 12-month visualisation of CO₂ concentrations in the air above the Australian continent (September 2014 to September 2015) is highly indicative that the continent remained a net sink, even as the very strong 2015 El Niño was developing.

Several authors have further suggested this anomalous sink in 2010–12 was mainly the response by dryland vegetation to the higher rainfall. It was therefore implied that sinks developed in La Niña years would quickly dissipate with the return of more 'normal' seasonal conditions and wildfires.

But this belies Australia's extensive areas of woody vegetation in the arid zone and elsewhere. In 2001 native vegetation

covered 6.7 million km² of the continent, with about 64 per cent dominated by woody plants. Perennial drought-resistant spinifex accounted for 74 per cent (1.7 million km²) of remaining native grasslands.

A rising trend in woody biomass carbon was also reported in our northern savannas for the 20-year period 1993 to 2012, including years of well-above and well-below average rainfall, through observations obtained from satellite-borne passive microwave sensors.

The result is net of any concurrent loss in biomass due to tree clearing, woody plant deaths and fires occurring during the monitored period. Validation is provided by many published ground-based and aerial photo interpretation studies.

QUESTIONS

Given these findings one may well ask why has the Australian Government (through 'Direct Action') committed up to \$2.5 billion to purchase CACs?

So far these contracts seem to be mostly based on modelling of native vegetation systems with questionable accuracy and precision surrounding the inputs. For example:

- Where is the evidence that confirms the history, structure and composition of vegetation on remotely sensed, remotely located and extensive Carbon Estimation Areas (CEAs), which can individually cover thousands of hectares?

- What field measurements are undertaken – and with what accuracy and precision – to validate inputs and outputs of the Emissions Reduction Fund's FullCAM modelling tool applied to each claimed CEA?

The simple fact is that any carbon flux in the vegetation contributing to these contracts is already captured by inversion of CO₂ detected by GOSAT and OCO-2 sensors.

At the very least, Australia's total net CO₂ emissions are much lower than has been implied by the NGGI. Averaged across years we are highly likely to remain a net sink.

Why pay \$2 billion dollars or more for CACs with greatly limited land coverage, when a spatially comprehensive, accurate and precise accounting of net CO₂ fluxes for *all* of continental Australia can be derived from satellite sensors – at minimal cost to Australia's budget? ☺

■ Article sources are available from the author.

Dr Bill Burrows FTSE is a retired Senior Principal Scientist (Queensland Department of Primary Industries). His 40-year research career addressed the ecology and management of Queensland's grazed woodland communities, including implementation of the TRAPS vegetation monitoring system, as well as biomass flux determinations in native woodlands for the CRC for Greenhouse Accounting and the Australian Greenhouse Office. He is a past President of the Australian Rangeland Society and the Tropical Grassland Society of Australia, and a Fellow of the TGS and Australian Institute of Agricultural Science.

LIVESTOCK EMISSIONS CAN BE REDUCED

Scientists say the global livestock sector can maintain the economic and social benefits it delivers while significantly reducing emissions.

A new analysis published in *Nature Climate Change* estimates that livestock could account for up to half of the mitigation potential of the global agricultural, forestry and land-use sectors, which are the second largest source of emissions after the energy sector.

The global livestock sector supports about 1.3 billion producers and retailers around the world, and is a significant global economic contributor.

The lead author of the study, CSIRO's Dr Mario Herrero, said this new account of the mitigation potential for the global livestock sector is the most comprehensive analysis to date as it considers both the supply and demand sides of the industry.

"A key finding is that we can get the best mitigation potential from the livestock sector if we take an integrated view of land use and practice change that considers the whole of agriculture and forestry, as well as looking at dietary patterns and how we address the needs of global nutrition," he said. "Livestock has a role in a healthy

and sustainable diet, and the sector has an important economic and social role, particularly in developing countries. We need to balance these health outcomes and the economic and social benefits, while also capturing the mitigation potential the livestock sector can offer.

"New management practices such as rotational grazing and dietary supplements can increase livestock production and reduce greenhouse gas emissions.

"If appropriately managed with the right regulatory framework, these practices can also achieve improved environmental health over and above the greenhouse gas benefits delivered, for example through improved ground cover and soil carbon."



A communal dairy centre in Yunnan, China.

PHOTO: ILRI/STEVIE MANN

NEWS

CSIRO signs STEM deal with Stile

CSIRO's publishing business and online education business Stile Education have signed a commercial contract to develop digital resources for school teachers focused on science, technology, engineering and maths (STEM).

Stile Education was founded by Australia's Chief Scientist Dr Alan Finkel AO FTSE.

ATSE's STELR project was one of the first programs to deliver content to students online through Stile and has progressively added and distributed content through this vehicle. Teachers using the Stile platform to deliver STELR modules have been most supportive of the initiative.

Stile permits students to complete online activities that look like games but are actually educational science lessons. The results are then saved for teachers to review and mark.

Dr Finkel and CSIRO Chief Executive Dr Larry Marshall came up with the idea of connecting CSIRO's world-renowned science expertise and children's publishing experience with Stile's innovative digital education programs last year, with the aim of better engaging Australian students in STEM.

CSIRO Publishing Director Andrew Stammer said that children were using smartphones, social media and video games more regularly so teachers were embracing technology to ensure they were communicating on the same level.

"Making sure that kids actually engage in school work is an ongoing

challenge for schools as more technology is used in our everyday lives," Mr Stammer said.

"We've been communicating about science to kids for the past 30 years through CSIRO's Double Helix publications, which explain science in a fun and engaging way," Mr Stammer said.

The Double Helix material would now be incorporated into sophisticated digital lessons, accessible online and be readily modifiable by teachers, allowing customisation by class, or even by student, he said.

Stile is a three-year-old education technology start-up headquartered in Melbourne. Last year, almost 100,000 Australian school students answered more than five million questions on Stile's eLearning platform.

Stile is a partner in the Inspiring Science & Mathematics Education (iSME) project – a collaboration between Southern Cross University, the University of Wollongong, Charles Darwin University and ATSE, which received \$996,500 through the Australian Maths and Science Partnerships Program Competitive Grant Round in 2014.

iSME is designed to enhance teaching and learning of the science and maths curriculum in Years 7 to 10 and involves the development of at least five authentic,

multidisciplinary classroom modules which use cutting-edge science and engineering contexts and the latest educational theory from the partner universities and other research institutions to excite and engage students.

iSME modules will be delivered through a web-based platform and are designed to increase both the enthusiasm and engagement of secondary school students for STEM subjects and careers and to increase the number of students choosing maths and science courses at tertiary level.



CSIRO's Andrew Stammer and Marcus Zipper (left) signing the agreement with Byron Scaf and Daniel Pikler from Stile Education.

MATHS BAR TOO LOW – MATHEMATICIANS

Mid-level mathematics should be made a prerequisite for students looking to enrol in science, engineering or commerce degrees, according to a new 10-year plan for mathematics in Australia.

Currently only 14 per cent of Australian universities require science students to have studied intermediate mathematics in Year 12.

The plan, developed by the National Committee for Mathematical Sciences, makes a dozen key recommendations, including increasing professional development for out-of-field maths teachers and a new national mathematics research centre to link industry and research.

It also highlights an urgent need to address the low participation of women and rural Australians in the mathematical sciences.

Professor Nalini Joshi FAA, chair of the National Committee, said improving the mathematics skills of the next generation was vital for future workforce demands.

"We are in the era of big data but what good is data without the ability to interpret and analyse it? We need people who have the skills to take that raw information and turn it into something useful,"

Professor Joshi said.

"Maths underpins just about everything – from the technology in your smartphone to the banking and financial systems that support our economy to how we measure and predict our health. Maths is also the cornerstone of all scientific endeavour – so if we are training new scientists without a good understanding of maths, Australian science will soon be in trouble."

National Committee member and Director of the Australian Mathematical Sciences Institute Professor Geoff Prince said: "This plan is a clear vision for governments, universities and industry to shape mathematical sciences over the next 10 years, starting now. Fundamental to that vision is education.

"We know that 75 per cent of the fastest-growing occupations will need science, technology, engineering and mathematics (STEM) skills, and that maths is at the heart of this skill set. If we're not preparing our teachers and students the way we should, Australia will be left behind by the rest of the world."

Digital literacy key for the future

Digital literacy is a key to the future job prospects of Australian workers, according to a new report, *Tomorrow's Digitally Enabled Workforce*.

The report outlines a range of scenarios and trends that are shaping the jobs of the future in Australia's economy, identifies the future needs of a digitally skilled workforce and offers deep analysis of the challenges faced.

It was released by the ACS (Australian Computer Society) – the professional association for Australia's ICT sector – in conjunction with CSIRO's Data61, the ANZ Banking Group, the Commonwealth Department of Employment and Boston Consulting Group.

The trends each relate to a specific influence on the workforce, and are based on research undertaken by a team from CSIRO and Data61. They specifically address the exponential growth of technology, shifting nature of the labour market in a sharing economy, the rise of entrepreneurship, the need for greater demographic inclusion, the shift towards higher education standards and the growth of the creative, knowledge and service economies in the future.

"What is becoming abundantly clear is the need for better education in the technology space," said ACS CEO Mr Andrew Johnson. "This report shows us that digital skills will be a requirement not only in the technology space, but in almost every job in the next 20 years.

"If we are able to drive a greater focus on education, we will develop an economy that is driven by highly skilled, digitally literate workers.

"We can, and must, be at the cutting edge of innovation, especially in the creative and knowledge economies. This report provides us with a range of challenges that need to be addressed, and we look forward to meeting them."

Launching the report, Senator Micala Cash, Minister for Employment and Minister for Women, said it provided a deeper insight into the changing landscape of our workforce, brought about by huge technological shifts. "How Australia's workforce fares in the long term will depend on our ability to help workers make transitions to new and better jobs – our biggest challenge will be to ensure no one is left behind."

The report found STEM knowledge is used in 75 per cent of the fastest-growing occupations and noted Australia's diminishing interest and performance in STEM.

The report said job freelancing had not yet taken hold in Australia but was a growing employment model in other countries, such as the US.

If ideal jobs did not exist, workers might have to create them, the report suggested.

The report predicted service industries, particularly education and healthcare, would continue to drive job creation, meaning "social interaction skills and emotional intelligence will become increasingly important".

The report said Australia's workforce would be diverse, with one in five Australians older than 65 in 2035, high female participation and a large proportion of migrants being of working age.

The report said employment trends would result in new job types such as bigger big-data analysts, complex decision-support analysts, remote-controlled vehicle operators, customer experience experts, personal preventative health helpers and online chaperones.



UNSW PART OF PLUS ALLIANCE

Three universities – the University of New South Wales, King's College London and Arizona State University – have formed the PLuS Alliance, launched in London in February, to "develop innovative solutions ... in global health, social justice and sustainability while progressing the responsible innovation of advanced technologies".

The universities' presidents told the launch that universities had a responsibility to work together to help solve global challenges.

The PLuS Alliance says that, "by combining the cutting-edge research capabilities and innovative education approach of three universities in different parts of the world" it will "undertake cross-border research collaborations" to address significant issues related to health, social justice, sustainability and innovation.

"The PLuS Alliance will deliver innovative education programs at scale, catering to needs of students around the globe and across the socio-economic spectrum. The Alliance will offer online and on-ground educational programs to qualified students from around the globe who are seeking degrees, certification or training.

"By working together to provide access to world-class education, the PLuS Alliance will produce a globally minded workforce, able to work across cultures and countries to help solve the world's most pressing challenges, focusing on sustainability, global health, social justice and the responsible innovation of advanced technologies."

Welcoming guests to the launch event in London, the President and Principal of King's, Professor Ed Byrne AC FTSE – former Vice Chancellor of Monash University – said: "King's is committed to working with UNSW and ASU, to align our cultures and ambitions to make an impact on challenges the world faces today. We want to look at the big questions, understand what can be achieved and focus our attention on working collaboratively to make a difference."

A COPY OF THE FULL REPORT IS AVAILABLE AT
WWW.CSIRO.AU/TOMORROWS-DIGITALLY-ENABLED-WORKFORCE

NEWS

SKILLS MIX CHANGING TOWARDS ICT

With tertiary graduates currently representing only one per cent of the ICT workforce of 628,000, satisfying the skills mix now being demanded by employers requires a stronger focus on retraining and re-skilling the existing workforce, according to a new report launched by the ACS, the professional association for Australia's ICT sector.

This reshaping of the workforce must include a focus on encouraging more women and mature-age workers to pursue ICT careers, the report says.

It notes that only 28 per cent of the ICT workforce are women, compared to 43 per cent across all professions, and only 11 per cent are mature-aged workers, compared to 15 per cent across the total workforce.

The 2016 *Australia's Digital Pulse* report, prepared by Deloitte Access Economics, shows that while the digital economy will grow from five to seven per cent of GDP by 2020, new LinkedIn data highlights that a major skills shift is underway in our economy.

For ICT specialists, six out of the top 10 skills now sought are non-technical skills such as project management, sales and customer-service skills, and for 2.5 million Australians in non-ICT roles digital literacy skills are an increasingly important part in their job.

Commenting on the findings, ACS President, Mr Anthony Wong, said: "LinkedIn's data highlights that a significant and rapid skills transformation is happening in our economy. Responding to this challenge will require governments, employers and the education and training sector to work collaboratively and, importantly, to reassess current approaches to both training and recruitment.

"A clear message from the Report is that our economy now needs ICT specialists with creativity, entrepreneurship and strategic business skills, whilst non ICT workers increasingly require a base level of digital competency."

Managing Director for LinkedIn in Australia, New Zealand and South-East Asia, Mr Clifford Rosenberg, said: "We are already seeing widespread digital disruption across key Australian industries, which is leading to skill shifts. It is imperative that businesses train their employees with both tech skills and soft skills required for the digital economy.

"Analysis of 25 hottest skills in Australia shows that 17 of the most sought-after are technology-related as more mainstream businesses integrate technology into their core business. Our data also shows that eight of the top 20 skills demanded by employers hiring new technology workers are broader than core technical skills such as relationship management, customer service, strategic planning and contract negotiation."

Deloitte Access Economics partner, Mr John O'Mahony, said: "The contribution of digital technologies to Australia's economy is forecast to grow by 75 per cent to 2020 and, needless to say, there is going to be strong demand for a workforce equipped to support this growth, and the opportunities that will come with it.

"The biggest driver of digital growth will be the greater use of digital technologies, such as cloud computing, data analytics and other such developments, in all aspects of business by people traditionally considered non-ICT workers. But our analysis also shows that there is significant demand for technical roles, including in areas that only emerged in recent years, such as cloud-computing specialists and cyber security."

Research–business links are 'low-hanging fruit'

Innovation and Science Australia chair Mr Bill Ferris AC has told Australia's university leaders that increasing collaboration for commercialisation of research is both desirable and achievable.

"Right now, despite a host of recent indicators praising our scientific and creative abilities, we are dead last in the OECD rankings of academia and business collaboration for innovation," he told the Universities Australia's 2016 Higher Education Conference in Canberra.

"Our alarming collaboration ranking is a direct contributor to our poor performance at commercialising our discoveries and this cannot continue.

"The good news is that improving collaboration between research and industry is the low-hanging fruit for quick wins when it comes to driving innovation."

Mr Ferris said the Government's announced changes to criteria for the allocation of research funding to universities were needed to reward engagement with industry.

"New arrangements recommended by Dr Ian Watt and taken up under the Government's National Innovation and Science Agenda would simplify research block grants into two streams and seek to give universities an incentive to achieve greater industry and other end-user engagement, in addition to providing grants on the basis of traditional tests of research excellence," Mr Ferris said.

"At the same time, I understand we need to continue to excel in fundamental research. I don't accept that research excellence and clever commercialisation are mutually exclusive.

"Improving the research funding mix is welcome because it will encourage more and more researchers to reach out."

He told a CEDA event in Sydney a few days earlier that the Government's National Innovation and Science Agenda was a potential "game changer", providing a comprehensive blueprint that included a number of significant measures addressing the key barriers to innovation and entrepreneurship in Australia.

"NISA recognises that unlocking the nation's entrepreneurial potential requires many keys to many locks. In my view there are six key challenges to accelerating innovation and entrepreneurship in Australia:

- access to risk capital funding;
- access to business and entrepreneurship skills;
- access to international markets;
- lack of active collaboration for commercial outcomes – among universities, research institutes, business entities, government and venture capitalists;
- insufficient investment and interest in STEM curricula in our schools, VET colleges and universities; and
- risk-averse culture that often results in the fear of failure trumping the excitement of gain."

NEWS

Education system “destroying students’ innovative capacity”

It is time to change the education system before it destroys the innovative capacity of our children, according to Dr Michael Myers OAM, President of Engineers Australia’s Sydney Division.

“Industry is crying out for an education system which develops soft employability skills, including teamwork, collaboration, communication, presentation, innovation and problem-solving. But none of these are currently measurable components of the education process,” he says.

“Education in Australia has become fixated on students achieving the Australian Tertiary Admission Rank (ATAR), which is the primary criterion for entry into most undergraduate and university programs in Australia. This has created an elitist, structured and bureaucratic educational environment that is killing the innovative capacity we seek to build in our children.

“A focus on an ATAR, by definition, rules out any level of failure as being acceptable. It has our students only doing what will get them the best ATAR. It is teaching our students to take the easy road (to play the system). It squashes a willingness to bite off more than one can chew and to chew like crazy ... and to possibly fail ... key indicators of innovation at work.

“If we are to promote innovation we must re-evaluate and possibly

devalue the dependence on the ATAR score.

“We need our children back loving science, technology, engineering and maths because it interests them and it doesn’t matter if they don’t get the highest mark. Innovation is built on people willing to push the boundaries, to try different approaches and to not be scared of making a mistake.

“To encourage a ‘have a go mentality’ we must as a nation learn to accept failure. Innovation is about trying something and accepting failure as a positive outcome from which we can re-evaluate our strategies and try again,” he says.

The education system should be focused on generating motivated children willing to have a go at the hard stuff who are not scared of making a mistake. We need children with a passion for creativity and a passion for the careers they choose and the education system at all levels should be an environment that incubates this passion.

“We should thus change the way we measure the performance of our education system, away from a fictitious score developed half way through the process, to a measure of the quality of the employability skills of the students coming out of that system.”



Michael Myers

GIRLS TOP SCIENCE & ENGINEERING AWARDS

Tasmanian student Hannah Sutton has won the Investigation category in the 2016 BHP Billiton Science & Engineering Awards for school students.

Hannah, from Elizabeth College, Hobart, was acclaimed for her investigation of a possible treatment for Alzheimer’s using a peptide, Caerin 1.9, found in the skin glands of the Australian tree frog.

The second category, Engineering, was also won by a female

student. Macinley Butson, from The Illawarra Grammar School, Wollongong, developed a solar-power-generation device for third world communities and also discovered a way for the device to produce a clean water supply.

Jade Moxey, from Sapphire Coast Anglican College, Bega, took second place in the Investigation category, working on the spread of seeds through cattle, and third place went to Madeleine Maloof, of Presbyterian Ladies’ College, Sydney, for her

work on tooth enamel lost from whitening toothpastes.

Samuel Kantor, from Moriah College, Sydney, placed second in the Engineering category for developing computer vision technology to help disabled people control their computers.

Third placed was shared by two Canberra students, from Daramalan College. Lachlan Wilson and Terence Johnson produced graphs to illustrate the accelerating rise in ocean mass accounted for by ice melting in the Polar

Regions.

Mr David Thodey FTSE, Chair of CSIRO, which manages the awards, said they showed the inventiveness and excellence of the future scientific and engineering leaders of Australia.

NEW STEM GUIDE FOR YOUNG INNOVATORS

The Government has released a new one-stop guide to more than 250 digital technology, entrepreneurial and STEM programs – called

SPI ((STEM Program Index) 2016 – that school principals can now download from the Chief Scientist’s website.

The resource highlights the growing range of workshops, competitions and activities – from early childhood to high school – provided by government and non-government organisations, businesses, universities and other agencies.

SPI 2016 was produced by the Office of the Chief Scientist with help from the Australian Industry Group, as part of the STEM Skills Partnerships program.

Australia’s Chief Scientist Dr Alan Finkel AO FTSE and Assistant Minister for Innovation Wyatt Roy launched the guide with students at Banksia Beach State School, at Bribie Island, north of Brisbane.

“It’s an invaluable collection of programs delivered in-class, online, after school or during holidays,” Mr Roy said. “All of the programs are designed to help fast-track our young people to the jobs of the future.”

“This index is a measure of our commitment to a future for all Australians,” Dr Finkel said. “We need to challenge our students to excel in STEM subjects. To do this we must challenge ourselves to engage, excite and inspire.”



Hannah Sutton



Macinley Butson

NEWS

CSIRO coatings a key to LIGO

The world's science community was agog in February with news of the discovery of elusive gravitational waves – ripples in space time caused by a violent cosmic event taking place in the distant universe.

The discovery, made by the Advanced Laser Interferometer Gravitational-wave Observatory (LIGO) in the US, confirmed scientists' long-held view – predicted by Einstein's general theory of relativity – that gravitational waves were real.

Scientists from Australian universities and CSIRO were celebrating their part in the discovery of the waves. The Australian Partnership in Advanced LIGO was led by the Australian National University. Scientists from CSIRO, the University of Adelaide, the University of Melbourne, the University of Western Australia, Monash University and Charles Sturt University also contributed to the discovery.

In order to aid the hunt for gravitational waves, LIGO recently received \$200 million worth of upgrades. One of the major components of this was the installation of ultra-high-performance optical mirrors, many of which were coated by researchers from CSIRO.



LIGO optics coated by CSIRO.

According to Dr Cathy Foley PSM FTSE, Science Director of CSIRO Manufacturing, the upgrade of the LIGO detectors increased the sensitivity of the system by around 10-fold.

"Through the use of interferometry, which is the merging of two sources of light, LIGO is designed to measure changes between the two arms of each detector. The two giant detectors, which are located on opposite sides of the US, are then compared to confirm the findings," Dr Foley said.

"The interferometer system includes a series of mirrors which are coated with multiple, precisely-controlled layers of optical materials to give the required reflective properties, and lastly a top layer of gold, designed for thermal shielding.

"The coatings, which were developed and applied at CSIRO, are among the most uniform and precise ever made. This precision

ensures that LIGO's laser remains clean and stable as it travels through the detectors.

"We really are world leaders in this area, and are thrilled to play a part in this discovery," she said.

Dr Alan Finkel AO FTSE, Australia's Chief Scientist, said that as a physics enthusiast he would "dream of days like this". He said he expected it would be the "most significant announcement in cosmology in my lifetime".

PROVING SOLAR BENEFITS AT THE EDGE OF THE GRID

The Australian Renewable Energy Agency will provide \$8.4 million funding for Canadian Solar and Scouller Energy to construct a 5 MW DC (4.5 MW AC) solar farm near Normanton, north-west Queensland.

Normanton Solar Farm will be jointly owned by Canadian Solar and Scouller Energy. Canadian Solar Australia has been contracted to construct the solar plant. Ergon Energy has signed a power purchase agreement to buy electricity from the plant.

ARENA CEO Mr Ivor Frischknecht said the Normanton Solar Farm would help demonstrate how integrating solar into the grid could improve energy reliability in regional Australia.

"Like many regional Australian communities, Normanton is on the fringe of one of our major electricity networks," Mr Frischknecht said.

"Power generated in Rockhampton is fed across more than 1000 km of transmission lines to the Normanton area. Electricity transmitted over long distances typically experiences significant losses along the way.

"Adding renewable energy generation closer to where it's needed can provide more reliable and efficient power. This is a key ARENA investment focus for fringe-of-grid and network constrained areas.

"Normanton Solar Farm will act as a test case for network provider Ergon Energy to understand the true impact on network losses. This will provide a starting point to explore regulatory changes that would support more renewable energy installations in fringe-of-grid locations across Australia."

DANES PLAN GIANT WIND FARM IN NORTH SEA

Danish firm Dong Energy plans to build the world's biggest wind farm – off the north-east coast of the UK in the North Sea, some 120 kilometres off the Yorkshire coast – to be operational by 2020.

Named Hornsea Project One, its 190-metre-tall turbines are planned to provide enough power for a million homes from a projected 1.2 gigawatts (GW) of power at its upper limit.

The UK is reported to have more offshore wind installations than any other country, with the Government said to prefer offshore farms due to the difficulties in finding suitable sites and getting planning permission for on-shore sites.

Dong Energy recently predicted that one-third of all UK power could be provided by wind by 2030.

Around 2000 jobs are anticipated to be created during the construction of the new wind farm, with 300 permanent employees required to operate the offshore plant, and some of the 7 MW turbines will be built at a Siemens factory in the nearby city of Hull.

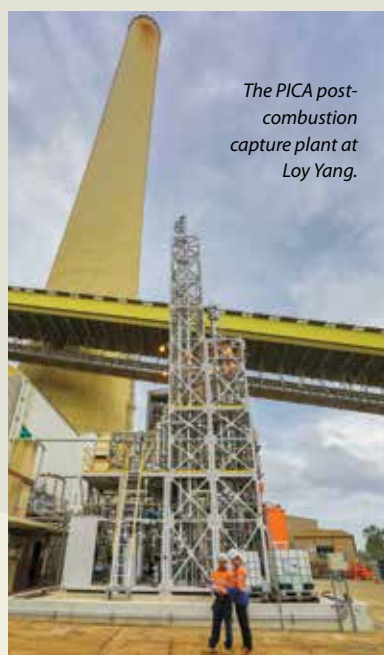
Almost 965 km of cables will be responsible for harvesting the energy and getting it back to land, enough to stretch from one end of the UK to the other.

Currently the largest offshore wind farm in operation is the 630 MW London Array of 175 turbines located 20 km off the Kent Coast in the outer Thames River estuary.

PICA aims to improve CO₂ capture

CSIRO, AGL Energy (AGL), Brown Coal Innovation Australia and Japan's IHI Corporation have launched a two-year research program to improve efficiency of carbon dioxide (CO₂) capture.

They are partnering on the PICA post-combustion-capture (PCC) research project, which will evaluate innovative processes using



The PICA post-combustion capture plant at Loy Yang.

gases drawn from AGL's Loy Yang brown-coal-fired power station in south-east Victoria. The program is targeting a 40 per cent reduction in energy use of current capture processes to overcome these challenges.

While CO₂ is already being captured at large scale around the world, cost and efficiency challenges remain an impediment to wide-scale commercial implementation.

Researchers will examine the energy efficiency of CO₂ capture configurations, the

effectiveness of two new solvents into which CO₂ will be absorbed, and measure the total amount of CO₂ removed.

The PICA (derived from the first letters of PCC, IHI, CSIRO and AGL) research plant is 21 metres high and was built by IHI in Japan and transported to the Latrobe Valley where it will operate around the clock, capturing 150 to 200 tonnes of CO₂ each year.

It is expected the PICA plant testing and evaluation campaigns will be completed by the end of 2017.

CEFC \$9M TO MELBOURNE

The Clean Energy Finance Corporation (CEFC) is lending up to \$9.1 million to the University of Melbourne to finance emissions and cost-saving initiatives aimed at reducing the university's energy bills, while increasing productivity and sustainability.

CEFC said the finance would enable the university to accelerate its implementation of innovative energy-efficient and renewable energy technologies, including voltage optimisation, freezer upgrades, solar photovoltaics, solar thermal and micro-turbines.

The university expects these to reduce its grid electricity use by eight per cent, and deliver carbon emissions abatement of more than 9000 tonnes per year. The university, with some 47,000 students, has the energy requirements of a town the size of Warrnambool.

AGL BACKS RESIDENTIAL BATTERY STORAGE

Australia's AGL Energy has invested \$28 million to buy a minority stake in US-based battery storage solutions provider Sunverge to help accelerate its push into distributed generation and rooftop solar and storage and smart software.

AGL is the exclusive channel partner for the sales of Sunverge's intelligent energy storage systems in Australia.

Sunverge is one of the leading manufacturers and suppliers globally of batteries and intelligent battery fleet management systems and software. These capabilities enable owners to manage their own renewable energy generation efficiently. They also help utilities and energy service providers manage those renewable power sources and link them into 'virtual power plants' to meet peak energy demand across neighborhoods, communities and entire service areas.

AGL's \$20 million investment sees it join current investors Australian Renewable Energy Agency (ARENA), SB China Venture Capital (SBCVC), Siemens Venture Capital and Total Energy Ventures International.



The Moree Solar Farm.

MOREE SOLAR FARM FEEDING THE GRID

The Moree Solar Farm in northern NSW has successfully achieved generation and is now feeding 56 MW of renewable solar energy into the National Electricity Market, enough to power 15,000 average homes.

Developed by Fotowatio Renewable Ventures (FRV), the Spanish solar developer owned by Saudi Arabian conglomerate Abdul Latif Jameel Energy and Environmental Services, the Moree operation is Australia's first utility-scale single-axis tracking and largest polycrystalline solar farm.

"FRV believes there is strong market support for large-scale solar in Australia and is looking forward to celebrating first generation from some of our other developed sites in the coming years," said FRV CEO Mr Rafael Benjumea.

Australian Renewable Energy Agency (ARENA) CEO Mr Ivor Frischknecht said large-scale solar in Australia was making solid headway towards reaching commercial maturity.

"In the past six months we've seen more than 210 MW from ARENA-supported solar farms start feeding into the grid and power Australian homes and businesses with renewable energy," Mr Frischknecht said. "The Nyngan, Broken Hill and Moree solar farms, along with approximately 200 MW set to be built through ARENA's \$100 million large-scale solar round, will help push costs down by developing local supply chains, increasing financier confidence and advancing innovative renewable technologies."

NEWS

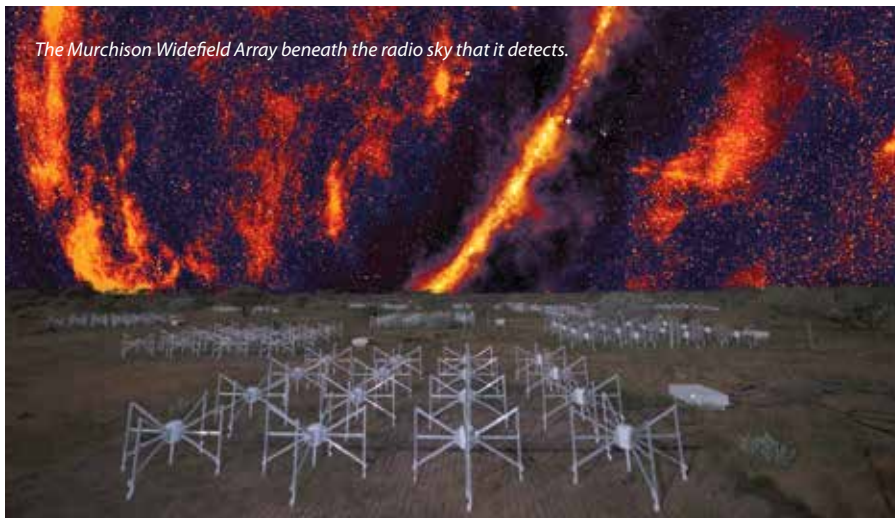


PHOTO: MELBOURNE PLANETARIUM

Capturing the Cosmos goes national

Capturing the Cosmos is a new show created by Melbourne Planetarium in partnership with CAASTRO, the ARC Centre for All-sky Astrophysics.

Narrated by Melbourne's Academy Award winner Geoffrey Rush and written and directed by Dr Tanya Hill, astronomer and Planetarium Manager at Museum Victoria, *Capturing the Cosmos* explores CAASTRO's cutting-edge research about our place in space.

The full-dome planetarium show, which explores the earliest processes in the universe and the forces that have shaped it since, was launched at the Melbourne Planetarium in March and will run nationally at the Scitech Planetarium in Perth, the Sir Thomas Brisbane Planetarium in Brisbane, the Queen Victoria Museum and Art Gallery Planetarium in Launceston, the Wollongong Science Centre and Planetarium, the Sydney Observatory and the Adelaide Planetarium. This is the first time a planetarium show has ever been launched with a nationwide release.

Focusing on all-sky data collected from next-generation telescopes – such as the Murchison Widefield Array (MWA) and SkyMapper – which features in 'Capturing the Cosmos', CAASTRO brings together Australia's and the world's top astronomers to revolutionise the way we understand the cosmos.

"Each of these telescopes is helping us study key aspects of our universe," Dr Hill says.

"SkyMapper is helping us to understand

Dark Energy. Dark Energy can't be seen just like we can't see the wind, but like a snowflake spiralling around on a windy day, you can see the effect that the wind has. Astronomers have seen the effect that Dark Energy has: it actually pushes space apart. What Dark Energy is, or how it works, we don't understand yet, but all-sky astrophysics and telescopes like SkyMapper are set to help us to learn more."

The MWA is a radio telescope that explores the past, Dr Hill says.

"When we look up at the night sky, we are looking back in time. Light has taken so long to reach us that we are seeing things as they were millions or even billions of years ago. But there's a limit. If we look back any further, we hit a time that astronomers call the Dark Ages that we can't see into.

The MWA is going to be one of the first telescopes that can peer across the Dark Ages and help us understand how the first stars and galaxies lit up the universe."

'FOOTPRINTS' OFFER CLUES TO ZINC

Geologists have found evidence of mineral 'footprints' that may point to undiscovered, high-grade zinc deposits underneath known deposits in the Northern Territory's McArthur Basin.

CSIRO researchers studied existing drill cores and found that the geology around the McArthur River zinc mine is replicated in older rocks underneath – suggesting that similar geological processes that led to the McArthur River deposit also happened hundreds of millions of years earlier, before the rocks at McArthur River were deposited on top.

Despite the fall in bulk commodity prices overall, shortfalls in zinc supply have meant that demand for the metal remains strong. New zinc discoveries are needed to fill the supply hole and would provide a welcome productivity boost to Australia's mining and minerals industry.

Australia has been a world-renowned zinc producer for more than 130 years, but production is slowing down.

"We're focusing our research efforts on under-explored areas, and areas with surface cover, to drive the next wave of discoveries," CSIRO's lead study author, Dr Sam Spinks, said.

"We haven't found a deposit yet, but the high zinc concentrations and metal haloes in these rocks are what geologists regard as 'distal footprints' to potential metal mineralisation.

"This work will lead to more targeted exploration drilling, helping companies save costs while reducing their environmental impact," Dr Spinks said.

RAIL UPGRADE IN SA

The Australian Rail Track Corporation (ARTC) will fast-track a major upgrade to the east-west rail link, involving 1200 km of rail replacement between Adelaide and Tarcoola, which will deliver a substantial boost to freight productivity in South Australia and the national freight network.

The upgrade will replace decades-old rail with stronger steel, weighing 60 kg a metre compared to the current 47 kg/m, which will permit axle weight to increase from 23 to 25 tonnes at 80 km/h – enabling heavier loads and increased speeds.

Under the deal, announced by Prime Minister Malcolm Turnbull and ARTC CEO John Fullerton, ARTC will partner with Arrium Steel to deliver the upgrade, substantially boosting demand for steel production at Arrium's Whyalla facility.

ATSE PEOPLE

Tanya Monro



Tanya Monro joins CSIRO Board

Professor Tanya Monro FAA FTSE, Deputy Vice Chancellor and Vice President of Research and Innovation at the University of South Australia, has been appointed to the CSIRO Board.

She joins Monash University Provost Professor Edwina Cornish AO FTSE, who was recently also appointed to the CSIRO Board, and Mr David Thodey FTSE, who is CSIRO Chairman.

Announcing her five-year appointment, Industry, Innovation and Science Minister Christopher Pyne said Professor Monro's background as a highly regarded physicist and her experience in the higher education and research sectors will complement the expertise of the CSIRO Board.

"It is important that CSIRO, Australia's premier science research organisation, has board members who offer the right combination of skills, knowledge and expertise. Professor Monro will bring a valuable mix of skills to the CSIRO Board with her broad knowledge of innovation," Mr Pyne said.

"Professor Monro is an experienced board member and chairperson whose membership on the Commonwealth Science Council and the South Australian Economic Development Board will be of great benefit to her role on the CSIRO Board."

Professor Monro also chairs the Deputy Vice Chancellor Research Group of the Australian Technology Network of Universities and the National Youth Science Forum Council.

"Innovation is central to the Government's economic agenda and Australia's future prosperity," Mr Pyne said. "Collaborative initiatives with the university sector and

industry help CSIRO make the most effective contribution to the Australian innovation system. Professor Monro will bring a strong understanding of the value of these collaborations to the board."

Professor Monro is best known for her work in photonics – the science and technology of the photon, the fundamental particle of light – and is an ARC Georgina Sweet Laureate Fellow.

Before joining the University of SA she was the Director of the ARC Centre of Excellence in Nanoscale BioPhotonics and of the Institute for Photonics and Advanced Sensing (IPAS) at the University of Adelaide. From 2005–14 she was a Professor of Physics and the inaugural Chair of Photonics at the University of Adelaide. In 2005 she also commenced as the Director of the DSTO Centre of Expertise in Photonics. From 1998 to 2005 Professor Monro worked within the Optoelectronics Research Centre in the UK.

Professor Monro was awarded the Bragg Gold Medal for the best physics PhD in Australia. Other awards she has received include the Eureka Prize for Excellence in Interdisciplinary Scientific Research (2015), the Beattie Steel Medal of the Australian Optical Society (2014) and the Australian Academy of Sciences' Pawsey Medal (2012).

LYN BEAZLEY AN AMBASSADOR

WA Australian of the Year 2015, Professor Lyn Beazley AO FTSE, pictured (left) with the Mayor of Mandurah, Marina Vergone, after an Australia Day citizenship ceremony at the seaside town, south of Perth. Professor Beazley has become an ambassador for the Australian of the Year program.

KEN MICHAEL HEADS BUSHFIRE LIAISON

Former Western Australian Governor Dr Ken Michael AC FTSE, a Fellow for more than 20 years, has been appointed by the WA Government to liaise with residents about the future of the town of Yarloop, which lost more than 160 properties, including many historic buildings, in a January fire.

Dr Michael, an engineer and former Main Roads commissioner, has established a State Recovery Coordination Group and urged residents to be patient, warning that the clean-up could take up to nine months.

Dr Michael said he would draw on experiences from the 2014 Parkerville fire that destroyed 57 properties in the Perth Hills.

He told media the community would be consulted extensively.

"The people will be telling us what they expect. There are people living in the area still and we need to make sure we're listening to them," Dr Michael said.



Ken Michael



ATSE PEOPLE

Rob Vertessy calls stumps at BoM

Dr Rob Vertessy FTSE will retire as Director of the Bureau of Meteorology on 29 April, after holding the position since 2012.

As head of the Bureau, he has steered the organisation through a period of rapid change which has seen significant advancements in meteorological science and technology.

Environment Minister Greg Hunt said Dr Vertessy had been an outstanding Director of the Bureau.

"Dr Vertessy has enjoyed a long and distinguished public service career in the field of science, initially working with CSIRO before permanently joining the Bureau in 2008 as the then Deputy Director of Climate and Water," he said.

"Dr Vertessy's sound stewardship and impressive scientific credentials have reinforced the Bureau's position internationally as a leading

meteorological information agency.

"In recognition of this, in 2015 Dr Vertessy was elected to the World Meteorological Organization Executive Council."

Dr Vertessy was preceded in the role by Dr Greg Ayers FTSE, who was Director from 2009–12. Before this Dr Ayers was Chief of Marine and Atmospheric Research at CSIRO.

Former ATSE President Dr John Zillman AO FAA FTSE was BoM Director from 1978 to 2003, Chairman of the Commonwealth Heads of Marine Agencies from 1994 to 2003 and Permanent Representative of Australia with the World Meteorological Organization (1978 to 2004).

Dr Sue Barrell FTSE is currently the Bureau's Deputy Director, Observations and Infrastructure.

Rob Vertessy



KADAMBOT SIDDIQUE HONOURED IN INDIA

Professor Kadambot Siddique AM FTSE (second from left) receives his certificate marking his election as the International Fellow of the Indian Society of Plant Physiology during the 3rd International Plant Physiology Congress held in New Delhi in December. Professor Siddique, who heads the Institute of Agriculture at the University of Western Australia, was acknowledged for "his outstanding contributions in the field of Plant Physiology and Cognate Sciences".

PAUL ZIMMET RETIRES FROM BAKER IDI

Professor Paul Zimmet AO FTSE is stepping down as a Director and staff member at the Baker IDI Heart & Diabetes Institute.

It is nearly seven years since he joined the board and more than 30 years since he founded the International Diabetes Institute, which merged with the Baker Heart Research Institute in 2008 to form Baker IDI. Professor Zimmet will continue as a clinician at the institute.

Professor Zimmet has been at the forefront of developing diabetes research and care and is recognised as one of the world's most influential diabetes experts.

He has published more than 850 research papers and has been listed in both the 2014 and 2015 editions of Thomson Reuter's 'World's most influential scientific minds' as one of only seven Australians of the 400 scientists in the Clinical Medicine category.

When he established the International Diabetes Institute in Melbourne in 1985, it was the first institute in Australia to concentrate only on diabetes and associated disorders. IDI became the largest diabetes

research institute in Australia, and a leading centre for diabetes research and care in the Asia-Pacific region. It had a major impact as the first World Health Organization Collaborating Centre, influencing many aspects of diabetes in Australia and the region.

Professor Zimmet's pioneering work in Pacific and Indian Ocean populations has been critical in the global prediction of diabetes. His epidemiological research covering many ethnic groups has contributed to the classification and diagnostic criteria for diabetes and improved understanding of the genetic-environmental and behavioural components of type 2 diabetes. He is routinely consulted by government and NGOs on research and other matters relating to diabetes.

Professor Zimmet's advocacy has received international recognition in raising the awareness of diabetes as an international public health emergency, and that recognition has helped to enhance the understanding of diabetes and improved care and prevention globally.

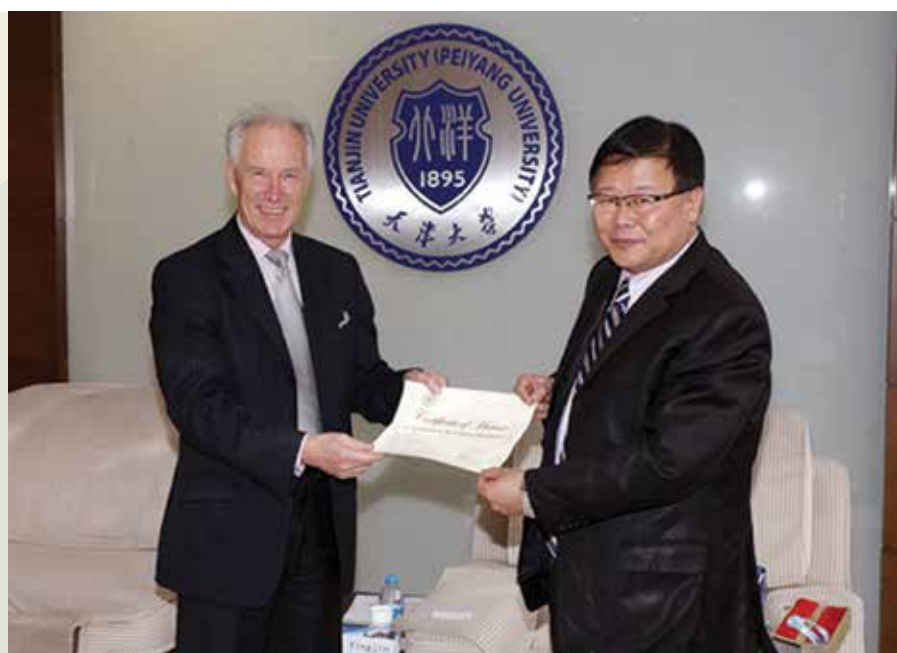
He holds Honorary Doctorates from Madrid's Complutense University, Monash University and Tel Aviv University. He has also received many international and national awards including the Kelly West and Harold Rifkin Medals from the American Diabetes Association, the Banting Award of Diabetes UK, the 2013 Research Australia Peter Wills Medal and the 2015 Howard Florey Oration of Adelaide University.

The Chairman of the Baker IDI board, Mr Peter Scott, paid tribute to Professor Zimmet: "Paul has made significant contributions to Baker IDI as a director, researcher and clinician, and to the global diabetes community more broadly. On behalf of the board I thank him and wish him well in his future endeavours."

Paul Zimmet



ATSE PEOPLE



The Vice President of Tianjin University, Professor Yingjin Yuan, confers the honour on Professor Johnston at a ceremony in Tianjin.

of Main Roads and successively held appointments as Deputy Chief Engineer and Assistant Commissioner before becoming Chief Engineer in the Coordinator General's Department and then Deputy Coordinator-General and finally Coordinator-General.

In this role he was responsible for the administration of Queensland affairs and intergovernmental relationships while retaining responsibility for state development and public works organisations.

He also served as Deputy Chairman of the Queensland Cultural Centre Trust, the Brisbane Exposition and South Bank Development Authority, and as a member of the Great Barrier Reef Marine Park Authority.

He graduated as a civil engineer from the University of Queensland, later completing postgraduate studies in traffic studies and business administration.

He was awarded an International Road Federation scholarship in 1958 and an Eisenhower Exchange Fellowship in 1972.

Between 1971 and 1986 he was a member of the Queensland Institute of Technology Council (1971–77), Griffith University Foundation Council (1971–78), UQ Senate (1978–86) and Bond University Advisory Council (1986–87).

LEONIE WALSH CHAIRS EXPERT PANEL

Dr Leonie Walsh, Victoria's Lead Scientist, has been appointed chair of the state's new Innovation Expert Panel, which will work to strengthen Victoria's position as an innovation hub. The Innovation Expert Panel will analyse and provide advice to the Government about new models for innovation, emerging trends and issues, and disruptive technologies and their potential to impact business growth across all industry sectors. The 14-member

panel includes some of the best-known names in innovation in Victoria as well as Adrian Turner, CEO of Data 61, who spent 18 years in Silicon Valley.



Leonie Walsh

China honour for Archie Johnston

Tianjin University – the oldest university in China and widely regarded as China's pre-eminent research-led institution for electronic engineering – has named Professor Archie Johnston FTSE an honorary professor.

Professor Johnston, Dean of the Faculty of Engineering and Information Technologies of the University of Sydney, joins an illustrious list of previous honorees at the university that has included Nobel Prize laureates, including the late Herbert Simon, who won the economics prize in 1978.

The Deputy Director of the School of Electronic Information Engineering at Tianjin University, Professor Wang Chao, praised the professional and academic achievements of Professor Johnston, one of Australia's foremost engineers.

He was the chairman of the judging panel for the Prime Minister's Science Prizes between 2010 and 2012 and held a similar position for the Australian Construction Achievement Awards in 2009. He was a peer reviewer for the Excellence in Research for Australia awards in 2010 and 2015.

Professor Johnston is the advisory Professor of the Shanghai Jiaotong University. He was appointed to this role in 2006 and in 2010 it was confirmed as a lifetime appointment. SJTU has listed him as one of the top 200 scholars worldwide.

Tianjin University opened in 1895, 45

years after the University of Sydney accepted its first students, and has more than 28,700 students on campus and 4450 faculty and staff, with 19 academic schools.

SIR SYDNEY SCHUBERT A QUEENSLAND ICON

Sir Sydney Schubert FTSE was a prominent figure in Queensland for many years as an engineer, administrator and university Chancellor.

The Academy regrets to advise Fellows that it has recently learned of the death, on 2 August 2015 in Brisbane, of Sir Sydney Schubert, aged 87.

Sir Sydney was a former Assistant Commissioner of the Queensland Main Roads Department before being appointed Queensland Government Coordinator-General in 1977, a role that incorporated the position of head of the Premier's Department. He was later the inaugural Chancellor of Bond University from 1987 to 1990, when Dr Don Watts AM FTSE was Vice Chancellor and President.

His 1988 nomination to the Academy noted that he had been created a Knight Bachelor in recognition of his distinguished service – reflected in a career in which he served in the Department



Sir Sydney Schubert

ATSE PEOPLE

Chris Roberts joins innovation panel

Dr Chris Roberts FTSE, non-executive Director of ResMed, has been appointed to the Board of the Federal Government's Innovation and Science Australia (ISA) – a new statutory board that will be tasked with placing innovation and science at the centre of government policy-making and will play a key role in helping deliver the National Innovation and Science Agenda.

The Government says the new board will have broader functions than its predecessor, Innovation Australia, including advising the Government on strategic innovation and science priorities and investment.

"The appointment of leading figures from the innovation and science sectors will add deep commercial and

research expertise across areas as diverse as agriculture, biotechnology and software," the Government's announcement said.

Dr Roberts has more than 40 years' experience in international medical device businesses including renal (dialysis), orthopaedics (electrical bone growth stimulation), cardiology (pacemakers), respiratory/sleep medicine (CPAP and ventilation) and otology (cochlear implants and acoustic implants).

He is a Plus Alliance Professor, which is a position across three universities: UNSW, King's College London and Arizona State University. Dr Roberts is the former Chief Executive Officer/President of Cochlear Ltd, the market leader in implantable devices for the hearing impaired.

Dr Roberts served as ResMed's

Executive Vice-President until he became Chief Executive Officer of Cochlear. He remains on the ResMed Inc board as a non-executive Director. Dr Roberts was a member of the National Health and Medical Research Council (NHMRC) and was also Chairman of Research Australia, a non-profit organisation promoting the importance of health and medical research.

He serves on the Cochlear Foundation, Jobs NSW Board, the Health Innovation Advisory Council of the NHMRC, the Centenary Institute of Cancer Medicine and Cell Biology Board of Governors, Monash University Industry Council of Advisers (MICA), NSW Innovation and Productivity Council, University of Technology Sydney VC's Industry Advisory Board and the UNSW Faculty of Medicine Advisory Council.

Dr Alan Finkel AO FTSE, Australia's Chief Scientist, is Deputy Chair of the Board.



Chris Roberts

UOW EXPERT WINS RAILWAY AWARD

Geotechnical engineering and rail infrastructure expert Professor Buddhima Indraratna, from the University of Wollongong, received the highest honour in railway awards at the recent combined Australasian Railway Association (ARA) and Railway Technical Society of Australasia (RTSA) awards night.

He received the RTSA Individual Award, made annually to a person who has made an outstanding contribution to the railway industry in the Asia-Pacific.

The award citation recognised his overall career achievement in providing an outstanding engineering and technical service to the railway community both nationally and internationally, the originality and innovation of his research, the degree of autonomy in which he currently operates, and the quality and appropriateness of leading-edge publications that have been presented in high-quality journals and at reputed international conferences.

RTSA, a joint Technical Society of Engineers Australia and the Institution of Professional Engineers New Zealand, was formed in 1997 to further the interests of the railway industry at large and its individual proponents.

Presenting the award, NSW Minister for Transport and Infrastructure Andrew Constance emphasised the need for greater railway efficiency in Australia.

Buddhima Indraratna (right) receiving the RTSA Individual Award from Minister Constance.



VANESSA GUTHRIE JOINS WACA BOARD

Toro Energy Ltd's Perth-based Managing Director and CEO Dr Vanessa Guthrie FTSE has been appointed to the WA Cricket Association Board.

Dr Guthrie has extensive executive and director experience in the resources sector and in community, government and publicly listed companies. She is currently non-executive Director of the WA Water Corporation and a Director and Vice Chair of the Minerals Council of Australia Board.

Dr Guthrie acknowledged it was an exciting time to be a part of cricket in WA and that there were tremendous growth opportunities for the WACA with the addition of the Perth stadium.

"We have a proud history of achieving great results in elite cricket in this state, and it is a privilege to be part of the team that is able to shape and grow the WACA as a business, as well

as promote the sport to participants at all levels," Dr Guthrie said. "Cricket forms part of every Western Australian's life, be it going to a game at the WACA Ground or playing cricket in the backyard.

"I'm looking forward to working alongside the high-calibre individuals who currently sit on the Board to achieve the WACA's goals."

The WACA Board is chaired by Dr Ken Michael FTSE, former Governor of Western Australia, Commissioner of Main Roads WA, chairman of the East Perth Redevelopment Authority, a member of the Economic Regulation Authority and Chancellor of the University of WA.



Vanessa Guthrie

Graduate Research Training.

www.unimelb.edu.au/research/



Join Australia's Best Minds

The University of Melbourne is seeking high calibre PhD students to contribute to projects at the forefront of international research.

At the University of Melbourne, one of Australia's leading research universities, you will become part of a dynamic research community, working alongside the best and brightest researchers in the country.

Our generous scholarship programs provide students with financial support and opportunities for international fieldwork and travel.

To find out more about undertaking a graduate research degree at Melbourne, visit: www.unimelb.edu.au/research/

dream large



THE UNIVERSITY OF
MELBOURNE



Source: Crossrail

Innovation key to delivering successful transport infrastructure

Major transport infrastructure projects are notorious for running over budget, over time and not meeting expectations.

With a rapidly growing urban population fuelling demand, Australia is pushing to become a world leader in transport infrastructure delivery.

The University of Queensland's Professor Mark Dodgson and Dr Sam MacAulay are studying some of Europe's largest projects to identify how innovation can lead to success.

Their studies include Crossrail, a \$30 billion new railway line currently under construction, which traverses London. It is predicted that, upon completion, Crossrail will increase London's rail-based capacity by 10 percent and be used by about 200 million passengers a year.

Some of its 37 new stations are being built in the busiest areas of central London, and parts of its 42km of tunnels are being bored less than a metre from existing underground train lines.

Undertaken in collaboration with colleagues at Imperial College and University College London, Professor Dodgson and Dr MacAulay's studies have identified how innovation contributes to managing such complexity.

Crossrail explicitly encourages and incentivises innovation. Its innovation strategy encourages suppliers and clients to

capture and share innovative ideas and solutions. As well as generating new innovations, the strategy strengthens cohesion between operational units, improves project performance and delivers substantial operating savings.

According to Professor Dodgson, Crossrail holds important lessons for improving outcomes in complex transport systems and ensuring such projects deliver on future operational requirements.

UQ's Business, Economics and Law researchers continue to solve some of the biggest challenges facing our world. Their work, both independently and in collaboration with industry, government and the community, positions the UQ faculty as a leading intellectual hub of business, economics and law research in Australia. For more information visit bel.uq.edu.au

The Federal Government's 2015 Excellence in Research for Australia exercise confirmed The University of Queensland as one of the nation's top three universities, measured by the quality of its comprehensive range of specialised research fields. UQ's outstanding critical mass offers researchers significant interdisciplinary capability.

Join more than 4,000 students currently pursuing a research higher degree at UQ. Visit uq.edu.au/grad-school



THE UNIVERSITY
OF QUEENSLAND
AUSTRALIA

Create change