

AUSTRALIAN ACADEMY OF TECHNOLOGICAL SCIENCES AND ENGINEERING (ATSE)



FOCUS

NUMBER 178
JUNE 2013



INFRASTRUCTURE PLANNING

**FINDING THE BEST APPROACHES,
MODELS AND PRACTICES**

Contributors discuss the major role that infrastructure planning, expenditure and operation play in the affairs of governments, the private sector and the community.

Resources / From competition to collaboration

June 2013 / 1 / [Andrew Pettifer](#)

Sport is competition and competition, for me, should be about sport. In business though I believe there is a better way. It's called collaboration.

I certainly feel that thrill when positioning for a project; getting on the bid list, preparing a proposal, presenting expertise at interview and the buzz of getting that call to say "you're on". So far, so good. But quickly the doubts start to creep in – did we under-price the job, can we meet the client's expectations and still turn a profit? Margins are tight, fees are low.

When the folly of rampant capitalism and unchecked commercial competition came to hit us all in the face in 2008 it brought about a global shock that you would have thought would have made us stop in our tracks and look for a better way (except of course that it had all happened before and the lessons remained unlearned).

The aftershocks have continued and even in the relatively sheltered economic conditions that Australia has enjoyed the construction industry has seen a series of failures of significant builders and sub-contractors. Consultants have soldiered on through even tighter fee competition that is fuelling a commercialisation of our profession and leaving staff and clients alike increasingly underwhelmed.

As a Principal at Arup I am pretty convinced that I can call upon the expertise of the finest collection of engineers and specialists that any global organisation has assembled. Our record stands for itself. But I also know that we don't have a monopoly on the best ideas. Whisper it quietly but ... there may be some things that other consultants do better than us. And for sure there are some projects that are just too large, complex and high risk for us to take on ourselves. In these circumstances we collaborate with our peers.

As a building services engineer I know how reliant we are on the expertise of the whole supply chain to get our designs turned into reality. I don't want to have to pretend that my opinions are correct just because "I'm the consultant" and spend my energies arguing with the sub-contractor even though their views are perfectly valid. And let's be honest, sub-contractors know a lot more about the practical challenges of actually installing and commissioning systems than consultants.

Projects should be a collaboration between clients, consultants, main contractors, sub-contractors and suppliers. The process should be designed such that each party adds maximum value whilst respecting the necessity of a fair commercial return for all concerned. This has to create a better outcome for the client than a series of dumb price driven competitive processes to get everyone on board at the tightest possible margins followed by arguments over cost-cutting and variations.

Read the rest of Andrew's blog at: <http://thoughts.arup.com/post/details/286/from-competition-to-collaboration>

Contributor /
[Andrew Pettifer](#)



I am a building services engineer, a sports fan and for the last six years, a part of the Arup family. As a leader in the buildings team in Sydney I take a lot of satisfaction from the work that we do and the influence that the Arup team has in helping to shape the skyline of our city.

I hope to influence how projects are procured and delivered with the objective of achieving better design and an enjoyable and rewarding experience for the people involved.

Email me: andrew.pettifer@arup.com

Thoughts /

The best solutions can only come about by continually listening, learning and challenging. That's why we've created Thoughts - a place for experts, practitioners and enthusiasts to talk about the issues affecting the built environment now and in the future.

Please join us.

www.arup.com/thoughts

3

Infrastructure planning in a rapidly changing world

By Jose Luis Irigoyen

7

Transport in Asian megacities gives planning insights

By Surya Acharya

11

The key to turbocharging our infrastructure

By Megan Motto



Front cover: The Sydney Harbour Bridge – an Australian infrastructure icon.

PHOTO: ISTOCKPHOTO.COM

- 12 Better planning, certainty and transparency needed
- 15 The infrastructure dilemma: effective planning is critical
- 17 Nation needs a science and technology policy
- 17 ATSE launches five-year Strategy Plan
- 20 500 acclaim Australia's visionary innovators
- 23 Extreme Science hits the high spots again
- 25 Steel's green future rests on waste
- 41 ATSE in *Focus*



Seoul is a megacity facing the challenge of moving millions in a reliable, affordable and sustainable way (Page 7).

FOCUS

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
12 July 2013.

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.

Copyright © ATSE 2013

PUBLISHER

CEO: Dr Margaret Hartley FTSE
Editor: Bill Mackey

AUSTRALIAN ACADEMY OF
TECHNOLOGICAL SCIENCES AND
ENGINEERING (ATSE)

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

ACN 008 520 394
ABN 58 008 520 394
Print Post Publication No 341403/0025
ISSN 1326-8708

Design and production:
Coretext 03 9670 1168 www.coretext.com.au



**Monash research
is *helping stop*
the spread of
Dengue fever by
making mosquitoes
immune to the
disease.**

**We think that's
*brilliant.***



1800 MONASH
monash.edu

CRICOS Provider: Monash University 00008C



MONASH University

Where brilliant *begins*

Infrastructure planning in a rapidly changing world

Road construction in Azerbaijan.

PHOTO: WORLD BANK

The need for access to good quality, reliable infrastructure is universal, yet the 'access gap' remains very large.



By Jose Luis Irigoyen

jirigoyen@worldbank.org

In the past two decades, we have seen dramatic improvements in living standards in the developing world. GDP has increased by 80 per cent in developing countries over the past 20 years, despite an increase of 1.2 billion in the population, and more than 500 million people have risen out of poverty.

On this path toward social and economic development, infrastructure has played a key role in delivering growth, reducing poverty and addressing broader development challenges. In East Asia, for example, two-thirds of the acceleration of GDP growth rate in 2001–05 (over 1991–95) can be attributed to infrastructure development.

Despite the progress, huge challenges remain. Even with the decline in the share of people living in poverty, close to 1.4 billion people still live in extreme poverty (on US\$1.25 or less per day). The need for access to good quality, reliable infrastructure is universal, yet the 'access gap' remains very large.

An estimated 1.4 billion people still have no access to electricity, although we have the technologies to reach them. At least 780 million people lack access

to safe drinking water and 2.4 billion have no access to improved sanitation, with major consequences for their health – around 1.7 million deaths a year (of which 90 per cent are children) are directly attributable to unsafe water and poor sanitation and hygiene.

Moreover, around 800 million rural dwellers do not have access to an all-weather road, meaning they are cut off from the world in the rainy season, and about two-thirds of the world's population has yet to gain access to the internet.

Developing countries face a massive investment gap to meet their populations' infrastructure needs, and ensure that infrastructure is low-emitting and climate-resilient. To do this they need to increase both the scale and the pace of investment in infrastructure. This challenge is exacerbated by rapid urbanisation and climate change.

The number of people living in cities will increase by 2.8 billion between 2010 and 2050 and 96 per cent will be located in low- and middle-income countries. Worldwide, the number of mega-cities (cities with more than 10 million inhabitants) is expected to reach 37 by 2025, more than twice as many as in 2000, serving as home to more than 600 million residents.

In the People's Republic of China alone, at least 220 cities will have more than a million residents. In Africa, the fastest urbanising continent, the urban population is forecast to reach one billion by 2040 – equivalent to the total population in 2009.

This comes with social problems – more than 70 per cent of Africa's urban population suffers from inadequate housing, water supply or sanitation.

The World Bank recently released the report *Turn Down the Heat*. It states

An estimated 1.4 billion people still have no access to electricity, although we have the technologies to reach them. At least 780 million people lack access to safe drinking water and 2.4 billion have no access to improved sanitation ... around 1.7 million deaths a year (90 per cent of these children) are directly attributable to unsafe water and poor sanitation and hygiene.

that our world could warm by 4°C by the end of this century – with devastating effects, especially in poor countries – if we do not take concerted action now.

Finding solutions to these issues goes beyond the access and growth agenda – it requires tackling the complexity and inter-connectivity among sectors.

For example, responding to rapid urbanisation requires coordinated planning in transport, water, information and communications technology (ICT) and many other sectors, including social development. Mitigating the effects of greenhouse gas emissions requires a certain type of investment in transport and energy. Investment decisions in the energy sector have implications for water use and therefore on agriculture and the environment.

Meeting environmental goals and adapting to climate change will require an infrastructure that is less damaging to the environment and more resilient to natural disasters and other climate risks.

Although more complex, the potential

benefits of resolving these second-generation issues are tremendous – they can help accelerate growth and place a country on a more sustainable development trajectory.

Infrastructure is at the core of the World Bank Group's (WBG) mandate to foster growth, reduce poverty and encourage shared prosperity. Infrastructure – transport, water, energy and ICT – represents the WBG's largest business line.

The US\$109 billion infrastructure portfolio accounts for 35 per cent of the total WBG assistance to client countries and the private sector. The WBG is one of the largest financiers of infrastructure among the multilateral development banks (MDBs) – large enough to play a catalytic role, but small compared to the needs.

The WBG's support for infrastructure focuses on helping countries get on a more sustainable development path by improving access to basic services and delivering transformational investments that optimise co-benefits. Additionally, the Bank prioritises the mobilisation of private capital for infrastructure

investments through the expanded use of public-private partnership (PPP) arrangements and guarantee instruments.

We have identified several defining trends that are emerging from this new context and shaping the future of infrastructure development in low- and middle-income countries. For example:

1 Infrastructure planning needs to be more integrated

Spatial and transport development plans need to integrate national, regional and local infrastructure needs. Integrated planning is key to managing multiple demands on limited city space. The city of Curitiba, Brazil, provides a successful example of integrated public transport corridors and land use planning.

2 Infrastructure needs to promote inclusion of disadvantaged groups such as the poor, the elderly and people with disabilities

Rapid urbanisation drives poor working households out of central localities and cities, so urban transport needs to provide affordable commutes. Road



Sir Bob Rhodes

PHOTO: STEVE RHODES

Sir Bob Watson visits ATSE

A high-level ATSE team met Sir Bob Watson, one of the world's leading experts on global environmental issues, including climate change, ozone depletion, biodiversity and sustainable development, in May to discuss a variety of issues.

The meeting at the Academy's Melbourne office focused on sustainable development and discussed topics ranging from science to governance and in particular the areas of energy security and food security.

A range of ATSE work was discussed including the Green Growth in Australia projects – with particular emphasis on the Food and Fibre

Project; sustainable resource usage; the role of science, technology, research and innovation in lifting productivity; and the role of international collaboration in strengthening science, technology and innovation.

Professor Snow Barlow FTSE, who is leading the ATSE Green Growth – Food and Fibre work, gave the meeting an overview of the project.

The ATSE team included ATSE President Dr Alan Finkel AM FTSE and CEO Dr Margaret Hartley FTSE; Professor Barlow, University of Melbourne; Dr John Bell FTSE, Senior Policy Adviser, ATSE; Professor Adrienne Clarke AC FAA FTSE, Chancellor, La Trobe University; Professor Ana Deletic FTSE, Director, Centre for Water Sensitive Cities; Professor Dave Griggs FTSE, CEO ClimateWorks Australia and Director Monash Sustainability Institute; Dr Glen Kile AM FTSE, Victorian Division Chair; Professor Mike Manton FTSE, former ATSE Director; Dr Graeme Pearman AM FAA FTSE, Chair, ATSE Climate Change Advisory Group; and Mr Mike Taylor AO FTSE, Director, Crawford Fund.

Sir Bob is internationally known for his work in former roles as Chair of the Intergovernmental Panel on Climate Change (IPCC), Chief Scientific Adviser for the UK Department of Environment, Food and Rural Affairs (DEFRA) and Chief Scientist and Senior Adviser for Sustainable Development at the World Bank. He is currently the UK's representative to the UN Open Working Group on Sustainable Development Goals. He has received many national and international awards and prizes for his contributions to science, including the 2010 Blue Planet Prize. He was the Director of the Science Division and Chief Scientist for the Office of Mission to Planet Earth at the National Aeronautics and Space Administration (NASA). Sir Bob then became Associate Director for Environment in the Office of the President of the US in the White House.

While in Melbourne, as Sir Louis Matheson Distinguished Visiting Professor at the Monash Sustainability Institute, he delivered lectures on the topic 'Is there a sustainable future for the world?'

traffic injury affects the poor and vulnerable disproportionately, with pedestrians, cyclists and motorcyclists accounting for half of the 1.24 million road deaths every year, so road safety policies need to target these groups.

3 Countries need to plan for a low-carbon transport sector

Without a modal shift, transport is set to become the largest emitter of greenhouse gases. A comparison between the cities of Atlanta and Barcelona shows what is at stake: Atlanta covers an area of 4280 square kilometres and emits 7.5 tons of CO₂ per year, while Barcelona, with a similar population, covers only 162km² and emits a mere 0.7 tons of CO₂ annually. Infrastructure choices today will determine future fuel use.

Another priority is to **change the way infrastructure is financed**. We need to consider both who finances and who pays for infrastructure services. It is important to broaden the sources to raise revenue. There is little political appetite to raise taxes, yet relying on fuel taxes will not deliver the stream of revenues needed to support the necessary scale-up.

The trend is toward sources that link payment with immediate benefits, such as user charges, value capture and betterment levies. Creating incentives for better use of existing capacity is also important.

Expanding the options for private sector financing can also help. The private sector is already a mature source of funding for some countries. Basel III and other challenges are shifting financing from commercial banks to institutional investors. Australia and Canada's pension funds have the highest asset allocation to infrastructure, but it is only about five to six per cent. The provision of a deep pipeline of well-structured projects that give financial industry certainty remains the biggest concern.

PPP investment in the developing world is significant, but is increasingly concentrated in a few middle-income countries. PPPs mobilised US\$170 billion of investment (in 2010), compared to about US\$95 billion from MDBs and

PHOTO: RICHARD TIMBURY



Mr Irigoyen addresses the ATSE-Infrastructure Australia workshop.

Infrastructure is at the core of the World Bank Group's (WBG) mandate to foster growth, reduce poverty and encourage shared prosperity. Infrastructure – transport, water, energy and ICT – represents the WBG's largest business line. The US\$109 billion infrastructure portfolio accounts for 35 per cent of the total WBG assistance to client countries and the private sector.

official development assistance (in 2009).

During the period 2001–10, five countries (Brazil, China, India, Mexico and the Russian Federation) accounted for more than 50 per cent of PPP investment, while low-income countries accounted for only five per cent. PPP investment has proved easier in the energy and telecom sectors than in the transport and water and sanitation sectors.

A differentiated approach is required to address the challenges to unlocking the enormous potential of PPPs.

Faced with challenges such as rapid urbanisation and climate change, low- and middle-income countries need to step up investment in infrastructure for access and growth, while ensuring greater sustainability and resilience. The infrastructure choices they make today will lock in lifestyles, energy use and vulnerability.

Better infrastructure planning and

greater mobilisation of private finance for infrastructure development are key to helping countries choose a more sustainable and prosperous development path.

MR JOSE LUIS IRIGOYEN is the Director for the Transport, Water, Information and Communications Technologies, and Infrastructure Finance Department in the Sustainable Development Network (SDN) of the World Bank, and heads its Global Expert Team on Public Private Partnerships. He is the Chair of its Transport and Water Sector boards, which operate with corporate responsibilities for sector strategy, human resources and knowledge management, and oversee the transport and water portfolios (which combined comprise 418 projects in 133 developing countries with about \$65 billion in commitments). He oversees the implementation of the World Bank Group 'ICT for Greater Development Impact' sector strategy and a portfolio worth \$1.2 billion in lending and technical assistance covering investments in connectivity, ICT-based services and development of ICT industry.

**CONTRIBUTIONS
ARE WELCOME**

Opinion pieces on technological science and 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

Building an extreme heat framework for our future.

Extreme heat events are becoming an ever increasing feature of the Australian summer and have claimed more lives than any other natural hazard in Australia over the past 200 years.

With more than 123 temperature records broken across the nation last summer our response to heatwaves and a changing climate has become a vital policy challenge that stands to affect energy costs and infrastructure and our way of life.

Researchers at the University of South Australia's Barbara Hardy Institute, led by Professor Wasim Saman, are tackling the issue head-on by developing a technical, socioeconomic and regulatory framework that will better prepare Australian households to cope with extreme heat events.

Professor Saman said "the group is working to establish the likely impacts of heatwaves on households and energy infrastructure as well as looking at new house design options and the ability of existing homes to handle heatwaves throughout Australia"

Changes to regulatory requirements including a peak demand in energy star rating (NatHERS), the Building Code of Australia and maximum energy consumption regulations have been recommended, as actions aimed at reducing the impacts of heatwaves in the future.

Professor Saman is recognised internationally as a research leader in sustainable and low carbon living for his research leadership in the CRC for Low Carbon Living, as well as his most recent work on the design and evaluation of the Lochiel Park Green Village - Australia's most environmentally friendly housing development.

"Our research is demonstrating that the transition to affordable and climate adapted zero energy housing in Australia is possible using available materials and technologies" said Professor Saman.

The project is funded by the National Climate Change Adaptation Research Facility, a multidisciplinary body delivering information and generating knowledge to assist society in adapting to climate change.

For more information about this project visit unisa.edu.au/barbarahardy

This research into energy infrastructure is another example of how UniSA's researchers are successfully delivering solutions to the important issues of today.

Image: Lochiel Park Green Village.



**University of
South Australia**

Seoul is a megacity facing the challenge of moving millions in a reliable, affordable and sustainable way.

Transport in Asian megacities gives planning insights

PHOTO: ISTOCKPHOTO.COM

By adopting rail as the backbone of the urban transport system, developed Asian megacities have turned the challenge of moving millions into running public transport systems as profitable businesses.



By Surya Raj Acharya
surya@jterc.or.jp

Asian megacities distinguish themselves from their Western peers in terms of the nature and scale of urban transport problems.

A megacity means a large population and diverse economic activities, which generates a huge volume of travel demand. For example, Tokyo has a metropolitan population of more than 31 million, spread over an area with a 50-kilometre radius from the city centre, which generates more than 50 million trips daily.

Since economic activities and jobs are heavily concentrated in the metropolitan core (Tokyo has 23 Wards), most trips are between the suburban areas and the core. Moreover, a significant portion of daily trips is concentrated into narrow bands of morning and evening peak hours.

Although the metropolitan populations of Seoul, Shanghai, Manila and Jakarta are a little less than that of Tokyo, the city structure and trip patterns are strikingly similar to Tokyo. These cities are facing the challenge of moving millions in a

reliable, affordable and sustainable way.

Another key element is the challenge of closing the demand-supply gap in the mobility market because of the sheer speed of economic growth and urban expansion. It took almost 100 years for the population of London to increase from two to eight million. The corresponding figure for New York is 70 years, while those for Tokyo, Seoul, Manila and Jakarta are 55, 21, 33 and 36 years respectively.

Rapid pace of income growth has fuelled motorisation, but expansion of road networks is not catching up the process. Because of a rapid increase in household income, car ownership in developing Asian megacities is growing very fast and is now near to the level of developed cities. In the year 2000, the total number of passenger cars in Jakarta City was 1.23 million, and this reached 4.22 million in 2009, an annual average growth rate of 16.6 per cent.

Although developed Asian megacities such as Tokyo, Seoul, Hong Kong and Singapore are known for lower

car-ownership rates, some developing megacities such as Bangkok and Jakarta are on a higher car-ownership trajectory, with around 400 cars per 1000 population in 2009 (corresponding figures for Tokyo and Seoul are only 244 and 215 respectively).

Expansion of road infrastructure is too slow to respond to the higher pace of motorisation. As a result, the urban road networks in Asian megacities are inadequate by international comparison. In New York and Paris, the road area accounts for 21 per cent and 25 per cent of total land area respectively. These figures are within the normal range (20 to 25 per cent of land area) that urban planners recommend for a metropolitan core. In contrast, Tokyo, Seoul, Jakarta, inner Shanghai and inner Bangkok have allocated only 16.3, 13.6, 7.3, 12.2 and 7.1 per cent of city area to roads.

Compared with their Western peers, Asian megacities have a relatively shorter timespan to adjust supply provisions to meet the burgeoning demand, which ironically calls for higher investment

in infrastructure, especially when an economy is still at the developing stage. It also calls for institutional innovations since the developing megacities cannot rely on the slow and natural course of an institutional evolution.

Under such circumstances, Asian megacities are facing a wide range of urban transport problems and are taking various policy initiatives, which potentially offer valuable insights for infrastructure planning.

Mass transit

Developed Asian megacities, such as Tokyo, Hong Kong and Singapore, have successfully utilised rail transit to serve large-scale and high-density demand. In fact, by adopting rail transit as a workhorse for urban mobility, these cities have turned the challenges of moving millions into the opportunity of running public transit in a commercially profitable way.

By international comparison, the market share of public transport in Asian megacities is quite impressive, particularly in cities like Tokyo, Seoul, Hong Kong

and Singapore. For example, latest person/ trip surveys show that the shares of public transport (rail and bus) in total motorised trips for Tokyo's 23 Wards, inner London and New York City remained at 81, 58 and 41 per cent respectively, while the corresponding figures for commuting trips are 92, 73 and 64 per cent respectively. This clearly shows the dominance of public transport in Tokyo.

In New York City, 36 per cent of commuting trips are by car while the figure for Tokyo is just 8 per cent. Other developed Asian megacities are also closely following Tokyo's patterns in public transport use.

The underlying key factors for a higher market share of public transport include both forces of 'pull' (towards public transport) and 'push' (away from private automobiles). Pulling forces entail an extensive network of urban railways offering reliable and high-quality services. Pushing forces are about taxing or pricing of road transport to reflect the real cost of driving, such as higher fuel and vehicle taxes, tolled expressways

and market-based parking fees.

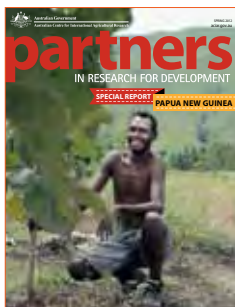
For example, the toll fee in the metropolitan expressway network in Tokyo ranges from 500 yen (A\$5.20) (up to 6km) to 900 yen (A\$9.35) for 24km and more. For a 20km trip, the toll fee for the expressway is 800 yen (A\$8.30), while the train fare for the Tokyo Metro network is only 270 yen (A\$2.80) and for private commuter railways is about 300 yen (A\$3.10).

The limited road space, road traffic congestion and higher downtown parking fees also exert a powerful pushing force. Likewise, higher population density and mixed use create favorable conditions for public transport use. In fact, in Tokyo and other developed megacities of Asia, urban railways have interacted with land-use and shaped the city structure into a transit-friendly form. The interactive feedback between urban rail and land use has triggered and sustained a virtuous cycle, and thereby results in transit-oriented, compact land use and higher quality railway services.

Another indicator for the exemplary

Excellence in delivering information

- AUSTRALIA'S LEADING AGRI-SCIENCE PUBLISHER
- PROFESSIONALLY WRITTEN AND PRODUCED PUBLICATIONS
- INFORMATION PRODUCTS THAT SHOWCASE R&D AT WORK
- TALK TO US IF YOU NEED TO: reach new audiences
create effective communications
explain, engage and convince



coretext
CONTENT MATTERS

performance of public transport systems in developed Asian megacities is the profitability of urban railways. Latest operation data show that the ratio of operating revenue and operating expenses (including depreciation) for metro rail systems (subways) in New York, London, Paris, Tokyo (Tokyo Metro), Hong Kong and Singapore (SMRT) remained as 0.58, 0.95, 0.60, 1.29, 1.80 and 1.37 respectively.

The figures demonstrate a contrasting comparison between Asian and Western megacities – metro systems in the West operate with a substantial level of public subsidy, while Asian systems are running profitably. Such financial performance of Asian metro systems possibly contributes to changing the prevailing notion of ‘public transport for essential service with subsidy’ to ‘public transport for quality service and profitable business’.

Land use coordination

Performance of an urban transport system depends heavily on the coordination between transport and land use. Perhaps because of the scarcity of urban land and hence higher land value, land-use regulation is politically very sensitive even in developed countries such as Japan and Korea.

This poses a special challenge to achieve better coordination between transport and land use. In addition to making effort through conventional land-use planning instruments, Japanese cities adopted so-called ‘value capture’ schemes, which were first promoted by private railway companies.

Through such schemes, private railway companies undertook railway and real estate projects together and cross-subsidised rail investment with real estate profit. This approach naturally encouraged private railway companies to go for high-density development around railway stations, and resulted in transit-oriented urban development.

The value capture approach has subsequently been successfully adopted by other Asian cities such as Hong Kong and Singapore, and there is growing interest

in other developing Asian megacities. The case of Asian megacities also demonstrates that weak land use or planning regulation can be complemented through judicious investment in major transport projects, which can induce desirable changes in land-use patterns through market process.

Another important issue for Asian megacities is identifying the right timing for different planning and policy interventions in order to shape the process of urban evolution appropriately to achieve long-term goals.

In developing countries, at the vision formulation and infrastructure planning level, there is gap between what is ‘doable’ and what is ‘desirable’. The professional communities can make contributions in terms of making a distinction between issues of ‘technical imperatives’ and

‘political choices’, which are often mixed up in the exciting approach of infrastructure planning in developing countries.

DR SURYA RAJ ACHARYA is currently a research advisor at the Institute for Transport Policy Studies, Tokyo. He has more than 23 years of national and international interdisciplinary experience in the areas of urban and regional transport planning, infrastructure investment, sustainable development policies, system dynamics and program and project development, implementation and evaluation. Dr Acharya has previously worked for the Government of Nepal, IUCN (the World Conservation Union) and the UN Economic and Social Commission Asia and the Pacific, in Bangkok. He has taught graduate-level courses on transport and spatial development policy as a visiting professor at the National Graduate Institute for Policy Studies, Tokyo, and has been a visiting lecturer at the University of Tokyo.

Latest operation data show that the ratio of operating revenue and operating expenses (including depreciation) for metro rail systems (subways) in New York, London, Paris, Tokyo (Tokyo Metro), Hong Kong and Singapore (SMRT) remained as 0.58, 0.95, 0.60, 1.29, 1.80 and 1.37 respectively.



Traffic congestion in Beijing.

PHOTO: WORLD BANK

LETTERS TO THE EDITOR

ATSE Focus welcomes letters from readers in response to published article or on technological science and related topics.

PLEASE KEEP LETTERS BRIEF. LONGER LETTERS MAY BE RUN AS CONTRIBUTED ARTICLES.

Please address to editor@atse.org.au



**We ask,
we seek,
we solve.**

The key to turbocharging our infrastructure

Australia has a solid foundation, strong reputation and industry support for fundamental change. Leadership is the key to unlock the potential.



By Megan Motto
megan@consultaustalia.com.au

Often referred to as the 'lucky country', it would seem that Australia is seen by the rest of the world as even more so, post-GFC. Our strong headline economic indicators and stable political and business environment should make us attractive to overseas investment.

With the headline political and economic conditions in place, and pretty good weather to boot, why is it so difficult and expensive to plan and build infrastructure in Australia? For years government and the public have lamented the challenges, but it is high time we found ways to overcome our infrastructure backlog.

Consult Australia has considered these issues for some time. Our October 2010 report *Transporting Australia's Future*, and more recently our work through the Transport Reform Network (TRN) and through the Urban Coalition on *A New Deal for Urban Australia*, explore the governance arrangements and financing mechanisms required to kick-start Australia's infrastructure program over the longer term.

For Australian taxpayers to get the best 'bang for their buck' when it comes to public infrastructure, we need to make sure the right infrastructure gets built in the first place – and make sure it gets built in the most efficient manner feasible.

To make sure the right infrastructure gets built, bipartisan support for independent advice is critical. The current model we have with Infrastructure Australia (IA) works well, but this should not preclude us looking overseas for inspiration to improve. In Canada, we see Infrastructure Canada integrated as part of the Transport, Infrastructure and Communities portfolio of the Canadian Government and, similarly, Infrastructure

UK sits within Treasury. In other jurisdictions infrastructure decisions are made by or within a ministerial portfolio. In South Africa, Cabinet has established the Presidential Infrastructure Coordinating Committee (PICC) to develop and ensure the implementation of a single common National Infrastructure Plan.

The key strengths of the IA model are its independence – and its robust, transparent cost-benefit analysis process. Although not perfect, this model provides a greater level of confidence in spending decisions according to need and benefit and also gives industry the surety it requires to make business and funding decisions going forward.

While in a modern democracy it is unlikely that infrastructure decisions will ever be divorced from politics, long-term decision-making (beyond both the normal budgetary and election cycles) and the establishment of a secure pipeline of projects is critical to attracting investment and ensuring the private sector is resourced and prepared.

This sort of vision is do-able. The new Building Canada plan represents the largest and longest federal investment in provincial, territorial and municipal infrastructure projects in Canadian history, with \$4.7 billion a year in new funding over 10 years, starting in 2014-15. The South African Government is also working to develop a 20-year planning framework beyond one administration to avoid a stop-start pattern to infrastructure roll-out.

Consult Australia, both independently and collectively through our work with the Urban Coalition, makes a number of key recommendations including increasing the resources and remit for IA and ensuring the States and Territories have similar bodies through which they can independently plan, coordinate and evaluate proposals around the country.

Furthermore, the establishment of a new Federal minister and department for cities and urban development would help by looking at policy issues such as health, education and social cohesion through an



Infrastructure for the 21st century – the new face of Sydney.

urban lens – providing a unique opportunity to address these policy priorities in a more holistic way. It would also ensure that policy makers got the best value for money from their total infrastructure spend.

There are also opportunities to improve collaboration between government and industry. The National Infrastructure Plan Strategic Engagement Forum (NIPSEF) launched in the UK brings together more than 60 different stakeholders from across the infrastructure delivery chain to aid government in the delivery of the National Infrastructure Plan.

Consult Australia also supports the re-establishment the Infrastructure Finance Working Group within IA. The group would be a permanent advisory committee to IA and government, supported by a dedicated secretariat, and consider opportunities to drive lasting improvements to the planning and financing

of infrastructure across the nation.

With large amounts of public funds being spent on infrastructure, it is incumbent on governments to ensure they get maximum value for money through the procurement process. In order to share expertise and identify and deliver solutions to improve productivity and value for money, Consult Australia recommends the establishment of an independent Australian Centre of Procurement Excellence.

The Australian Government alone issued nearly \$42 billion worth of work across some 82,000 contracts valued at more than \$10,000 in 2011-12. Just a one per cent efficiency dividend would equate to nearly half a billion dollars in savings. If this also included the value of procurement across six states, two territories and 562 local governments, the opportunities would translate to savings for investment in for example, new

infrastructure, hospital beds, police and other in-demand government services.

In the construction sector alone, a 2009 report estimated the cost of disputation at \$7 billion a year, a figure that is likely to have grown. Similarly, a 2008 survey of pressure points in the Australian construction industry found that poor procurement practices had led to 26 per cent of projects in Australia, worth more than \$1 billion, running over budget by \$200 million or more, while a 2006 study found that only 56 per cent of projects were completed on time.

There are many opportunities for efficiency gains through the use of better procurement methodologies and value-for-money approaches such as early engagement of the supply chain (Integrated Project Delivery) and technology such as Building Information Modelling (BIM).

Even if governance and collaboration frameworks are fixed, and efficiencies

Better planning, certainty and transparency needed

Improved strategic planning, rolling 10-year infrastructure budgets and further transparency in decision-making are needed if Australia's infrastructure sector is to support Australians' economic and social aspirations.

These were key conclusions from a gathering of more than 50 infrastructure leaders from Australia and overseas in Melbourne recently, organised by the Academy and Infrastructure Australia (IA).

The workshop – arranged by ATSE's Built Environment Working Group – noted that improving infrastructure planning and investment would better equip Australia to deal with challenges such as raising productivity growth, dealing with demographic change and pressures on government budgets.

Australia must also grasp the challenge of climate change adaptation, it said. This would drive the development of different infrastructure solutions that had demonstrated resilience. Technology and innovation offered cost-effective solutions to key challenges facing infrastructure in Australia.

The key changes required were:

- 1 More robust long-term plans.
- 2 Medium-term budgets to support development of a project pipeline.

- 3 Focus on maintenance and service improvements through high-value/low-cost projects.
- 4 Reforming the way we pay for infrastructure.
- 5 Early customer and community engagement.
- 6 Raising transparency in decision-making.

Speakers included:

- Mr Jose Luis Irigoyen – Director of Transport, Water, Information and Communication Technologies, World Bank, Washington;
- Dr Guy Felio – President, Infrastructure Strategies & Research Inc, Ottawa;
- Mr Michael Deegan – National Infrastructure Coordinator, IA;
- Dr Surya Raj Acharya – Senior Research Fellow, Institute for Transport Policy Studies, Tokyo;
- Mr Jordan Schwartz – Manager Infrastructure Policy, World Bank, Washington;
- Ms Megan Motto – CEO of Consult Australia; and
- Dr Kerry Schott – Board Member, Infrastructure Australia.

Key conclusions

The workshop participants agreed some key conclusions to enhancing Australia's infrastructure planning:

1 More robust long-term plans

Governments need to follow through on their own commitment to the development of robust and integrated long-term (15 to 30-year) strategic plans for our cities, as agreed by the Council of Australian Governments (COAG) in December 2009. They also need to deliver on their commitments to develop medium-term (five to 15 years) prioritised infrastructure and land-use plans, so that industry has greater confidence to invest and the community has greater certainty. There is a need to improve the quality and consistency of project proposals that are aligned with the strategic plans and that robustly demonstrate net economic, social and environmental benefits.



Workshop convenor Max Lay gets the proceedings off to a jovial start.

PHOTO: RICHARD TIMBURY

realised, Australia will still need to consider the ongoing financing and funding for infrastructure. Between now and 2041, dependency ratios will almost double from 19 to 39 per cent, meaning that the overall taxation base traditionally tapped to fund infrastructure will be challenged. Add to this dilemma the (over) politicisation of debt and lack of political will to discuss user-pays and it is clear that if new financing arrangements are not soon found, Australians will run out of luck pretty quickly.

It is not a matter of 'not enough money'. Australia is ultimately a wealthy nation – we have a low debt-to-GDP ratio, and we are also one of the lowest-taxed nations in the OECD.

There is currently \$1.2 trillion dollars in superannuation savings, which is well suited to infrastructure as an investment class. The trick will be to find mechanisms to unlock the growing proportion of those

funds, which are in the self-managed class. Mum-and-dad investors want to invest in something for the future of their children and grandchildren, but they also want security and strong returns for retirement.

The Urban Coalition suggests that as a nation we might unlock private sector dollars through a new Urban Infrastructure Fund. The aim would be to create, in partnership with the States and Territories, a new urban infrastructure investment asset class, which would offer lower-risk, attractive, credit-enhanced returns with appeal to both institutional and retail (mum-and-dad) investors, and create a new source of infrastructure funding.

According to Mark Zandi, chief economist at Moody's and Senator John McCain's former economics adviser, \$1.57 is returned to the economy from every taxpayer dollar spent on infrastructure, so the argument of the productivity

uplift of critical Infrastructure is clear.

Australia has a solid foundation, strong reputation and industry support for fundamental change. Leadership is the key to unlock the potential.

MS MEGAN MOTTO is Chief Executive Officer of Consult Australia, the association for professional services firms within the built and natural environment. She has extensive board experience and is currently a Director and Councillor of the NSW Business Chamber, Director of the Australian Construction Industry Forum, Councillor of the Australian Chamber of Commerce and Industry, and sits on the NSW State Advisory Council for the Committee for Economic Development of Australia (CEDA). She holds positions on the Department of Infrastructure and Transport's National Urban Policy Forum, the Department of Finance and Deregulation's Procurement Consultation Committee, and Roads Australia's Steering Committee of the Transport Funding and Pricing Reform Network.

2 Medium-term budgets to support development of an enhanced project pipeline

Governments should move beyond the current four-year approach to budgeting to strengthen the current IA investment pipeline. Like governments in Canada and the US, governments in Australia need to be presenting 10-year budgets and estimates of their prospective infrastructure outlays. (As part of its 2013 budget, the Canadian Government has committed to maintain funding for 10 years to the Building Canada Fund.) Infrastructure outlays should be related to a minimum, fixed percentage of GDP or state product.

3 Focus on maintenance and service improvements through high-value/low-cost projects

Rebalancing investment priorities is needed to give greater attention to the maintenance of existing assets and targeted, comparatively inexpensive investments at pinch points, rather than focusing primarily on mega-projects. Pinch-point interventions need to be based on a network-wide focus on improving services. This approach has been advocated in the UK's National Infrastructure Plan. An enhanced pipeline of integrated projects will allow industry to effectively develop plans and allow for a competitively priced infrastructure and better workforce management, particularly in engineering,

4 Reforming the way we pay for infrastructure

Dealing with financing alone is not enough. New ways of approaching funding are required, for example, user charging and beneficiary charging, such as value capture and levies. Recycling capital through the sale of existing assets and investing the proceeds in new projects needs to be pursued to provide 'deal flow' for investors.

5 Early customer and community engagement is key to ensure 'ownership' of plans and projects

Across all infrastructure sectors, governments and infrastructure providers should invest more in understanding what their community and customers want and what they are prepared to pay for. An intimate understanding of these factors can then drive the formulations of plans and, in turn, projects to meet customer expectations.



PHOTO: RICHARD TIMBURY

ATSE President Alan Finkel and Fellows Vaughan Beck and Peter Johnson at the workshop.

6 Raising transparency

Infrastructure decision-making will always be a political task in a democracy. Further transparency in infrastructure decision-making will minimise inefficiencies and community distrust. The transparency model applied by Infrastructure Australia needs to be more widely followed. Publishing project business cases (or at least key findings and assumptions) will place a discipline on governments and oppositions, and improve the public's ability to scrutinise political promises.

INFRASTRUCTURE AUSTRALIA

Infrastructure Australia is a statutory body, established under the *Infrastructure Australia Act 2008*, which came into effect on 9 April 2008. Infrastructure Australia advises governments, investors and infrastructure owners on a wide range of issues, which include:

- Australia's current and future infrastructure needs;
- mechanisms for financing infrastructure investments; and
- policy, pricing and regulation and their impacts on investment and on the efficiency of the delivery, operation and use of national infrastructure networks.



Nuclear Energy for Australia?

Don't miss out!

Seats are limited and are selling out fast!

THE POWERHOUSE MUSEUM, SYDNEY
25-26 JULY, 2013

Nuclear energy for Australia? It's a question that is too important to ignore in any examination of Australia's energy options, but attracts immediate questions about the implications.

Are nuclear power stations safe? What would we do with the wastes? Where would such power stations be located? How would they be cooled? Are they dangerously radioactive? Can they be the source of nuclear weapons? Is the regulatory environment adequate? On the other hand – Could they reduce emissions and help Australia meet its carbon reduction targets? Would they provide low-cost baseload power, able to charge low-emission electric vehicles at night? Would they provide high level secure jobs – and more?

This is a "don't miss" event if you're part of – or interested in – the national debate about Australia's energy options.

► KEYNOTE SPEAKERS

Professor Peter Guthrie | *Professor of Sustainability, Cambridge University, UK*

Dr Ron Cameron FTSE | *Head of the Nuclear Development Division, OECD Nuclear Energy Agency, France*

Mr Lee Hee-Yong | *Senior Vice President, Overseas Nuclear Power Projects, KEPCO, Korea*

Dr Massimo Salvatores | *Senior Scientific Advisor to the Director of the Nuclear Energy Division of the CEA, France*

Mr Timo Äikäs | *Executive Vice President, Posiva Oy, Finland*

The **Academy of Technological Sciences and Engineering (ATSE)**, an independent body of professional engineers and technologists, believes the hesitant debate on nuclear energy in Australia needs to be responsibly refocused and reliably and factually informed. It is bringing together highly respected international and national speakers – representing the broad spectrum of opinion on nuclear power – to lead open debate in this two-day seminar on the key technological, economic, social and environmental issues relating to nuclear power generation.

REGISTER TODAY

www.atse.org.au/events | events@atse.org.au | 03 9864 0908

Inquiries to **Nichole Abruzzise** (03) 9864 0908 or Nichole.Abruzzise@atse.org.au

The infrastructure dilemma: effective planning is critical

Modern society is replete with examples of where the existing infrastructure is inadequate and where there are few signs that the situation will improve in the foreseeable future.

Effective infrastructure planning is a critical issue for Australia – Melbourne's EastLink.



By Max Lay
mmlay@bigpond.net.au

“Effective infrastructure planning is a critical issue for Australia, particularly as our population continues to grow. Infrastructure – notably transport, water, energy and communications – is vital for driving productivity, underpinning prosperity and for our way of life. It impacts on all aspects of our society. Establishing robust infrastructure plans is critical. Weaknesses in those plans impose economic costs that are usually difficult and expensive to correct.”

This statement was a key finding at the ATSE–Infrastructure Australia (IA) Infrastructure Workshop.

In this context, it is not surprising that the pressing need to plan, provide, operate and maintain infrastructure is almost universally accepted and often argued with strength and passion.

And yet modern society is replete with examples of where the existing infrastructure is inadequate and where there are few signs that the situation will improve in the foreseeable future. Why is this so?

To try to answer this question we need to first share some understanding of what we actually mean by the term ‘infrastructure’. What does it embrace? Surprisingly, perhaps,

infrastructure is a relatively new term and has a variety of definitions.

Australia's national dictionary, the *Macquarie Dictionary*, gives the following current definition:

1. the basic framework or underlying foundation (as of an organisation or a system);
2. the roads, railways, schools, and other capital equipment which comprise such an underlying system within a country or region; and
3. the buildings or permanent installations associated with any organisation, operation, etc.

Similarly, but more expansively, late last year Wikipedia explained:

“Infrastructure is basic physical and organisational structure needed for the operation of a society or enterprise, or the services and facilities necessary for an economy to function. It provides the framework supporting an entire structure of development. It is an important term for judging a country or region's development.

The term typically refers to the technical structures that support a society, such as roads, bridges, water supply, sewers, electrical grids, telecommunications, and so forth, and can be defined as ‘the physical components of interrelated systems providing commodities and services essential

to enable, sustain, or enhance societal living conditions’.

Viewed functionally, infrastructure facilitates the production of goods and services, and also the distribution of finished products to markets, as well as basic social services such as schools and hospitals; for example, roads enable the transport of raw materials to a factory.”

The doyen of English language dictionaries, the *Shorter Oxford*, did not deign to mention the word infrastructure in its 3rd edition, which ran from 1944 to 1992. For much of the 20th century, the term public works would have been used to describe most items now called infrastructure. In 1976 a major US bicentennial review said public works represent: “Investments in the future for the people who create them, and for succeeding generations.”

In an expansive and very recent analysis, Frischmann, an American legal academic, noted that “Infrastructure generally conjures up the notion of a large-scale physical resource made by humans for public consumption.” He considered that, currently, infrastructure predominantly embraces transport systems, communications systems, governance systems and services such as schools, sewers and water supply.

So, a relevant contemporary definition of infrastructure would see it cover capital-intensive physical facilities widely used for the production of a range of services, leading to:

- infrastructure – physical facilities used for the provision of services; and
- public infrastructure – infrastructure provided to supply services required by the community, but not achievable solely by usage charging.

Infrastructure planning as a topic of public debate would arguably exclude private-sector infrastructure, which could be fully and directly funded by charges levied on the use of the services provided.

Indeed, an almost-inherent characteristic of public-sector infrastructure within most current government systems is that the charges for use of the services it provides would not be sufficient to fund the provision of that infrastructure.

For example, most roads have no direct usage charges and even indirect charges such as fuel taxes are rarely hypothecated to the provision of road infrastructure. Similarly, there are many cases where public transport fares meet less than half the full cost of providing the transport service.

This is not an implied criticism of the associated infrastructure planning, as the overall benefits of infrastructure provision are often best reflected in the associated increases in surrounding land values, economic productivity and community well-being.

It often seems to me that the sewer system is a good example to consider in this context. The sewer is essential to our way of life but its provision is both expensive and time-consuming. We would all use the system at least half a dozen times a day, but would never dream of paying a fee each time we used it. The user-pays principle breaks down here – and in much infrastructure operation – because it primarily makes our way of life possible.

Our property has much enhanced value because it is sewered and we are happy to pay a fee related to that value.

Now the same argument applies to transport, but is rarely pursued. The value of a property is enhanced when it is serviced by transport. At a basic level, without road access, land may well have zero value. At a higher level, suburban access to a tram or train has a major beneficial impact on property values.

Thus, it is not surprising that many are

now advocating that a major component of all infrastructure provision be via a 'value enhancement' or 'value capture' model. The Committee for Melbourne recently produced a fine discussion paper explaining the approach in more detail.

Of course, the fare box will still play a role since one of the great lessons of the 20th century was that efficiency gains arise when users at least pay the marginal costs of their usage.

Stemming from the above definitions, a second, but related, key aspect of infrastructure is that its provision is not an end in itself, directed at providing an acceptable financial rate of return to those who have invested in its provision.

Rather, public infrastructure is provided to meet a wider set of community expectations. Once these expectations have been agreed and articulated, the specific associated infrastructure requirements, funding sources and levels – and implementation timetables – can be established as a logical, unemotive process.

However, as a community we very frequently jump directly into a detailed debate about the specific and narrow merits of alternative infrastructure proposals competing for scarce funds.

The debate is inevitably meaningless as it avoids the elephant in the room, which is defining the service outcomes we want to achieve over timespans that will always exceed electoral cycles.

We must see infrastructure as an investment in the future, requiring shared community vision for our future society, effective long-term planning and funding methods, and efficient operating practices.

Megan Clark extends her CSIRO term

CSIRO Chief Executive Dr Megan Clark FTSE has agreed to extend her term with CSIRO to the end of 2014.

"The Board has full confidence in Dr Clark and supports the continuing execution of the CSIRO strategy which is focused on answering big questions and increasing Australia's productivity through the organisation's world-class science capability," said CSIRO Chairman Mr Simon McKeon.

Under Dr Clark's leadership over the past four-and-a-half years CSIRO has significantly increased its engagement with industry and the community.

Dr Clark has set the CSIRO vision of building five global innovation precincts for Australia in plant and agricultural, resource, environmental, human life, and materials and manufacturing sciences. She has also led a strong focus on ensuring the safety and welfare of CSIRO people and affiliates and embedding a values-based culture.

Dr Clark will continue to implement the 2011–15 strategic objectives, including providing a platform for the organisation under a future new Chief Executive to lead the development and implementation of the 2015–20 Strategic Plan.

PHOTOGRAPHY BY NOEL BUTCHER



Megan Clark

DR MAX LAY AM FTSE, a Fellow since 1985, is a world expert in road and transport engineering. He has held senior appointments at the State Electricity Commission of Victoria, BHP Engineering, the Australian Road Research Board (ARRB), VicRoads, SKM and private consultancies. He was a Director of ConnectEast, Melbourne's Eastlink operator, has been an adviser to Roads Australia on road pricing, and in 2009 was awarded the John Shaw Gold Medal for his outstanding service to road transport in Australia. He was President (1995–96) and Councillor (1978 to 2002) of the Royal Society of Victoria, a Director (1986 to 2002) and President (1999 to 2002) of RACV, and President of the Australian Automobile Association (2000–02).

Nation needs a science and technology policy

Australia needs a national science and technology policy as a core Government objective.

A clearly articulated Science and Technology Policy Statement would provide the much-needed linkage between the Government's existing education policy and its industry and innovation policy, ATSE said in a May media release launching its own S&T Policy.

A robust and strategic science and technology policy framework would ensure Australia had world-leading research, knowledge generation and innovative technology that could be applied to address our societal needs and demands now and into the future, ATSE said.

This policy would give all sections of society surety for the future and establish clear national goals of placing Australia in a world-leadership role in delivering:

- advanced population health – by shifting investment into prevention measures and reducing risk factors for chronic diseases (for example, diabetes, obesity, cancer and age-related disease);
- advanced agriculture – ensuring our global competitive advantage is sustained while enhancing environmental values;
- advanced manufacturing – shifting our base

to high-technology, high-value products that are globally competitive;

- advanced service sector delivery – including advanced rural medicine and ICT and other technology platforms; and
- advanced resources management – including the mining, water and energy sectors.

ATSE believes that technological sciences, engineering and innovation will contribute significantly to Australia's social, economic and environmental wellbeing – and need to be backed by a national science and technology policy.

"We call for a sustained and strategic investment in science and technology so that by 2020 Australia will have advanced our knowledge and capabilities essential for the industries of the future," ATSE President Dr Alan Finkel AM FTSE said, releasing the ATSE statement.

"Barriers need to be removed to allow the seamless transfer of these capabilities into knowledge-intensive and advanced-technology industries, services and practices that address Australia's national needs and ensure economic growth, social equity, wellbeing and environmental sustainability.

"The Academy believes that Australia

has a great asset in its existing science and technology expertise and has ample capability to expand this asset.

"To achieve this promise Australia must improve its performance in translating its investments in science and technology research into applications that drive Australian industry, businesses and services, as well as delivering social and environmental benefits.

"This will need a commitment for all key players in the Australian science, research and innovation system to work more collaboratively and effectively together," Dr Finkel said.

This would include public-to-private-sector collaboration, government-to-government cooperation, and government-to-industry-to-community engagement. Public-to-private-sector collaboration is particularly important for Australia, given that around 70 per cent of our research capability is concentrated in the public sector, while the reverse has occurred in European countries, with 70 per cent of researchers embedded within industry.

"To achieve more effective public and private sector collaboration, governments will need to enhance their use of organisations within the national system, such as the Academy, for independent, robust, evidence-based policy advice," Dr Finkel said.

The ATSE Science and Technology Policy statement is included in the mailing of this issue of ATSE Focus.

ATSE launches five-year Strategy Plan

The Academy has completed and launched its 2013–17 Strategy Plan, which takes a serious look at the current environment, lists a range of aspirations for where ATSE should be in 2017 and lays out plans to get there in five strategic steps.

ATSE President Dr Alan Finkel AM FTSE launched the plan at Assembly 10 in Melbourne in May.

Its Vision is: "A future in which technological sciences, engineering and innovation contribute significantly to Australia's social, economic and environmental wellbeing."

It has a five-part Mission, to:

- advocate the application of technological sciences and engineering to innovation;
- deliver robust, independent and trusted evidence-based advice on technological issues of national importance;
- promote national and international collaboration in technological science, engineering and innovation;
- celebrate the success of individuals and companies in technological innovation; and
- promote science, technology, engineering and mathematics education at secondary and tertiary levels.

Its five key strategies are:

- Strategy 1: Create impact through the provision of independent and trusted advice.
- Strategy 2: Focus on technology-driven innovation to enhance prosperity.
- Strategy 3: Provide leadership in STEM education.
- Strategy 4: Celebrate achievements in science, technology and innovation.
- Strategy 5: Further develop our own capacity and effectiveness.

The ATSE 2013–17 Strategy Plan is included in the mailing of this issue of ATSE Focus and is on the ATSE website at www.atse.org.au/ATSEStrategyPlan





Additional call for 2013 **veski** innovation fellowships

Are you, or do you know, an outstanding international scientist or researcher looking to join Victoria's science & innovation communities? Learn how being part of the prestigious **veski** family helps our innovation fellows.



Victoria Prize for Science & Innovation

Do you know a leading Victorian who has made, or has the potential to make, a significant scientific discovery or technological innovation? Nominate them for a 2013 Victoria Prize for Science & Innovation valued at \$50,000 in either the life or physical sciences.

Victoria Fellowships

Have you recently met an emerging Victorian scientist or researcher who would benefit from an overseas study mission grant? If so, encourage them to apply for a 2013 Victoria Fellowship valued at up to \$18,000.

veski is now calling for applications for three of Victoria's most prestigious science & innovation programs.

Applications close towards the end of June 2013.

Find out more at veski.org.au/fellowships



Taking statistics to the rice industry

The way we grow rice could help combat worldwide food shortages, says Australia's new member of the International Rice Research Institute (IRRI) board.

Professor Kaye Basford FTSE from The University of Queensland has been appointed to the IRRI Board of Trustees, joining 14 other members from 11 countries around the world including Germany, Japan, the US, the Philippines, China and India. She is the only Australian on the board.

Professor Basford said she was honoured by the appointment and would draw on her own research at the interface between quantitative genetics and biometry (applying statistical analysis to biological data) as it has led to major benefits in plant improvement programs.

"With new sustainable rice farming techniques, we can work with the public and private sector to help improve the yield and quality of their rice in an environmentally sustainable way, and help governments formulate policy to improve the equitable supply of rice," Professor Basford said.

"Our mission is to become a global leader in rice germplasm development, future production systems and education to alleviate poverty, hunger and malnutrition, and make rice production more sustainable.

"I am looking forward to learning more about the research programs that are being undertaken at IRRI, and contributing to setting policies and strategies to reach our goals," she said.

UQ Deputy Vice-Chancellor (Research) Professor Max Lu FTSE said Professor Basford's appointment reflected her international standing as a leading academic and researcher in biostatistics and agriculture.

Professor Basford is the leader of the Queensland Node of the high-profile Australian Centre for Plant Functional Genomics (ACPFPG) and in 1998 was awarded the Australian Medal for Agriculture, the highest accolade from the Australian Institute of Agricultural Science and Technology.

Professor Basford is the President of the UQ Academic Board and was Head of the School of Land, Crop and Food Sciences, one of the schools that merged to form the School of Agriculture and Food Science. Professor Basford is also immediate Past President of the International Biometric Society.



Kaye Basford

PHOTO: LYLE RADFORD

NICTA STUDENT DRIVES CARGO MOVEMENTS

Intelligent software developed by PhD student Elena Kelareva will be part of an important upgrade to the software that has helped set an all-time loading record at Australia's largest port and earned her a prestigious student award for IT-enabled business innovation.

Elena is a NICTA-sponsored PhD student at The Australian National University.

OMC International, the Australian maritime engineering company where Elena developed the software, has recently adopted the DUKC® Optimiser tool as an add-on to its industry-leading Dynamic Under-Keel Clearance DUKC® software. The Optimiser is now being used by the Port Hedland Port Authority.

"In June last year, six ships leaving Port Hedland under DUKC® set a new port loading record when they carried a combined total cargo of more than a million tonnes of iron ore on the one tide," said Peter O'Brien, CEO, OMC International.

"We are looking forward over the next few months to enhancing the DUKC® with the DUKC® Optimiser, which is currently being trialled and which will assist the Port to further optimise the increasing volumes and sizes of vessels through the Port channels."

The DUKC® Optimiser automates the process of determining sailing times of ships through the port so as to maximise the amount of cargo ships can safely carry, taking into account factors such as tide, waves and currents. This process is usually done manually, with variable results. An automated scheduling system can find better solutions that allow more cargo to be loaded onto the same set of ships, or more ships to sail on each high tide.

Elena first became interested in scheduling while doing a summer research project in artificial intelligence at NICTA during her undergraduate degree at the University of Melbourne. After graduating, she worked as a software developer at OMC, and grew familiar with the manual scheduling practices existing at ports. She was sure she could develop an improved, automated system. She has since gone on to postgraduate studies with NICTA and the ANU, Canberra, to further explore the potential of the DUKC® algorithms.

"When an opportunity for a scheduling project came up in my work at OMC, I jumped at the chance," Elena said. "Many cargo ports could improve their capacity by improving the efficiency of their scheduling."

DUKC® Optimiser is the first ship scheduling approach that uses time-varying constraints on the ship's draft (the distance between the waterline and the bottom of the ship's keel). An analysis of its 2012 installation at Port Hedland indicates potential multi-million-dollar annual revenue increase for cargo shippers.

The NASSCOM Innovation Student Award she won was presented at CeBIT 2013 in Sydney in May.

Port Hedland serves the mineral-rich Eastern Pilbara region in Western Australia, and is Australia's largest port by annual throughput, being the first to exceed the 100 million tonne (Mt) ceiling in 2004–05. The port finished marginally below the 200 Mt milestone in 2010–11, making it the largest bulk minerals export port in the world.



Elena Kelareva receives her award.

PHOTO: NEIL DUNCAN/DEUTSCHE MESSE

500 acclaim Australia's visionary innovators

A crowd of more than 500 guests honoured Australia's leading innovators – our heroes in science and technology – at a glittering, sold-out dinner at the Melbourne Convention and Exhibition Centre in May.

Seven commercialisation high achievers were presented with prestigious ATSE Clunies Ross Awards for impacting global development in information technology, missile defence and medical diagnosis.

Their contributions are providing real-life impacts and significant economic pay-offs for Australia. The crowd warmly acknowledged

their achievements and feedback since the event has noted the high standard of the awardees' work and the value of the awards.

The ATSE Clunies Ross Awards – 2013 was their 22nd year – recognise Australia's pre-eminent scientists and technologists who have bridged the gap between research and the marketplace by persisting with their ideas, often against the odds, to the point that their innovations have created broad economic, social or environmental benefits.

The 2013 ATSE Clunies Ross Award winners were:

Dr Simon Poole and Dr Steven Frisken

– Australia's most successful commercialisers of new technologies that have shaped the internet worldwide, some of which are key components of the NBN in Australia. Their products, including undersea communication systems, are sold to all the major telecommunications equipment manufacturers in Europe, the US, Japan and China, and have generated exports worth hundreds of millions of dollars from their factory in Sydney.

PHOTOS: RICHARD TIMBURY

The 2013 Clunies Ross Awards were proudly hosted by the Victorian Government and generously supported by

Platinum Sponsors

- CSIRO
- ANSTO
- Monash University

Silver Sponsor

- The University of NSW – Malcolm Chaikin Foundation

Bronze Sponsors

- The University of Queensland
- The University of Newcastle
- Leighton Holdings



Adi Paterson presents a Clunies Ross Award to Ian Croser.



Alan Finkel delivers his address.

Dr Anthony Radford, Dr James Rothel, Dr Paul Wood and Dr Stephen Jones

– who have fundamentally changed the way tuberculosis (TB) is diagnosed around the world, by inventing and commercialising revolutionary technology that is greatly assisting in global TB control in both humans and cattle. They played a role in successfully eradicating bovine TB in Australia.

Mr Ian Croser – a world-leading radar and communications innovator who developed anti-ship missile defence radar that was the first of its kind worldwide, then went on to further the technology with cost, space and weight savings. The technology has put Australia on the world stage and attracted hundreds of millions of dollars into the Australian economy. Significant impacts have included benefits to the Australian defence industry, improved border protection and less reliance on foreign technology.

The Hon Gordon Rich-Phillips, Deputy Treasurer of Victoria, was the lead speaker, representing the Victorian Government, a key sponsor of the event.

The Awards were presented by representatives from the other three principal sponsoring organisations: Dr Adi Paterson FTSE, CEO of ANSTO; Dr Megan Clark FTSE, CEO of CSIRO; and Professor Ed Byrne FTSE, Vice-Chancellor of Monash University.

These 2013 ATSE Clunies Ross Award Winners followed in the footsteps of past winners such as Professor Ian Frazer FRS FAA FTSE, inventor of the cervical cancer vaccine;



Megan Clark with Simon Poole (left) and Steven Frisken.

Nobel laureate Dr Barry Marshall FRS FAA, who discovered the bacteria that causes stomach ulcers; Dr Fiona Wood, inventor of spray-on skin; and Professors Martin Green AM FRS FAA FTSE and Stuart Wenham FTSE, international leaders in silicon cell technology.

The ATSE Clunies Ross Awards dinner was attended by more than 500 eminent entrepreneurs, decision makers, government officials, researchers, academics and business leaders and included an address by Dr Alan Finkel AM FTSE, Chancellor of Monash University and ATSE President, titled 'The Electric Planet'.

The event also included the presentation

by Dr Finkel of the ATSE Medal to Mr Bruce Kean AM FTSE. The ATSE Medal, awarded by the ATSE Board, noted Mr Kean's "outstanding and tireless service to the Academy and to the annual ATSE Clunies Ross Awards; and for championing the application of technology for the economic, social and environmental benefit of Australia over many years".

The 2014 ATSE Clunies Ross Awards dinner will be held in Perth, for the first time, with substantial sponsorship already in place and arrangements being overseen by the 2014 Awards Organising Committee, chaired by Professor Alan Robson AM FTSE.



Ed Byrne with (from left) Steve Jones, Tony Radford, Paul Wood and Jim Rothel.



Bruce Kean acknowledges his ATSE Medal.

60 years of discovery

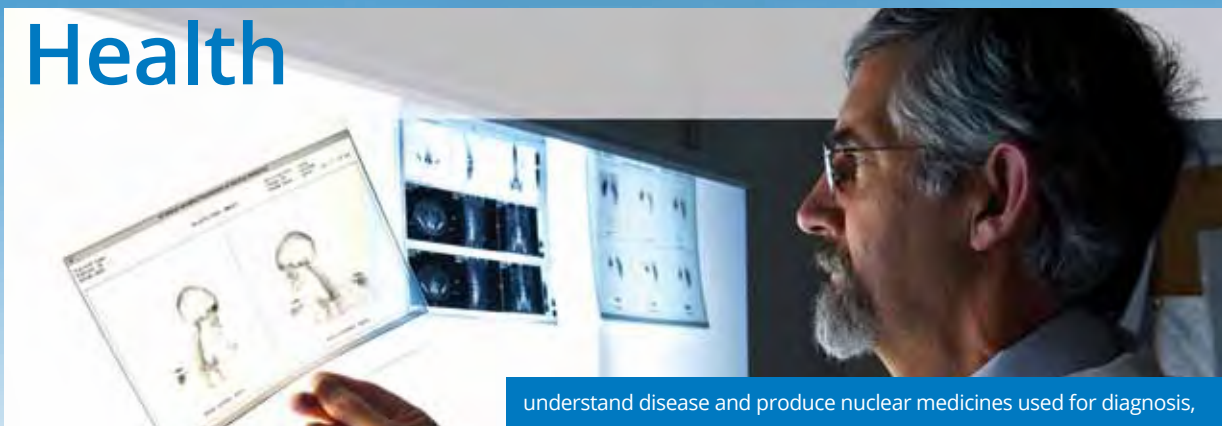
through nuclear science and technology

Environment



ANSTO scientists use nuclear techniques to measure climate change,

Health



understand disease and produce nuclear medicines used for diagnosis,

Innovation for industry



and develop solutions for industry including better clean energy devices.

PHOTOS: RICHARD TIMBURY



Morning tea at Extreme Science Experience 2013.

Extreme Science hits the high spots again

By Rod Dunstan, STELR Education Officer

This year's Extreme Science Experience (ESE) – at the enormous Melbourne Convention and Exhibition Centre, the day after the Clunies Ross Awards – was, as usual, a great success.

The ATSE Clunies Ross Award winners, honoured the previous evening, attended and were involved in all parts of the day, which was launched by the Victorian Minister for Education, the Right Honourable Martin Dixon,

who encouraged students to pursue the opportunities that a career in science and/or engineering could offer them.

ABC personality Bernie Hobbs, who did a splendid job as MC of keeping the event on schedule, introduced the 'Speed-Meet a Scientist' session, where 30 scientists and engineers joined the 174 students and their teachers in round-table discussions about science, career paths and doing something that makes a difference. The scientists rotated to a new table every 10 minutes, allowing

them to interact with five groups each.

Feedback again indicated this was a very popular part of the day with the students.

Next was a question-and-answer session where all awardees fielded questions from students.

A new addition to the ESE program for 2013 was the inclusion of two workshops for attending teachers. These workshops were

► More on page 24



(From left) Awardees Steve Jones, Tony Radford, Jim Rothel and Paul Wood join Victorian Minister for Education Martin Dixon in watching Eloise Steyn and Campbell Evans from Box Hill Senior Secondary College in the TB workshop.



Awardees Steve Frisken (left) and Simon Poole with the flaming rubens tube wave modulator.



Teachers get some professional development from Earth Ed staff member Matt Taylor (right).

PHOTOS: RICHARD TIMBURY

Paul Wood are the Victorian scientists who developed the now universally accepted test for identifying tuberculosis. Of course, their workshop was called 'TB or not TB – that is the question'. Students went through the process, very closely mimicking the real one, of testing samples from six 'patients' and determining if they had latent TB.

Teacher feedback on the day was overwhelmingly positive, with strong praise for the event from their students as well. As always, the day's success hinged on the crucial role our student volunteers from Young Scientists of Australia, Monash University, RMIT University and the University of Melbourne.

The Awardees also thoroughly enjoyed the day. As Paul Wood summed it up: "It was a great day and fun working with the students."

◀ From page 23

provided by staff of Quantum Victoria (a Victorian Government–La Trobe University partnership) and EarthEd earth science centre, and were instigated by the Department of Education and Early Childhood Development, the event's major sponsor, and overseen by their own staff.

Then it was time for the workshops. Facilitators Peter Pentland, Sally Parker and myself (Rod Dunstan) had worked with the awardees over the preceding months to produce hands-on workshops based around the area of each awardee's research.

Awardee Ian Croser's workshop, 'A Blip on the Radar', included students experimenting with microwave detectors kindly supplied by Melbourne Company, IEC. The workshop also challenged the students to make a 'stealth bomber' that could avoid radar detection.

Simon Poole and Steve Frisken put on a

smorgasbord of activities in their workshop, entitled 'Seeing the Light Fantastic'. They were ably assisted by Owen Brasier and Bjorn Stumberg, among others. Students climbed through laser mazes, talked to each other using laser phones and honed their karaoke skills on the gas-powered rubens tube wave modulator. It had to be seen to be believed – being heard notwithstanding.

Awardees Jim Rothel, Steve Jones, Tony Radford and



Awardee Ian Croser watches as a student fashions his version of a 'stealth bomber', designed to avoid radar detection.

Australasian industry researchers help found new world body

Australia and New Zealand's leading industrial researchers are among founding members of a new international body that aims to boost technological innovation world-wide.

The Australasian Industrial Research Group (AIRG), the peak body representing innovation and technological development in Australian and New Zealand business, was one of six international organisations that joined together in Washington last week to form the World Federation of Industrial Research Associations (W-FIRA).

The first organisation of its type, W-FIRA's mission is to increase and develop cooperation on a global scale to further the leadership of technological innovation throughout the world.

W-FIRA founding members include AIRG and research bodies from Brazil, Europe, Japan, Korea and the US.

Leaders from industrial research associations met in Washington in May to sign the W-FIRA Articles of Establishment.

AIRG President Ms Leonie Walsh FTSE, Director, Productive Management Solutions Pty Ltd, signed the articles, saying: "It was apparent from our first gathering in Washington that each of the member countries shares common goals and challenges around advancing technological innovation through key areas such as maximising impact from research outcomes, improving collaboration across public and privately funded research and

developing next-generation technological innovation skill sets."

The Australasian Industrial Research Group (AIRG) is a not-for-profit organisation established in 1964, and is a peak body representing innovation and technological development in Australian and New Zealand business, with the aim of enhancing the effectiveness of industrial research, as well as to stimulate and develop an understanding of research as a force in economic, industrial and social activities. AIRG is made up of companies and organisations with engagement in science-based innovation and R&D, as well as representatives from public research agencies, universities and service groups.

Steel's green future rests on waste

Steel makers have a largely untapped opportunity to make a meaningful contribution to solving the world's growing waste problem while cutting their own production costs, Australian innovator Professor Veena Sahajwalla FTSE has told a global iron and steel industry meeting in the US.

Delivering the Howe Memorial Lecture – the global iron and steel industry's most prestigious invited address – in Pittsburgh, Professor Sahajwalla released research demonstrating that many problematic waste materials can be cleanly and safely absorbed into steel making.

Working with Arrium Ltd (formerly OneSteel), Professor Sahajwalla's earlier research into high temperature reactions in electric arc furnace steel-making led to the invention and commercialisation of a steel-making process utilising waste, she said.

OneSteel's plants in Sydney and Melbourne had transformed 1.6 million waste tyres into new steel to date, after testing proved that coke mixed with polymers such as rubber sourced from waste tyres performed better than metallurgical coke alone in electric arc furnaces. The process not only reduced the cost of raw materials but enhanced furnace efficiency, cutting power usage.

In addition to waste tyres – a significant environmental threat worldwide – steel makers can potentially absorb a wide range of other wastes, including large-scale agricultural residue and various plastics, according to new UNSW research she described in the Howe Memorial Lecture.

"That opportunity lies in the high temperatures of steel making furnaces. I am not suggesting we burn waste for energy. What I am proposing is that we leverage high temperatures to literally re-form waste materials into resources," Professor Sahajwalla says.

"In doing so, steel makers can play a leading role in globally significant, large-scale recycling, without making fundamental changes to the way we manufacture steel – by re-purposing major waste streams as raw materials, simultaneously reducing production costs and enhancing the sector's environmental credentials."

She said the impetus for steel makers to innovate had never been greater due to the rising costs of raw materials, global pressures for competitive pricing and environmental considerations. Meanwhile, waste stockpile were accumulating at an accelerating rate.

"These are clearly incompatible trends which, if we persist with business as usual, will only increase tensions for the industry – making a clear case for change."

In a speech delivered at UNSW for an Australia/China climate change forum recently, Professor Sahajwalla said she found waste "very attractive".

"Whether it's used tyres, plastics, food or agricultural residue – or even what's left after your old car has been stripped of its useful parts and scrap metal – I'm always looking for 'the beauty within'," she said.

"By thinking outside the square, and carefully recalibrating some important industrial processes, we can convert waste back into raw materials for production.

"In steelmaking we have already shown that by adding an optimised blend of granulated waste tyres and plastics to electric arc furnaces we can efficiently 'react' the waste at high temperatures during steel production. A bonus is that the waste blend improves furnace efficiency so also reduces electricity usage.

"Our research is revealing that many other waste materials, from palm shells to Bakelite, can be transformed efficiently and cleanly at high



Veena Sahajwalla at work.

temperatures. In fact, in our recent experiment mixes of coke and various wastes performed better than coke alone."

She suggested the addition of a fourth 'R' – 're-form' – to the mantra of 'reduce, reuse, recycle'.

"To achieve this, we need to start looking at our rubbish for its 'beauty within' – what useful elements might be recovered and re-formed into raw materials for production if we could create opportunities for waste to be integrated into key industrial processes?

"Our research shows that the carbon and silica in automotive waste, along with some metal also left over after stripping, can, for example, be successfully re-formed to create metal alloys.

"Instead of being constantly derided as part of the environmental problem, industry could lead a revolution in recycling," she said.

"And, by sourcing a proportion of raw materials from waste, both the cost of industrial production and the impact of that production on the environment can be reduced, which is an unequivocal 'win, win'."

Professor Sahajwalla, director of the University of NSW's Centre for Sustainable Materials Research and Technology, was the 2012 Winner of The Australian/Shell Innovation Awards.

NEW ANTARCTIC BASE IN HOBART

The Australian Antarctic Division has a new state-of-the-art cargo and quarantine hub on Hobart's waterfront that aims to banish bugs, rats and other 'alien' hitch-hikers from boarding ships travelling south.

The \$2.5 million facility has vermin traps, impenetrable walls and automatic shutter doors to reduce the risk of introduced species reaching the fragile Antarctic and sub-Antarctic environments. The cargo and quarantine centre also has a cold and cool store, fumigation area, briefing rooms and warehousing space.

"This new facility will improve the efficiency of our screening, processing and management of all cargo and equipment to help prevent the introduction of non-native animals or plant species," said Dr Tony Fleming, the Director of the Division.

The Antarctic Division will begin operating from the new facility in time for the first voyage of the season in September.

Science and Mathematics Specialist Centres.

Why not treat your school's enthusiasm and passion for science and mathematics by visiting our Science and Mathematics Specialist Centres?

At each of the Specialist Centres, you can experience and engage with new and emerging science and technologies.

At the Science and Mathematics Specialist Centres you can:

- solve criminal cases and investigate medical breakthroughs
- discover complex interactions and diversity of life in ecosystems
- walk on the surface of Mars and command Mission Control
- marvel at the dynamism of Earth and explore energy sources
- unlock the wonders of the human body and sport science
- explore the interface between virtual and real worlds through game-based learning.



www.earthed.vic.edu.au/



www.gtac.edu.au/



www.ecolinc.vic.edu.au/



www.vssec.vic.edu.au/



www.quantumvictoria.vic.edu.au/



www.biolab.vic.edu.au/



PHOTO: CHRIS DICKINSON

Investigator, under construction, will house the new radar.

New weather radar takes to the oceans

Some of the big questions about weather, climate and the atmospheric conditions in remote areas of the world's oceans will now be able to be answered following the purchase of a dual-polarisation weather research radar to sit atop Australia's new research vessel *Investigator*.

The dual-polarisation weather radar is part of a new generation of weather technology that is being compared to the difference between black-and-white and colour television technology. The greater detail provided by the state-of-the-art device will allow meteorologists to gather more information about the atmosphere than ever before, including clearly seeing the difference between rain and snow.

The Executive Director for the Future Research Vessel Project, Toni Moate, said the two-tonne weather research radar will be installed on the highest point of *Investigator* and will be able to collect cloud and weather data anytime, anywhere in the world's oceans.

"Data will be gathered from clouds towering 20 kilometres over the tropical ocean to cold ice storms in the Antarctic, in a 150-kilometre radius from the ship, and will have a broad range of research applications," Ms Moate said.

Investigator is a 93.9-metre, purpose-built research vessel under construction and due for delivery in late 2013 as the flagship of Australia's Marine National Facility. It will be owned and operated by CSIRO, which runs Australia's Marine National Facility, and will replace the 66-metre research vessel *Southern Surveyor*.

Australia's scientific community has been advising on the fit out and design of *Investigator* since the inception of the project, providing

recommendations on specialist equipment, like the weather radar, via a Technical Advisory Group.

"With *Investigator* we will be able to source weather data from places we have previously not been able to access, such as the deep Southern, Indian and Pacific oceans," said Dr Peter May from the Bureau of Meteorology and the Centre for Australian Weather and Climate Research, a member of the Technical Advisory Group.

"This advanced radar will tell us not only how much it is raining but also the size of the drops, what mixtures of water and ice are present in the clouds, and what types of ice crystals are present.

"It will be a keystone for the study of cloud formations and contribute to improvements in numerical weather forecasting and climate prediction models over the vast areas of ocean surrounding Australia," Dr May said.

CHINA PILOTS CARBON TRADING SCHEMES

China has plans to reduce emissions by 40 to 45 per cent by 2020, including the world's largest national carbon trading scheme.

Speaking at the Australia-China Climate Change Forum in Sydney, China's most senior official with responsibility for climate change, Vice-Chairman Xie Zhenhua, challenged the "misunderstanding" that China – the world's biggest polluter and second largest economy – was failing to act on emissions.

He detailed plans for seven pilot carbon-trading schemes to be operating in urban and provincial areas before the end of this year, the decommissioning of scores of "dirty", outdated industrial plants and coal-fired power stations and significant investments in non-fossil-fuel energy sources, including nuclear, wind and solar power.

Vice-Chairman Xie held bi-lateral talks at the University of NSW with his Australian counterpart, the Minister for Climate Change, Industry and Innovation, Greg Combet, before telling the conference that China had much to learn from Australia's experience in implementing a carbon-trading scheme.

Earlier, a senior official from China's Department of Climate Change, Dr Jiang Zhaoli, told the conference China would face a "horrific" future with unimaginable consequences for its people and its natural environment if it did not act decisively now to curb pollution.

UNSW's Centre for Energy and Environmental Markets will work with Chinese researchers in several of the seven regions identified for pilot carbon-trading markets, including Beijing and Shanghai, to study the design, implementation and operation of the pilot schemes plus other key issues for successful emissions reductions.



Minister Combet and Vice Chairman Xie at UNSW.

High-performing wireless gets go-ahead

CSIRO and EM Solutions will develop one of the world's highest-performing radio systems, with the highest data rates and lowest costs per bit per kilometre. The new five Gbit/s millimetre-wave radio system will deliver data rates up to five times higher than microwave systems commercially available today, and will complement optical fibre in providing data backhaul from enterprises and cellular sites around the world.

Dr Ian Oppermann, Director of CSIRO's Digital Productivity and Services Flagship, said CSIRO's partnership with EM Solutions was an exciting opportunity to work with a leading-edge microwave transmission equipment manufacturer and harness CSIRO innovations to deliver high-performance, cost-effective broadband services that would help boost global productivity.

After a world-wide search, an international telecommunications service provider has chosen EM Solutions to develop a prototype product based on CSIRO's and EM Solutions' technology. The new product's combination of a high data rate, long transmission distance, and record low cost per bit will be especially valuable in Australia.

Dr Rowan Gilmore FTSE, CEO of EM Solutions, says the new product would address a real challenge for telecommunications service providers: rapidly providing gigabit-per-second data links when laying optical fibre is cost-prohibitive or simply not feasible because of distance or terrain.

"One example of where this wireless technology could be used in Australia is at new mining sites in remote areas, where there is need to rapidly and cost-effectively deploy a high-data-rate communications link to the nearest fibre point-of-presence," Dr Gilmore said. "CSIRO is the world leader in high-data-rate, high-performance microwave and mm-wave transmission technology, and we are excited to be working together with them to bring this product to market for our customers."

Commercial availability of the new product is expected in 2014.

EM Solutions is recognised by customers around the world for manufacturing technologically superior microwave modules and systems that deliver next-generation satellite and broadband communications. It offers differentiated microwave products that embed its unique IP and are available on demand. Since 1998, the company has produced integrated RF modules and systems used in radios, radar and remote sensing applications for defence and commercial customers around the world.



Rowan Gilmore

As part of its Ngara wireless program, CSIRO has developed two multi-gigabit point-to-point backhaul systems for the telecommunications industry – a cost-effective, digitally aggregated, multi-band, high-throughput microwave system and a high-performance mm-wave system. The aim of the Ngara wireless program is to make broadband services affordable and widely available.

Dr Gilmore joined EM Solutions as a Director in 2007 and became Managing Director and CEO in October 2011. His previous experience includes Vice President, Engineering, at Compact Software, where he introduced the world's first harmonic balance nonlinear circuit simulator, and as Vice President, Network Services Europe, for SITA-Equant, the global airline IT company, now part of France Telecom's Orange network. Most recently he was CEO of the Australian Institute for Commercialisation, where he helped numerous start-up companies and worked to accelerate technology transfer between research institutions

and industry. He is an adjunct professor of both business and electrical engineering at the University of Queensland.

Dr John Ness, EM Solutions' Chief Technology Officer, helped found EM Solutions in 1998 and was awarded the prestigious ATSE Clunies Ross Award in 2010 for excellence in innovation.



Researchers say we can expect more heatwaves.

Australia's summer heatwaves are lasting longer and have been increasing in number over the past 60 years, a University of NSW study shows. During those six decades, days 12°C to 14°C above average have been appearing more frequently throughout the year, according to a detailed new study of heatwaves by Dr Sarah Perkins from the UNSW Climate Change Research Centre and the Centre of Excellence for Climate System Science.

"Heatwaves have been increasing worldwide but the trend is even more marked across large parts of Australia, which as a continent has warmed faster than the global average," Dr Perkins says.

"Not only are we seeing more heatwaves in Australia but trends are suggesting that the hottest temperatures recorded during heatwave events are rising faster than the overall average temperatures for these events."

To achieve their results the researchers used a new classification method they developed for a recent global heatwave study. The method defines heatwaves as periods of three days or more where the temperatures fall into the top 10 per cent of the hottest temperatures ever recorded for specific times of year. By taking this approach, the researchers were also able to look beyond the summer months and detect periods of unusually warm weather throughout the year, which they have analysed at the global scale.

"Interestingly, the anomalous warming events during the cooler months revealed through our research were increasing faster than summer heatwave events," Dr Perkins says. "This could have important impacts on agriculture, particularly for the production of winter crops."

The Bureau of Meteorology has confirmed that the latest summer was Australia's hottest on record. The average temperature across the country was 28.6°C, 1.1°C above normal, and exceeding the previous record set in the summer of 1997-98 by more than 0.1°C. A new daytime maximum temperature record was also set at 35.7°C, or 1.4°C above normal, and 0.2°C above the 1982-83 record.

The most extreme heat occurred in the first three weeks of January during an exceptionally widespread and prolonged heatwave. The highest temperature recorded during the heatwave was 49.6°C at Moomba, SA.

Of the 112 locations used in long-term climate monitoring, 14 had their hottest day on record during the summer of 2012-13 – the largest number in any single summer. Record temperatures were also set in two capital cities: 45.8°C in Sydney and 41.8°C in Hobart. A new record was also set for the number of consecutive days the average maximum daily temperature for Australia exceeded 39°C – seven days between 2 and 8 January 2013, almost doubling the previous record of four consecutive days in 1973.

Despite heavy rainfall on the east coast, compounded as ex-tropical cyclone Oswald cut a steady path down the east coast, for most of Australia it was a dry summer. Nationally, summer rainfall was at its lowest since 2004-05. Victoria had its driest summer since 1984-85 and SA since 1985-86.

System sends data for a song

A new communications system being trialled at the University of South Australia (UniSA) could radically lower the cost of using satellites to send and receive sensor information collected in Australia's vast unpopulated areas.

The innovative signal processing system also enables a satellite to 'hear' thousands of different signals at once with no loss of quality.

"Imagine if you were in a room with 10,000 people, and they were all trying to talk to you at once," says Professor Alex Grant, Director of UniSA's Institute for Telecommunications Research (ITR), who led the project.

"This new technology makes it possible for you to hear and understand everyone, all at the same time."

Professor Grant says the innovative system, called the Global Sensor Network, would make it easier and cheaper to investigate what is going on in Australia's remote regions, as well as remote regions globally.

The network would provide a low cost, two-way satellite messaging system for many applications, such as environmental monitoring, livestock tracking, animal and fish migration research, remote control of mining and drilling sites, national security and defence, and vessel tracking.

The network would consist of: an array of low earth orbit satellites, on board each of which was a receiver to record and process sensor data; multiple terminals on land and in the sea containing GPS receivers and sensors; and a ground-based data hub.

Each ground terminal would transmit packets of information, such as location and temperature, to a satellite. This data would be decoded and sent to a collecting hub, where it would be processed into useable information.

COLLABORATION WILL PLAN OUR ELECTRICITY GRID

CSIRO has announced a \$13 million research collaboration between CSIRO and four leading Australian universities – the University of Sydney, University of Newcastle, University of Queensland and University of New South Wales – to develop the nation's capacity to plan and design the most efficient, low-emission electricity grid for Australia.

Launching the Future Grid Cluster, Dr Tom Hatton, CSIRO Energy Group Executive, said the electricity sector was undergoing a huge transformation, a change not seen since the Industrial Revolution.

"We are facing unprecedented change in the electricity system over the next 20 to 30 years. We're talking about change to a system that has seen stability for decades and has used technologies and energy sources that are predictable and controllable. Moving away from that is going to require a great deal of effort and capacity building," Dr Hatton said.

"The Future Grid Cluster brings together Australia's best research capabilities and provides a framework the electricity sector needs to make \$240 billion worth of decisions in the next two decades."

The project is supported by \$10 million worth of in-kind contribution from university partners and a \$3.2 million grant from the CSIRO Flagship Collaboration Fund – established to enable the skills of the wider Australian and global research community to be applied to the major national challenges targeted by CSIRO's Flagship research program.

The research cluster will draw together engineering, economic and policy aspects of grid development and optimisation with four major areas to be covered in the research:

- improved understanding of impacts of different loads, generation sources and energy storage on system security, led by the University of Sydney;
- planning and co-optimisation of electricity and gas networks, led by the University of Newcastle;
- economics of alternative network development paths and estimates of total cost and price impacts, led by UQ; and
- policy measures and regulatory changes to facilitate a smooth transition to a de-carbonised future grid, led by UNSW.

SILICON UPGRADE POINTS TO CHEAPER SOLAR

Solar engineers from the University of NSW have developed an innovative method to dramatically improve the quality of low-grade silicon, promising to significantly improve the electrical efficiency and reduce the cost of solar panels.

The UNSW team has discovered a mechanism to control hydrogen atoms so they can better correct deficiencies in silicon – by far the most expensive component used in the making of solar cells.

"This process will allow lower-quality silicon to outperform solar cells made from better-quality materials," says Scientia Professor Stuart Wenham FTSE from the School of Photovoltaics and Renewable Energy Engineering.

Standard commercial silicon cells currently have a maximum efficiency of around 19 per cent. The new technique, patented by UNSW researchers earlier this year, is expected to produce efficiencies between 21 and 23 per cent, Professor Wenham says.

"By using lower-quality silicon to achieve higher efficiencies, we can enable significant cost reductions," he says.

The solar industry has long been focused on bringing down the cost of silicon. However, cheaper silicon also means lower-quality silicon, with more defects and contaminants that reduce efficiency. It has been known for several decades that hydrogen atoms can be introduced into the atomic structure of silicon to help correct these defects but, until now, researchers have had limited success in controlling the hydrogen to maximise its benefits or even understanding why this happens.

"Our research team at UNSW has worked out how to control the charge state of hydrogen atoms in silicon – something that other people haven't previously been able to do," Professor Wenham says.

Hydrogen atoms can exist in three 'charge' states – positive, neutral and negative. The charge state determines how well the hydrogen can move around the silicon and its reactivity, which is important to help correct the defects.

"We have seen a 10,000-times improvement in the mobility of the hydrogen and we can control the hydrogen so it chemically bonds to things like defects and contaminants, making these inactive."

The project, which has been supported by the Australian Renewable Energy Agency, is expected to be completed in 2016.



Stuart Wenham

More Fresh Science on show

Fresh Science is a national event that brings together scientists, the media and the public. It is supported by the Australian Government, Museum Victoria, CSL Ltd and *New Scientist* magazine. State finals in 2012 were also supported by the University of Queensland, ANSTO and the South Australian Department of Further Education, Employment, Science and Technology. *Focus* brings you a quick look at the work of some of the 2012 young scientists who were selected and supported to be ambassadors for science in Australia.

COWS MILK USED TO PROTECT AGAINST HIV

Melbourne researchers have developed cows milk that protects human cells from HIV. The milk contains antibodies that defend against the human immunodeficiency virus (HIV).

The next step will be to develop it into a cream that women can apply to protect themselves from contracting HIV from sexual partners.

The University of Melbourne's Dr Marit Kramski and colleagues found using cows to produce HIV-inhibiting antibodies was cheaper than existing methods.

They worked with Australian biotechnology company Immuron Ltd to develop the milk. The scientists vaccinated pregnant cows with an HIV protein and studied the first milk that cows produced after giving birth.

The first milk, called the colostrum, is naturally packed with antibodies to protect the newborn calf from infections. The vaccinated cows produced HIV antibodies in their milk.

"We were able to harvest antibodies specific to the HIV surface protein from the milk," Marit says. "We have tested these antibodies and found in our laboratory experiments that they bind to HIV and that this inhibits the virus from infecting and entering human cells."

Cows cannot contract HIV. But their immune systems develop antibodies against the foreign protein. The HIV-inhibiting antibodies from cows' milk will be developed into a microbicidal cream applied to the vagina before and/or after sex to protect women from contracting sexually transmitted infections. Other microbicides are being developed around the world but the antibodies in this research are easier and cheaper to produce, providing a new HIV-prevention strategy.

"We hope that our anti-HIV milk antibodies will provide a user-friendly, female-controlled, safe and effective tool for the prevention of

sexually acquired HIV infection," Marit says.

About 30 million people worldwide live with HIV and there is presently no effective human vaccine.

The research was supported by the Australian Centre for HIV and Hepatitis Virology Research and the NHMRC.

GAMING ADDICTION CAN CONTROL YOUR THOUGHTS

A psychology researcher has collected some of the first scientific evidence that video gaming can be addictive in a way similar to gambling and alcohol.



Olivia Metcalf

"People who spend an excessive amount of time playing video games are powerless to stop themselves from thinking about gaming," says Olivia Metcalf, who did the research for her PhD at ANU.

"This is a pattern typical of addiction," she says. "Many people have claimed that video games can be addictive. But this is some of the first hard evidence."

Olivia presented about 20 video gaming 'addicts' with different words and asked them to respond to the colour of the word, not the meaning. They were significantly slower to name the colour of gaming-related words

compared to words that had nothing to do with gaming. Non-addicted gamers showed no difference in response times.

"We found that the attention system of an excessive gamer gives top priority to gaming information. Even if they don't want to think about gaming, they are unable to stop themselves. This likely makes stopping or cutting back on gaming even more difficult," Olivia says.

"This phenomenon, known as attentional bias, is found across heroin, nicotine, alcohol and gambling addictions, and is thought to be a significant factor in the development of an addiction."

While most people who play video games do so without suffering negative consequences, a minority of gamers experience significant adverse changes to their diet, sleep, relationships, work and school commitments as a result of their inability to stop gaming. There has been significant debate as to whether excessive gaming can be considered an addiction.

A forthcoming edition of the standard reference book which defines mental health disorders – the *Diagnostic and Statistical Manual of Mental Disorders (DSM-V)*, published by the American Psychological Association – recommends that internet-use addictive disorder, including excessive gaming, be regarded as an area for further study.



Marit Kramski preparing human cells for testing in the lab.

PHOTO: GREGOR LITCHFUS

PHOTO: SUE JACKSON, CSIRO



(From left) Emma Woodward with authors of the Gooniyandi seasonal calendar, Mervyn Street, June Davis and Helen Malo from the Muludja community in Fitzroy Crossing, WA.

CROCODILE EGGS MEASURE RIVER HEALTH

Ngan'gi speakers know it's time to look for freshwater crocodile eggs when the red kapok trees near the Northern Territory's Daly River burst into flower. This can occur at a different time each year, but the environmental link is solid.

A Darwin-based scientist has converted this link and other intimate Aboriginal knowledge of Australia's landscape into an environmental management tool.

CSIRO's Emma Woodward worked with Aboriginal elders as part of the Tropical Rivers and Coastal Knowledge (TRaCK) research program to develop six seasonal calendars from six different language groups from the Northern Territory and Western Australia. The calendars provide early warning signs of environmental change, which will help scientists manage water use and monitor the impacts of climate change.

"Changes or disturbances to patterns of expected behaviour and connections between plants and animals are noticed and queried immediately, potentially alerting us to more serious higher-level problems," Emma says.

Each calendar depicts between four and 13 seasons in an annual cycle of climatic and ecological understanding. Focusing on river systems, they follow the activities of plants and animals which are driven by the monsoon in northern Australia.

Emma has captured indigenous ecological knowledge from the Ngan'gi, Malakmalak, Gooniyandi, Walmajarri, Wagiman and Larrakia Aboriginal language groups across WA and the NT. Schools and universities have shown interest in the calendars as an educational resource. The Larrakia calendar, from the Darwin region, for instance, is being converted into an interactive online educational version.

Emma says her work taps into a previously underutilised resource. "Aboriginal knowledge is different and adds to western science. It can make a unique and important contribution to the problems of managing the Australian environment.

"Aboriginal people have a deep understanding of the connections between everything in the environment. Their observations have revealed relationships and links between plants, animals, water and climate that we weren't aware of before.

"Aboriginal people are key water users and bring valuable

knowledge about these important resources, including detailed information about fish behaviour and habitats within the rivers.

"Indigenous ecological knowledge is being used in other countries for environmental monitoring and management but it is still very early days in Australia. The calendars are the first step in facilitating this process."

GALAXIES IN THE THICK OF IT GROW UP FAST

In a quest to learn more about our own galaxy, a Sydney astronomer has identified dozens of previously unknown galaxies in a distant cluster.

Using one of the world's largest optical telescopes, Dr Amanda Bauer – an ARC Super Science Fellow at the Australian Astronomical Observatory – and her team around the world have been studying this cluster closely. They have found that the galaxies close together in the crowded centre of the cluster mature faster than those in isolation on the cluster's outskirts.

"We are trying to find out why galaxies stop growing and mature, because this will tell us something about the ultimate fate of our own galaxy, the Milky Way," Amanda says.

A galaxy grows when it is forming new stars. Amanda is trying to find out what stops galaxies from doing this, therefore reaching maturity.

Distant galaxy clusters are relatively rare, she says. They are some of the first systems that formed after the Big Bang and represent the largest structures in the universe held together by gravity.

"We have only recently been able to study them in detail. Using a new technique on the Gemini North Observatory telescope in Hawaii we were able to look at one particular galaxy cluster, where we identified dozens of new galaxies.

"The galaxies in clusters are slowly but constantly moving and evolving. We are trying to understand the influence that a galaxy's neighbourhood has on its fate."

The centre of the cluster is crowded with galactic neighbours in a sea of hot gas. The galaxies influence each other through gravitation, and the hot gas seems to put a brake on star formation.

To understand better how these crowded environments can enhance and then end the growth cycle of galaxies, Amanda and her team are now embarking on an Australian-based project to find new galaxies of varying levels of isolation. They will combine existing data with observations from large telescopes in Hawaii and Chile, and the Hubble Space Telescope. They hope their results will help them understand how the Milky Way Galaxy developed, and how it will interact in future with its galactic neighbours.

The Milky Way exists under the influence of the nearby Andromeda galaxy and two smaller galaxies, the Magellanic Clouds. These galaxies will eventually collide and merge.

"The current prediction is that this will happen in several billion years. Our research should tell us how long the resulting galactic system will form new stars before it settles into maturity."

PHOTO: AMANDA BAUER, AAO



Amanda watching the sunset from the top of the Anglo-Australian Telescope in New South Wales.

SIX-LEGGED MINERS STRIKE GOLD

Termites and ants are stockpiling gold in their mounds, carrying it from deep underground, new CSIRO research has found.

Dr Aaron Stewart and his CSIRO colleagues have shown Australia's smallest and most numerous mining prospectors can not only show us where new gold deposits are, but also accumulate metals in their bodies.

In Australia – geologically the world's oldest continent – new mineral resources are becoming increasingly difficult to find, because they tend to be overlain by layers of sand, gravel and soils.

But insects provide valuable clues to where these resources lie.

"What is really great about ants and termites is that we can use their work instead of spending vast amounts on expensive drilling," says Aaron, a research scientist with CSIRO in Perth.

"After 150 years of exploration, the easiest deposits near the surface have been discovered. We need new ways of finding gold. Most of Australia is covered by a layer of earth that hides buried minerals. But signs of a resource are often close to the surface.

"In some places we have shown that termites and ants can bridge



PHOTO: AARON STEWART, CSIRO/FRESH SCIENCE
An ant mound near Kalgoorlie.

that gap by bringing up evidence from five metres down. Our new research shows that it is not only the really big termite mounds like the ones found in northern Australia that can be useful. Small termite and ant mounds that occur all over the country can do the job."

At thousands of dollars a hole, the traditional exploration method of drilling grids of holes is very expensive.

"Exploration companies are very keen to find ways of reducing costs," Aaron says. "By helping to narrow down the area that needs to be drilled we can reduce the cost of finding new deposits."

Several exploration companies are already working with CSIRO to develop and refine the method.

Aaron's research was published in the journal *Geochemistry: Exploration, Environment, Analysis* in November, has also appeared in *PLoS ONE* and earned him recognition as a 2012 Fresh Science winner.

SMiS backs science and maths teachers

From primary school through to senior secondary and from the inner city to remote Australia, Scientists and Mathematicians in Schools (SMiS) creates and supports unique, flexible, ongoing partnerships between volunteer teachers and scientists or mathematicians.

SMiS, a CSIRO Education program, brings real-world science and mathematics into classrooms, inspiring and motivating teachers and students in the teaching and learning of science and mathematics. It also broadens awareness of the variety of careers available while increasing scientists' and mathematicians' engagement with the wider community.

SMiS relies on the interest and involvement of individual scientists and mathematicians, who volunteer their time to establish ongoing partnerships with individual volunteer teachers.

Scientists in Schools patron, Dr Jim Peacock AC FRS FAA FTSE, initiated the program in 2007 during his time as Chief Scientist of

Australia and it has become a successful, well-established national program with more than 3200 professional partnerships between scientists, mathematicians and teachers created. Currently, more than 1175 scientists and mathematicians across Australia are involved in 1459 active partnerships.

The program's importance has been recognised both nationally and internationally. Most recently,



Felix Lipkin, CSIRO Ecosystem Sciences, partnered with Marnie Sparrow, Sandringham College, Victoria, to show students his work.

the SMiS story was presented at the 2nd International STEM (Science, Technology, Engineering and Maths) in Education Conference in Beijing and at the first International Teacher-Scientist Partnership Conference in Boston.

Scientists, mathematicians and teachers volunteer and register online to receive personalised matching with a partner. Once established, partnerships are provided ongoing support from the SMiS team.

Each partnership is unique. The program's flexibility allows partners to take into account their workloads, expertise and the teacher's and classes' needs. Partnership styles include hands-on activities, presentations, demonstrations, mentoring, emailing and video conferencing.

There are no fixed or minimum hours. Scientists visit the school once or twice a year, a couple of times a term, or once a week or month. Other partnerships utilise ICT (email and video conferencing) and have little face-to-face interaction.

Many scientists and mathematicians have support from their employers for their participation in SMiS. Some organisations use their employee involvement in SMiS in their corporate citizenship and social responsibility plans – CSIRO, Australian Antarctic Division, ANSTO, IBM, CSL Ltd and Engineers Australia (Queensland Division).

The program is funded by the Australian Government and CSIRO, and managed by CSIRO Education. As a result of a review undertaken by the Chief Scientist, Professor Ian Chubb AO, SMiS received further funding for four years in the Government's 2012 Budget.

A number of ATSE Fellows apart from Dr Peacock support the program including: Prof Graham Mitchell AO FAA FTSE and Professor Tom Spurling AM FTSE (Victoria); Dr Geoff Garrett AO FTSE (Queensland); Dr Ian Chessell FTSE and Dr Oliver Mayo FAA FTSE (South Australia); and Dr Mick Poole FTSE (Western Australia).

– Janene Brown, Senior Project Officer, SMiS, CSIRO Education

Fellows who wish to participate can call 02 6276 6397 or visit www.scientistsinschools.edu.au for more information or to find the SMiS project officer in your region.

Artist's impression of the Early Start facility.



Fellows see children's museum established at UoW

A 12-year initiative of a group of ATSE Fellows lies at the heart of an exciting 'world first' that will transform teaching, research and community engagement in the higher education sector.

Dr Jon Jutsen FTSE, Dr Doreen Clark AM FTSE, Dr John Nutt AM FTSE and Professor Rolf Prince FTSE have nurtured a Children's Discovery Museum (CDM) project since 2001. Their ambition has been to introduce to Australia a family learning facility modelled on the highly successful 'children's museum' movement prevalent across the US and elsewhere.

The CDM group, assisted by a team of expert volunteers from the business and education sector, spent several years showcasing proof-of-concept education activities in venues throughout NSW. In 2009 CDM attracted the interest and support of Mr Christopher Abbott AM, a successful entrepreneur and philanthropist. Mr Abbott established the Abbott Foundation with the express purpose of supporting ventures that provide learning opportunities for young children, which will promote their interest and capabilities for further education.

Mr Abbott introduced the CDM concept to the University of Wollongong (UoW), which recognised the significant synergies to a project it was developing. CDM project officer Adam Selinger was seconded to UoW to assist in a grant application to the Federal Government for a new teaching, research and community engagement facility called Early Start.



Doreen Clark



Jon Jutsen

The successful outcome of the \$31 million application was announced last November and building work on the three-story facility has commenced. The Abbott Foundation donated \$7 million to the Children's Discovery Centre (CDC) component of the facility, the largest philanthropic gift in the history of UoW. CDM is contributing its intellectual property developed over the past 12 years.

The CDC will occupy 2000 square metres on the ground floor of Early Start, providing an accessible venue for families with young children to engage in innovative learning-through-play experiences and educational programs.

Examples of planned CDC activities, originally conceived by the CDM team, include:

- On Air – a working media room for creating digital content where visitors can download their production onto a USB or email it;
- Build It – a simulated house construction zone where participants can work collaboratively and become bricklayers, plumbers or architects on a busy site; and
- Water Play – which involves multiple uses of water from simple tactile investigation to exploring the engineering of dams, water-based transportation and the science and practical uses of hydraulic systems.

The CDC will be the practical expression of play-based learning, informed by research, and a model for effective early years learning in family and childcare settings. The CDC will be a leading advocate for investing in the early years and will open in early 2015.

A ROBOT REVOLUTION AT THE MUSEUM

CSIRO's latest robots have been roaming the galleries of Canberra's National Museum of Australia, bringing to life a day at the museum. They're using high-speed broadband to allow remote visitors to control their own view of museum exhibits while interacting with a museum educator.

A robot accompanies an educator around the museum, applying its navigational and sensing capabilities to plan its route and avoid obstacles and pedestrians. The robots have a motorised base with wheels, a touch-screen display, and a 'head' with a 360-degree panoramic camera. They also house several on-board computers and Wi-Fi antennas.

Robots B1 and B2 use telepresence technology to roam the galleries in a trial conducted by CSIRO in the museum's 'Landmarks: People and Places Across Australia' gallery, which features Australian icons such as Phar Lap's heart and the Holden Prototype No 1, the original Holden motor car.

During the trial, the robots will be accessible by schools and libraries with a connection to the national broadband network. Remote visitors, such as a class of school students in rural and regional Australia, can interact with an educator, providing an interactive learning experience.

The technology used for this project demonstrates the potential and benefits of the digital age and how the isolation of people in remote areas or those who can't physically get to many places can be reduced.

The total cost of the trial will be \$3.5 million, jointly provided by Department of Broadband, Communications and the Digital Economy, CSIRO and the National Museum of Australia.

The National Museum of Australia robot.



"Don't drop the ball" warns NWC

A National Water Commission report on Murray–Darling Basin Plan implementation urges renewed action and cooperation so that real benefits can start to flow to the basin and its communities. The report effectively puts governments on notice by alerting them to the priority areas the NWC will examine in its first full audit report, due in 2015.

Commission Chair Karlene Maywald FTSE said the Basin Plan represented a step-change in the way we govern and manage water resources in Australia's largest and most important river system.

"It is now up to basin governments to take action to implement the plan and honour the spirit of their 2008 intergovernmental Agreement on Murray–Darling Basin Reform," she said.

"This calls for strong leadership by governments and communities, willingness to work together and sustained commitment of resources. Significant investments by the Australian and state governments have already established a substantial volume of recovered and held water that is available for environmental use.

"However, there is now an urgent need for governments and their agencies to map a clear implementation pathway showing how they will deliver on the plan's requirements. Until this is in place, Commissioners consider there is a real risk to realising the benefits of all the efforts by governments and the community, and the many billions of dollars invested to date.

"Tangible evidence of progress will be vital in building trust in the plan's ability to secure good outcomes for the basin and its communities."

Through its audit role, the Commission will provide independent oversight on the effectiveness of the implementation of the Basin Plan and associated water resource plans.

DIY WATER TREATMENT FOR TUNISIA

A low-cost wastewater treatment system built entirely with recycled materials and parts from hardware shops will help transfer Australian expertise to classrooms in Tunisia.

Engineers from the University of NSW have teamed up with a



Olfa Khelifi and Stuart Khan working on the project.

visiting research fellow from Tunisia to develop a sustainable, 'do-it-yourself' membrane bioreactor (MBR) – a system used to treat residential and industrial wastewater so the effluent can be safely discharged or reclaimed for irrigation.

"Agriculture is one of the most water-intensive sectors and has led to the over-exploitation of groundwater resources in Tunisia. Consequently, safe re-use of reclaimed water is now a necessity, not just an option," says Assistant Professor Olfa Khelifi from the University of Tunis El Manar, located in the Tunisian capital.

"In many rural areas we have small agrifood factories whose operations are very water intensive. If we could introduce a low-cost treatment technology, I think these businesses, and other industries, would be very interested in adapting these systems."

She says this would also have significant environmental benefits as it could help initiate better oversight of how wastewater is discharged.

Professor Khelifi came to UNSW for a month with the help of a \$20,000 grant from the Council for Australian–Arab Relations, an initiative run by the Department of Foreign Affairs and Trade. She has worked with environmental engineer Dr Stuart Khan, a senior lecturer in the School of Civil and Environmental Engineering, and chemical engineer Dr Pierre Le-Clech to develop the sustainable treatment system.

The UNSW researchers have considerable experience building lab-scale MBRs for research purposes, but these incorporate technical components and cost about \$20,000. This expense is a major obstacle for reproduction in Tunisia. Their simplified system, which uses recycled materials and inexpensive parts, costs only about \$2500.

Dr Khan is leading an ATSE study (funded by the Australian Water Recycling Centre of Excellence) that will produce a report on drinking water through recycling, examining the benefits and costs of supplying direct to the distribution system, which builds on work in Australia and overseas to address social, environmental and economic considerations.

NEW WAY TO PROTECT WATER

Australian scientists have devised a way to model polluted groundwater with computer simulation and so better protect the Earth's main fresh water supply.

Researchers at the National Centre for Groundwater Research and Training (NCGRT) have developed a new model to predict where – and how fast – polluted groundwater can move from a contaminated site, allowing water managers to better locate and clean up the water.

This could help defeat an emerging threat beneath all the world's big cities and stave off a looming global water crisis, says Professor Craig Simmons of NCGRT and Flinders University.

"Groundwater contamination affects 140 million people in 70 countries," Professor Simmons says. "The water is increasingly polluted by pesticides, leaks from landfills and fuel dumps, residential and factory waste and other industrial contaminants which render it unusable and undrinkable."

In the case of Australia, he adds, the main threat to our groundwater supplies is salinity, although urban supplies are often contaminated with hydrocarbons from old fuel storages.

"Groundwater makes up 98 per cent of the Earth's fresh water. It provides drinking water to more than 1.5 billion people living in cities, and low-cost water to farmers and rural areas. In some countries, up to 90 per cent of urban groundwater is polluted, so we need to tackle the issues of contamination worldwide urgently."

PHOTO: BCG



Laying the degradable polymer film with the direct seeder.

Restoring native woodland with plastic

A novel degradable plastic film was the centrepiece at the launch of a five-year extension of the Cooperative Research Centre for Polymers (CRC-P). The launch was held at a Melbourne production site of Integrated Packaging, the largest local manufacturer of plastic stretch films.

Integrated Packaging's previous research with the CRC resulted in improved technology to control the degradation of plastic films in the environment.

One application of this technology being evaluated by this company in collaboration with Greening Australia and the Birchip Cropping Group (BCG) is the mechanical application of degradable film over the seeds of native trees at the time of planting. The film provides a temporary greenhouse that allows earlier planting, assists germination, improves water use efficiency and reduces pest damage. As the trees grow the film breaks down.

Continuing trials being conducted to evaluate the potential of this technology and refine its use have shown very encouraging results. This low-cost, high-value technology has the potential to allow the re-establishment of wildlife-rich woodlands in challenging semi-arid and degraded lands.

The Head of Division for AusIndustry, Ms Chris Butler, formally launched the extension of the CRC-P, supported by funding of \$14.5 million from the CRC program. With further resources provided by its participants, CRC-P will conduct more than \$60 million of research to assist Australian manufacturing to develop products that meet emerging global needs in three areas: health therapies and delivery, water and food security, and low-cost solar energy.

More than \$9 billion worth of polymers and polymer-based products are used annually in almost all sectors of the Australian economy. The CRC-P has a strong track record of developing technologies for the plastics industry.

Dr Peter Coldrey FTSE (Chair) and Dr Ian Dagley FTSE (CEO) of CRC-P hosted the launch of the five-year extension of the CRC. Dr Coldrey is former ATSE SA Division secretary. Mr John Grace FTSE, a Director of the CRC, attended, along with a number of Fellows from industry and CRCs.

CRC-P includes five companies (Virbac Australia, BASF, BlueScope Steel, Mesoblast and Integrated Packaging), 11 universities, CSIRO and ANSTO among its 23 participants.

\$200 MILLION FOR START-UP FUNDING

The Australian Government has pledged \$100 million in funding, through the Innovation Investment Fund (IIF), which will be invested into early stage, high-growth Australian companies.

The Minister for Climate Change, Industry and Innovation, Greg Combet, said \$100 million of Government funding would be matched dollar for dollar by private sector investors in Carnegie Venture Capital Pty Ltd (\$40 million), and GBS Venture Partners Pty Ltd and Innovation Capital Associates Pty Ltd (\$30 million each).

The IIF, a key Government vehicle for providing small and medium-sized enterprises with access to venture capital that commenced in 1998, has over three rounds established 16 funds and co-invested in new companies including Seek, Bionomics, Pharmaxis and Benthic Geotech.

"Venture capital helps turn ideas into successful businesses and new jobs," Mr Combet said. "It is a vital part of our innovation system, which is why the Government, as part of its Plan for Australian Jobs, has announced a new \$350 million round of the IIF Program.

"Successful start-ups are essential to creating new products, jobs and economic growth. The IIF will continue to co-invest government capital with private investor capital into early stage Australian technology-based companies."

BIODIVERSITY RESEARCH CENTRE IN CANBERRA

The Centre for Biodiversity Analysis, recently launched in Canberra, is a joint initiative established in partnership with CSIRO and the Australian National University (ANU) that aims to help Australia harness cutting-edge advances in biological sciences to inform better environmental management decision.

"The Centre is drawing on CSIRO and ANU's world-class expertise, and harnessing new and emerging technologies in biodiversity science to improve our knowledge of Australia's biodiversity and enable governments and conservation NGOs to translate policy into meaningful actions," said Professor Craig Moritz, Director of the Centre.

"It's estimated that Australia is home to over half a million unique living species, many of which are found nowhere else on Earth, but of these only about one-third are known to science.

"Improved knowledge of Australia's biodiversity – how many species, where they are, and how they evolve across environments and through time – will be especially important to ensure sustainable development and production, to maximise ecosystem benefits, and to protect our unique diversity in the face of rapid environmental change," he said.

Research by the Centre for Biodiversity Analysis will help to inform the sustainable management of Australia's unique ecosystems, such as the Great Barrier Reef.

PHOTO: MARIE DAVIES



73 years of sugar innovation hailed

Two Queensland University of Technology researchers, with a combined 73 years of sugar involvement, have received industry accolades for



Ross Broadfoot



Neil McKenzie

their commitment to innovating Australia's sugar industry at the annual Sugar Research and Development Corporation's (SRDC) Innovation Awards.

Professor Ross Broadfoot won the Industry Service Award for his 42 years of research into better ways of producing sugar crystals from cane juice. Since 1971 the sugar research veteran has helped every sugar mill in NSW and Queensland build more efficient factory processes and overcome technical difficulties.

Early in his career, Professor Broadfoot developed the continuous crystallisation vessel, which improved the final stage of the process of turning cane juice into sugar crystals. This innovation has been adopted broadly by mills across Australia and overseas.

Neil McKenzie received the SRDC Research Technician Award for

his 31 years supporting the industry. He oversees the manufacture, development and servicing of instruments designed specifically for the industry and has worked in more than 10 SDRC-funded projects.

FOOD INDUSTRY RESEARCH BOOST

The University of NSW will establish a research and training centre aimed at bolstering the Australian food industry after receiving more than \$2 million in funding from the Australian Research Council (ARC).

The ARC Training Centre for Advanced Technologies in Food Manufacture will investigate innovative ways to improve the quality, safety and nutrition of Australian food products, while training the next generation of food scientists and engineers.

The centre, which will be operated by the Food Science and Technology group in the UNSW School of Chemical Engineering, will receive an additional \$360,000 from six Australian and international industry partners.

"The aim is to develop healthier and safer foods in a more innovative and sustainable way by enhancing the interaction between food scientists, technologists and engineers," said Centre Director Jayashree Arcot, an Associate Professor in nutrition at UNSW.

"Many of Australia's major food companies are multinationals, so their research and development budgets are spent overseas," she said. "The objective of the centre is to develop better links with industry and to establish a platform for technology transfer."

Some of the key proposed projects include:

- investigating new processing technologies, and modifying existing ones, to improve the quality, taste, nutritional value and safety of food products;
- recovering starch and proteins from wastewater using membrane

technology and combining this 'waste' with polymers to develop new packaging products that can add value and reduce environmental waste; and

- using nanotechnology to develop biosensors and improve diagnostic capabilities for microorganisms, food allergens and chemical contaminants, thus enhancing food safety.

Partner organisations include the University of Newcastle, the University of Western Sydney, CSIRO and the NSW Department of Primary Industries.

\$4 MILLION FOR TWO TELEHEALTH TRIALS

CSIRO has been awarded more than \$4 million research funding by the Federal Government to trial two new telehealth technologies under the NBN-Enabled Telehealth Pilots Program.

The trials, Home Monitoring of Chronic Diseases for Aged Care and NBN-Enabled Indigenous Tele-Eye Care, will run for 12 months, involving more than 1300 patients in rural health clinics, hospitals, local healthcare districts, nursing homes and patients in their own homes across Australia.

Dr Sarah Dods, leader of health services for CSIRO's Digital Productivity and Services Flagship, says we need to think differently about how we deliver health services due to the pressure of rising costs, our ageing population and an increase in chronic disease.

"We are currently spending 20 cents in every tax dollar on health and that is forecast to increase to 40 cents in every dollar by 2043. At that point, health is predicted to consume our entire state government budgets if we don't change the way that we do things," Dr Dods says.

New ways of delivering health services are being made possible by the arrival of fast broadband infrastructure across Australia, especially in remote communities. This technology is reducing the need for travel, providing timely access to services and specialists, improving the ability to identify developing conditions and providing new ways to educate, train and support remote healthcare workers.

"They can also reduce the burden on our health system by helping hospital 'frequent flyers' – such as chronic disease sufferers and the elderly who accounted for more than 70 per cent of Australia's \$103.6 billion health expenditure during 2007-08 – manage their conditions from home," Dr Dods says.

IMAGE: TELEMEDCARE

CSIRO and six private and public health service delivery organisations are conducting Australia's first large-scale randomised control trial of telehealth services.



'Printed' human organs "just over a decade away"

University of Wollongong (UoW) scientists are at the forefront of a medical revolution using 3D 'printing' to reproduce human body parts.

Researchers from UoW's ARC Centre of Excellence for Electromaterials Sciences (ACES) and St Vincent's Hospital (SVH), Melbourne, have announced that they are just three years away from printing custom-made body parts, including muscle and nerve cells and cartilage. In just over a decade they believe will be possible to print human organs.

"It is already possible to print 3D biocompatible plastics and metals to manufacture patient-specific implants," ACES Director Professor Gordon Wallace FTSE says.

"Within a few years, we believe it will be possible to manufacture living tissues like skin, cartilage, arteries and heart valves using cells and biomaterials. Using a patient's own cells to create this tissue avoids issues of immune rejection. By 2025, it is feasible that we will be able to fabricate complete functional organs, tailored for an individual patient."

Professor Wallace and his team have been meeting with clinicians, medical device manufacturers and policy makers to discuss the future of fabricated medical implants.

Professor Wallace says 3D printing, or additive fabrication, uses machines to build 3D objects, layer by layer from digital data.

"While 3D printing is already being used in some medical applications, by bringing together the materials and scientists at ACES and the clinicians and researchers at SVH we have been able to accelerate our progress so that we are now on the verge of a new wave of technology leveraging 3D printing/additive fabrication techniques to deliver solutions to a number of medical challenges. These include bionic devices, and the regeneration of nerve, muscle and bone, as well as epilepsy detection and control."

Professor Wallace says the research will receive a huge boost with the June launch of an additive

biofabrication unit at SVH in Melbourne, expanding the program from its base at UoW's Intelligent Polymer Research Institute (IPRI), the lead node of ACES. The St Vincent's facility will be the first of its kind in Australia to be located in a hospital.

"This is an exciting development involving the establishment of a customised facility at St Vincent's, Melbourne. It would put our scientists and engineers in direct contact with clinicians on a daily basis and should fast-track the realisation of practical medical devices and the reproduction of organs."

'POCKET DOCTOR' HELPS DETECT SKIN CANCERS

A clever optical device that turns the ordinary iPhone into a personal skin scanner is being trialled in Queensland.

The new technology, called the HandyScope, allows individuals to scan their own skin, take photos of suspect spots, record them in an app, and then send the data on to health professionals.

It is being trialled by Queensland University of Technology (QUT)

senior research fellow Dr Monika Janda and her team from the School of Public Health, in collaboration with Professor David Whiteman from the Queensland Institute of Medical Research (QIMR) and Professor Peter Soyer from the Dermatology Research Centre, at the University of Queensland (UQ).

"Our group is the first to try out the HandyScope with consumers," Dr Janda says. "It is capable of doing really cool things. It automatically gets people to hold the iPhone at the right distance to take a clear photo, it has polarised light that goes deeper into the skin to show lesions more clearly and it has a 20-fold magnification capacity."

"Then it has an app attached to it that allows people to mark on a virtual body where the lesion is and they can send it straight to a health professional for quick feedback."

She said if the trial showed the HandyScope was useful and usable by consumers, it would revolutionise health care. Doctors could advise patients to use the device at home to keep an eye on suspect skin spots. This would enhance early detection and ultimately improve cancer treatment outcomes. Recovering skin cancer sufferers who visited a specialist every few weeks could use this technology to extend face-to-face examination intervals, which would be useful for people living in rural or remote areas.

In another Queensland initiative, a University of Southern Queensland (USQ) PhD student is researching the ability of smartphones to detect ultraviolet-A radiation, thought to be a major contributor to skin cancer, amongst other conditions.

"One of the main motivations (for the research) is that smartphones are very widespread and this everyday technology has a great array of sensors that could be used by just about anyone," says Damien Igoe, a physics, science and maths teacher who majored in physics (atmospheric science) at USQ. "This includes using the camera's image sensor with the appropriate filters to detect UV radiation."

"The ability of smartphones to detect UVA could, by increasing public awareness, potentially reduce the risk of skin cancer, which is very common in Australia."

Mr Igoe says a CMOS-based (consumer complementary metal-oxide semiconductor) smartphone image sensor possesses inherent sensitivity to UVA radiation and his research so far has supported the idea that smartphones can be used for scientific monitoring of UVA.

Damien Igoe has worked out how to measure UVA with the smartphone.



PHOTO: NASA/BILL INGALLS



The United Launch Alliance Atlas V rocket with the Landsat Data Continuity Mission spacecraft onboard pre-launch last February at Vandenberg Air Force Base, California: part of the 40-year data record of monitoring the Earth's landscapes from space.

Government launches space policy

The Australian Government has launched its first space policy – Australia's Satellite Utilisation Policy – saying it provides certainty and strategic direction for Australian users of satellite technology.

Launching the policy, the Minister Assisting for Industry and Innovation, Senator Kate Lundy, said on-going, cost-effective access to satellite capabilities was essential to Australia's future.

"Australians, whether they know it or not, rely on satellites every day," Senator Lundy said. "Whether it's for navigation, getting accurate weather forecasts, or communication in remote areas, Australians have a growing appetite for satellite services."

"This space policy will ensure that Australians can continue to access the satellite capacity we need through partnerships with other countries and commercial suppliers."

Senator Lundy said a good space policy would also pay economic dividends for Australia. Satellite imagery alone was estimated in a 2010 report to contribute about \$3.3 billion each year to GDP. Positioning technologies, such as GPS, were estimated in 2008 to have added \$1 billion per year to GDP, and this was forecast to grow to between \$6 and \$12 billion by 2030.

Senator Lundy announced that from 1 July 2013, a new Space Coordination Office in the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education would be responsible for coordinating Australia's domestic civilian space activities and showcasing that excellence.

Key aspects of Australia's Satellite Utilisation Policy include:

- giving priority to Earth observations from space; satellite communications; and position, navigation and timing;
- contributing to international 'rules of the road' for space through Australian space situational awareness infrastructure and diplomatic efforts;
- building and retaining high-quality Australian space expertise; and

- developing a plan to meet projected growth in Australia's satellite information needs by modernising and consolidating Australia's ground infrastructure.

ATSE has made strong contributions in this area, combining with the Academy of Science on a report in 2009, *An Australian Strategic Plan for Earth Observations from Space*, prepared by a working group of Academy Fellows and space science and Earth observation experts, and chaired by ATSE's former President, Professor John Zillman AO FAA FTSE.

The working group included Dr John Church FAA FTSE and Professor Michael Manton FTSE and was advised by a steering committee that included Professor John Richards AM FTSE, Dr Neville Smith FTSE and Dr Neil Williams PSM FTSE.

The report identified Australia's current activities, needs, capabilities and future opportunities in Earth observations from space (EOS), set out an overall strategy for the future and provided nine specific recommendations.

It noted that the satellite-provider nations had many new missions planned for the next 10 to 15 years, providing powerful new EOS capabilities for addressing Australia's needs.

"We have, however, become fully dependent on foreign-owned satellites and we can no longer significantly influence their capabilities in support of our unique requirements. Time is running out for our historical free-rider status on the international EOS system," the report noted.

Professor Andrew Dempster, Director of the Australian Centre for Space Engineering Research at the University of NSW, wants Australia to develop its own Earth-observation satellites.

"In this connected world, space-based technology is essential to daily activities such as ATM and credit card transactions, GPS navigation and satellite TV. Globally, the space industry generates revenues of around US\$250 billion per year. And in this environment Australia has a special place: we do not own or operate any satellites of our own. Instead Australia relies on other countries to give us free access to data from their satellites."

"We are 'freeloaders' depending on the 'kindness of strangers'," Professor Dempster says. "But this generosity can't last."

UNSW SPACE SYSTEMS ENGINEERING MASTERS

The University of NSW has initiated a new Masters program in Satellite Systems Engineering, with industry support and more than \$650,000 in support from the Federal Government's Space Policy Unit through its Australian Space Research Program.

The first of its kind in Australia, the program aims to help keep talented students in the country to bolster the space industry and train engineers with the skills necessary to support an emerging Australian space industry.

The program was developed by a consortium comprising UNSW; Optus Pty Ltd – Australia's only satellite owner and operator; France's Thales Alenia Space; and the Institut Supérieur de l'Aéronautique et de l'Espace.

Many of the programs offered overseas focus on specialised aspects of satellite systems, such as satellite communications, says Dr Elias Aboutanios, project leader and senior lecturer in the School of Electrical Engineering and Telecommunications at UNSW.

"In the UNSW program, students will learn about all aspects of the system – how to take a mission from idea to implementation and how to operate the satellite system from the launch phase until its end of life."

Another unique aspect of the program is a year-long 'hands-on' project for students to develop a Cubesat platform. These are micro-satellites that could provide Australia with a niche entry point into the space industry.

PHOTO:CSIRO



Using ReMoTe technology to provide real-time assistance when problems arise.

Factory bots the key, says CSIRO

CSIRO has launched a White Paper highlighting the issues facing Australia's manufacturing sector and presents a new category of technologies built to encourage human-robot work practices.

The paper outlines how current tools available to manufacturers are built for high-volume mass-manufacturing, but that new economic drivers require manufacturers to focus more on low-volume, highly customised and high value-added products.

Known as Lightweight Assistive Manufacturing Solutions, these new systems are designed to enhance workers' skills, actions and tasks, not to replace them. They include virtual reality headsets, smart robots that can be taught to multi-task and tele-supervised robots that can be controlled over the internet.

A drive towards more ICT-enabled advanced manufacturing was one of the key opportunities identified in 2012 by the Prime Minister's Manufacturing Taskforce report *Smarter Manufacturing for a Smarter Australia*.

"Australian Manufacturing is shifting away from large-volume production to mass customisation, and companies are telling us they need more flexible systems to deliver these more customised products. This White Paper seeks to highlight these trends and present solutions which will enable Australian industry to address these challenges," says co-author and CSIRO business development manager Dr Peter Kambouris.

"Industrial automation used in manufacturing today is limited, but developments in ICT and robotics present Australia with an opportunity to change the way we manufacture. CSIRO believes lightweight robotics and advanced ICT systems are one way of meeting this challenge."

A virtual headset called ReMoTe is one system being trialled by industry. Using a head-mounted camera a worker can beam what they can see to anyone (expert/helper) in a remote location. The helper can then project their hand gestures onto what the worker is looking at and virtually show them how to fix an issue or conduct a repair. Systems such as ReMoTe have been designed with safety in mind and allowing workers to safely execute complex tasks in hazardous environments.

IRON BIRD TO HELP PROTECT JSF FLEET

The Minister for Defence Science and Personnel, Warren Snowdon, has unveiled a full-scale model of the F-35A Joint Strike Fighter (JSF), which the Defence Science and Technology Organisation will use to study the effects of electromagnetic (EM) compatibility and interference on the aircraft.

Called 'Iron Bird', the Australian-built model will be tested under simulated EM conditions during the acquisition and through-life sustainment of the JSF. The study is part of ensuring the protection of the JSF against EM environmental effects such as lightning and static discharge, which can impair the performance and safety of aircraft.

The JSF is a fifth-generation aircraft with highly complex electronics, sophisticated software and a structural airframe made of composite materials. This exposes the aircraft to EM interference from naturally

occurring phenomena and human sources, including telecommunication transmissions and radar. The impact of these interferences needs to be well understood and appropriately managed.

DSTO has developed world-class expertise in the investigation of EM radiation impact on



2013 Apprentice of the Year, Dale Goldfinch (left) meets with Warren Snowdon in front of Iron Bird.

aircraft and is engaged directly with the US JSF Joint Project Office to undertake this study using the Iron Bird model. The data captured will help in providing potential reductions in the cost of owning the JSF fleet and enhancing the aircraft's capability. The research will also support the verification for compliance and airworthiness certification for the JSF aircraft.

Australia's first two F-35As are due to be delivered to a US training facility in 2014-15, when Royal Australian Air Force pilot and maintainer training will commence on the aircraft.

DSTO LAUNCHES VEHICLE SIMULATOR

The Defence Science and Technology Organisation has launched a new high-tech military vehicle simulator designed to replicate field conditions across different terrain.

The Land Motion Platform has been developed to study the simulated movement of military vehicles and generate information on how to best integrate technology with Army vehicles. The simulator will allow researchers to better understand human performance in a range of battle-like conditions, including a feature that can track the operator's eye state.

It was launched by the Minister for Defence Science and Personnel, Warren Snowdon: "This research represents a shift away from Army vehicles being viewed as just a means for transport and logistics – advances in technology will see our next fleet of Army vehicles operate as fully networked state-of-the-art technology hubs," he said.

"The DSTO research will provide answers on how our soldiers can operate effectively and safely in these unstable conditions while using sensitive electronic equipment."

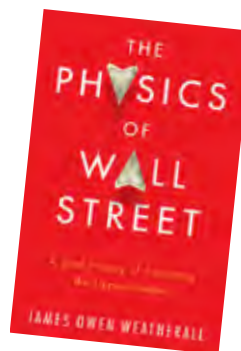
A new take on "geeks bearing formulas"



By Ian Rae

ianrae@bigpond.com

The Physics of Wall Street by James Owen Weatherall (Scribe, Melbourne and London, 2013. 304 pp. \$29.95)



The *Physics of Wall Street* is a book that valorises physicists who use their undoubted mathematical skills to play the market and the roulette wheel. After reading it, I came to the conclusion that the subtitle – ‘A Brief History of Predicting the Unpredictable’ – should have read “attempting to predict”.

That’s because Weatherall identifies only one example of feral physicists who consistently make money on the stock exchange. The firm Medallion, run by Jim Simons and James Ax, marked up a 2478.6 per cent return in the 1990s and continues to do well. You can judge the awe in which Weatherall holds this by the fact that he opted for precision rather than a nice round 2500 per cent.

Weatherall is an outsider, neither a physicist nor an economist. A philosopher of science, he has two PhD degrees, one in mathematics/physics and one in philosophy. His book is very readable, and my ATSE colleagues with basic mathematical

knowledge should have no trouble with it. The text is augmented by 20 pages of notes, 18 pages of index and a compilation of 350 references that includes such left-field entries as Thomas Pynchon’s *Gravity’s Rainbow*.

This history covers the work of people like Mandelbrot, Bachelier, Sornette, Black and Scholes, and bodies like the Santa Fe Institute and Goldman Sachs. The main players are seen to be American males. In a chapter entitled “Physics hits the street” Weatherall reflects that, following diversion of funds from the US space program to the war in Vietnam around 1970, “the physics job market collapsed”. Over the next decade graduate school enrolments in physics fell and many otherwise unemployed physicists joined financial institutions where they could ply their trade albeit with different numbers.

Other links to broader society, or at least its financial underbelly, are also explored: the break-up of the Bretton Woods agreement in 1971 and adoption

of floating currencies, which provided opportunities for hedge funds; the crash of 1987; and the development of collateralised debt obligations (CDOs) that “played a major role in the 2008 crash”.

Weatherall repeats Warren Buffet’s quip about “geeks bearing formulas” but he also has a few nice lines of his own.

For example, warning that models (= tools) have their limits and that those who do not heed them are always at risk of financial ruin, he writes that the “goal isn’t to find the final theory that will give you the right answer in every market setting. It’s much more modest. You’re trying to find some equations that give you the right answer some of the time, and to understand when they can be relied on.” And “we should never mistake a good model for the ‘truth’ about financial markets”.

He writes perceptively about the differences between scientific knowledge and the financial models. Science, Weatherall says, is tested through peer review and public scrutiny and when it passes these tests the knowledge and techniques can be widely adopted by practitioners. On the other hand, “investment banks and hedge funds are usually very secretive, which means that new ideas developed by such firms are rarely aired and debated the way the developments in scientific fields are”.

Reading this book, I learned that more and more robust models can be expected to evolve, and that their limits will be determined, although often only when they fail. What is actually working at the minute, however, is secret – still out there to be uncovered by a later generation of historians.

PROFESSOR IAN RAE FTSE, an Honorary Professorial Fellow at the University of Melbourne, is a former Technical Director of ATSE. He was President of the Royal Australian Chemical Institute (2006–08) and has served for more than a decade as a technical adviser to the United Nations Environment Program.

DEAKIN, DSTO LINK TO PROTECT TROOPS

A prototype bomb-disposal system providing operators with a realistic ‘grasp and feel’ of remote objects could become a vital capability to protect Australian troops during operations.

The Defence Science and Technology Organisation and Deakin University recently signed a licence agreement to further develop the technology to a standard suitable for future Australian Defence Force consideration.

The Minister for Defence Science and Personnel, Warren Snowdon, said the new robotic arm to counter improvised explosive devices relies on haptics (touch feedback) and could potentially be used by the ADF to safeguard troops or for battlefield surveillance.

The haptic arm system allowed operators to remotely grasp and feel the weight and texture of objects in real time, he said, noting that similar robots could also be employed in civilian environments to safely remove or neutralise hazardous materials.

Chief Defence Scientist Dr Alex Zelinsky FTSE said the licence agreement allowed Deakin to engage commercial partners to manufacture and distribute the technology and other haptic systems – and showcased how DSTO and universities could jointly mature new technologies in support of Defence.

Deakin Vice-Chancellor Professor Jane den Hollander said the mobile robotic platform incorporating the haptically enabled arm was adapted from an existing chassis design developed by Deakin’s Centre for Intelligent Systems Research.



ATSE
INFOCUS

NUMBER 178
JUNE 2013



Martin Green elected to Royal Society

Scientia Professor Martin Green AM FRS FAA FTSE, a world leader and pioneer in solar photovoltaic science and engineering, has been elected into the prestigious Fellowship of the Royal Society.

The Royal Society is the UK's national academy of science. Its self-governing Fellowship is comprised of some 1450 of the world's most distinguished scientists and engineers, including more than 80 Nobel Laureates.

"It's really quite an honour," says Professor Green, Director of the new Centre for Advanced Photovoltaics, based within the University of NSW's School of Photovoltaics and Renewable Energy Engineering.

In an academic career at UNSW spanning nearly 40 years, Professor Green has attracted talented researchers, supervised more than 60 PhD students and set numerous world records for silicon solar cell efficiency – including the current record of 25 per cent conversion efficiency.

He is renowned for developing and commercialising silicon solar cell technologies, and has often been referred to as the 'father of photovoltaics' – the science of converting sunlight directly into electrical energy.

He is now working on developing third-generation solar cells, which will combine other semiconductor materials on top of silicon to improve efficiency.

"Our UNSW research group would like to be the one to develop a practical cell that takes us from 25 per cent to over 40 per cent efficiency," he says.

Each year the Royal Society elects 44 Fellows and eight Foreign Members from more than 700 candidates.

"The university congratulates Scientia Professor Martin Green on this significant personal achievement," said Professor Les Field, Deputy Vice Chancellor (Research) at UNSW.

"Martin has been a prolific researcher and an incredibly valued teacher at UNSW for nearly four decades.

"Under his leadership, UNSW has established itself as a global leader in photovoltaic science, producing hundreds of PhD-qualified graduates and many leading solar entrepreneurs.

"He is an ambassador for this university and for renewable energy, and a perfect example of how Australian innovation and ingenuity can have an enduring impact around the world."

Professor Green becomes one of 17 Fellows and Foreign Fellows who carry the

Martin Green

FRS postnominal. They are: Professor Brian Anderson AO FRS FTSE, Dr Keith Boardman AO FRS FAA FTSE, Professor David Boger FRS FAA FTSE, Laureate Professor Graeme Clark AO AC FAA FRS FTSE, Emeritus Professor Bill Compston FAA FRS FTSE, Dr Hugh Durrant-Whyte FRS FAA FTSE, Professor Graham Goodwin FRS FAA FTSE, Professor Andrew Holmes AM FRS FAA FTSE, Professor Anthony Linnane AM FRS FAA FTSE, Professor Yiu-Wing Mai AM FRS FREng FAA FTSE, Dr Ramesh Mashelkar FRS FTSE, Sir Gus Nossal AC CBE FRS FAA FTSE, Dr Jim Peacock AC FRS FAA FTSE, Professor Alan Snyder FRS FAA FTSE, Professor Roger Tanner FRS FAA FTSE and Sir Gregory Winter Kt CBE FRS FTSE.

CLOUGH SCHOLARS NAMED

Two University of Western Australia engineering students, Joel Valli and Jessica Regan, who are in their penultimate year of a combined degree program, are the newest recipients of the 35-year-old Clough Scholars program.

Initiated in 1969 by former Clough Ltd chairman and managing director Dr Harold Clough AO OBE FTSE, the program reaffirms the longstanding relationship between Clough and the Faculty of Engineering, Computing and Mathematics at UWA. Past recipients include top government, business and resource industry leaders.

Clough CEO and Managing Director Kevin Gallagher said the quality of applicants for the Clough program was extremely high.

"Clough Scholars will be guaranteed summer internship and graduate positions at Clough although they are not obliged to take up these positions. While some Clough Scholars are our longest-serving employees, others have gone on to hold influential positions in other business firms, or industry and government, a tradition we are proud to be continuing at Clough Ltd," he said.

Scholars who join Clough will be part of an advanced training program, comprising leadership training and executive mentoring.

Three Fellows join AAS

Professor Max Lu FAA FTSE, University of Queensland, Dr Richard Richards FAA FTSE, CSIRO Plant Industry, and Dr Brian Walker FAA FTSE, CSIRO Ecosystem Science, have all been elected to the Australian Academy of Science.

The new Fellows were admitted to the AAS and presented summaries of the work for which they have been honoured at the Academy's annual three-day celebration, Science at the Shine Dome, in Canberra in May.

Professor Lu is the Deputy Vice-Chancellor (Research) and Foundation Director of the ARC Centre of Excellence for Functional Nanomaterials at UQ. He is a world-leading scientist in materials science and chemical engineering and has made many significant and sustained contributions, including the new method for synthesis of highly reactive single crystal TiO₂, new insights into the surface chemistry and modifications of nanoporous materials, molecular engineering of membranes and efficient photocatalysts for clean energy and water.

Dr Richards is known as the world leader in the use of physiological traits in the breeding of crop plants. He developed an approach now widely used that integrates understanding of the physiological basis of



Australian Ambassador Jane Hardy (left) looks on as Academy President Joaquín Poch Broto congratulates Paul Zimmet (right).

grain yield in drought-prone environments with the molecular and genetic bases of influential physiological traits.

Dr Walker is an ecologist at the forefront of the interdisciplinary area of resilience in complex adaptive systems. He is a Research Fellow with CSIRO Sustainable Ecosystems and is also Program Director and Chair of the Board of the Resilience Alliance, an international research group working on sustainability of social-ecological systems.

SPAIN HONOURS PAUL ZIMMET

Professor Paul Zimmet AO FTSE, Director Emeritus of Baker IDI Heart and Diabetes Institute and a leading world authority on diabetes, has been made a Member of the Spanish Royal Academy of Medicine (Real Academia Nacional de Medicina). This is the second major recognition for Professor Zimmet from Spain; he received an Honorary Doctorate from the Complutense University in Madrid in 2002.

The Spanish Royal Academy of Medicine was founded in 1734, becoming an official institution under Royal authority at the time of King Felipe V. Since 1968, the Academy has had a membership of 50 important national figures in medicine and a select group of international figures including several Nobel Prize winners.

Professor Zimmet was inducted as Académico de Honor at a special ceremony at the Academy in Madrid on in April. He is the first Australian to be accorded this honour. The Australian Ambassador for Spain, Ms Jane Hardy, attended the ceremony where Professor Zimmet gave an oration on the topic 'Diabetes – A Global Health and Economic Crisis'.

Professor Zimmet's appointment to the Spanish Academy recognises the major and longstanding contributions he has made in the fields of diabetes and obesity research and care. He was the first scientist to predict the global

epidemic of diabetes, now recognised as one of the largest epidemics in human history.

He is an Honorary President of the International Diabetes Federation and is Chairperson for the program for the World Diabetes Congress, which will be held in Melbourne later this year. It is expected to be one of the largest international medical congresses to ever come to Australia.

ALAN FINKEL PATRON OF SCIENCE MEDIA CENTRE

The Australian Science Media Centre (AusSMC) has announced ATSE President Dr Alan Finkel AM FTSE as the organisation's Australian patron. Dr Finkel has a long history with science and the media through his own work in neuroscience and engineering and as co-founder of the multi-award-winning science magazine, *COSMOS*.

"Alan Finkel bridges many sectors in Australia with his background in research, business and media and is thus well positioned to help the centre in its mission to bring more evidence-based science to the public through the media," said CEO Dr Susannah Elliott.

Chairman Peter Yates said: "I'm absolutely delighted and honoured that Dr Finkel has agreed to become the Australian patron of the Science Media Centre. We are very privileged to have two such distinguished people as patrons – Alan Finkel as our Australian patron and Professor Susan Greenfield as our international patron."

AusSMC is an independent, not-for-profit service for the news media, giving journalists direct access to evidence-based science and expertise. AusSMC works with journalists to help them cover science – as well as identify science angles in everyday news stories – and works with the scientific community to help them interact more effectively with the media.



Max Lu

Richard Richards



Brian Walker



Max Lu

Bob Ward: technology leader and glider pilot

Foundation Fellow Dr Bob Ward FTSE – a former Chief Defence Scientist and, before that, Head of research at BHP – died in Melbourne on 5 May 2013, aged 85.

Born in the UK and educated at Cambridge, Dr Ward was widely known and respected in science and technology circles in Australia, particularly in the field of metallurgy.

He was a researcher at the University of Sheffield – where he first encountered Professor Greg Tegart AM FTSE – before he



Bob Ward

became the Stelco Professor in the School of Metallurgy at McMaster University, Canada, in 1961.

He joined BHP in 1966 and was initially Director of Research (1966–70); at his retirement he was General Manager, Research and New

Technology (1970–88).

He was subsequently appointed Chief Defence Scientist at DSTO (1900–92). In his second retirement he was able to more fully indulge his personal interests, which included technology transfer, the history of technology, and gliding – which he enjoyed at Benalla, in central Victoria.

Dr Ward had a “significant influence” on the career of Professor Tegart, as he noted at Dr Ward’s funeral in Melbourne.

“Bob was one of my oldest friends and had a significant influence on my life and career. I owe him a large debt of gratitude and I will miss him!” Professor Tegart said.

Professor Tegart met Dr Ward at the Department of Metallurgy in the University of Sheffield in late 1955, before Dr Ward decided that he could gain more rapid experience and academic promotion in Canada – and moved to McMaster University in Ontario and then to BHP in Melbourne.

He was later responsible for Professor Tegart returning to Australia to manage BHP’s research facility in Melbourne.

“Our lives were closely intertwined from then on as BHP Melbourne Research Laboratories (MRL) developed a wide range of activities across BHP in technology development and application,” Professor Tegart said.

“Bob was a wonderful person to work

with and he had great support from Sir Ian.* Bob encouraged the development of strong links with academia and government.

“A major achievement of Bob’s career was his role in the 1970s in the creation of the Australian Academy of Technological Sciences and Engineering, which brought together a grouping of the leaders in technology and engineering in industry, academia and Government in Australia.

“It was formally inaugurated in early 1976 with Sir Ian as President. I was elected the following year. Bob took the lead in developing links with other Academies of Engineering around the world and in organising a Convocation of Academies in Melbourne in 1980. He served as President of the International Council of Academies of Engineering in 1983–84 during a period of expansion of Academies around the world,” Professor Tegart recalled.

** Sir Ian McLennan KCMG KBE FAA FTSE, Foundation President of ATSE and Chairman of BHP and later ANZ Banking Group.*

MAN OF STEEL RECEIVES U.S. HONOUR

University of NSW Scientia Professor Mark Bradford FTSE has been elected as a distinguished member of the American Society of Civil Engineers.

Professor Bradford, who is the Director of the UNSW Centre for Infrastructure Engineering

and Safety, is only the second Australian to receive the prestigious honour from the 161-year-old society.

“The Distinguished Membership is an acknowledgement of cutting-edge research being undertaken in structural engineering in Australia,” says Professor Bradford, a Laureate Fellow in the School of Civil and Environmental Engineering.

“The team I work with punches well above its weight in delivering research outcomes in a variety of ways on the international stage. We have made significant contributions in areas such as fundamental mechanics, structural and computational mechanics, experimental techniques and in influencing practice by the research ... in international design standards.”

Professor Bradford’s research at UNSW has focused mainly on steel and concrete structures, and improving the safety of buildings that we live and work in, and the infrastructure that we rely on. He has published extensively in civil engineering journals and has co-authored more than 20 books.

Professor Bradford joins a select group of 626 Distinguished Members elected over the American Society of Civil Engineer’s history, and drawn from its membership of 140,000 engineers. He will be presented with the honour at a formal ceremony at the society’s 143rd Annual Civil Engineering Conference in North Carolina in October.

Mark Bradford



Ken Jubb was an academic and veterinary leader

Emeritus Professor Ken Jubb OAM FTSE, a Fellow since 1982 and a former Clunies Ross Foundation Governor, was a distinguished veterinary pathologist and academic at the University of Melbourne for almost 50 years.

He was Dean of veterinary pathology for 21 years until his retirement in 1990 and served as Chair of the Academic Board and Pro Vice-Chancellor. He died in Victoria recently, aged 84.



Ken Jubb

A country boy from a farming family, Professor Jubb's veterinary interests showed early and he graduated in veterinary science from the University of Sydney in 1952 and headed for the New York State Veterinary College. In 1957 – at under the age of 30 – he was appointed Professor of Pathology at the Ontario Veterinary College, Canada.

In 1963, aged 35, he returned to Victoria to take the post of Professor of Veterinary Pathology at Melbourne, where he was based for almost 50 years until his death.

Ken Jubb had a considerable influence in many fields. Apart from his responsibilities as Dean, he contributed to the university's administration as a member of Council, as Pro Vice-Chancellor, Chair of the Academic Board and Assistant Vice-Chancellor responsible for academic policy, planning and review of academic support systems.

His veterinary science impact ranged wide – Malaysia, Indonesia, China and the Philippines, and at Murdoch University in Perth.

He was a Foundation Fellow of the Australian College of Veterinary Scientists and served on the Zoological Parks and Gardens Board of Victoria for more than 20 years, including spells as Vice Chairman and Chairman.

He was a member of a small committee advising the Australian Government on bilateral programs for science and technology and convened a committee to oversee the establishment of the Werribee Technology Precinct, west of Melbourne.

The Australian Veterinary Association honoured him with the Gilruth Prize in 2011, its highest honour. In 1989 the American College of Veterinary Pathology awarded him

honorary membership.

In the 22 years after his retirement, until just before his death, Professor Jubb was an active Emeritus Professor, engaging in a wide range of activities at the university.

HAMISH TYRWHITT CHAIRS ASIA BOARD

Mr Hamish Tyrwhitt FTSE, Executive Director and Chief Executive Officer of Leighton Holdings, has been appointed chair of the Government's Strategic Advisory Board on Australia in the Asian Century.

He is joined on the Board by two other new members – Professor Margaret Gardner



Hamish Tyrwhitt

AO, Vice-Chancellor of RMIT, and Ms Rebecca Dee-Bradbury, President, Developed Markets, Asia Pacific, of Kraft Foods.

Mr Tyrwhitt, who has extensive experience in Asia, was Managing Director of Leighton Asia Ltd and Leighton Contractors

(Asia) Ltd before taking up his current post.

Of the myriad projects and operations of Leighton in Asia, a trades school set up in India to train local recruits to basic Australian qualifications merited special mention in the White Paper, *Australia in the Asian Century*, released in October 2012.

The White Paper sets ambitious goals for Australia to meet by 2025 and provides policy directions to help the country make the most of the tremendous array of opportunities arising from the region's rapid growth.

Mr Tyrwhitt, Professor Gardner and Ms Dee-Bradbury will join those members of the Board who advised the Government on the

White Paper's development. They are Telstra Chairman Ms Catherine Livingstone AO FTSE, former Treasury Secretary Dr Ken Henry AC, Emeritus Professor Peter Drysdale AM from the ANU's Crawford School of Public Policy and Mr John Denton, Partner and CEO of Corrs Chambers Westgarth Lawyers.

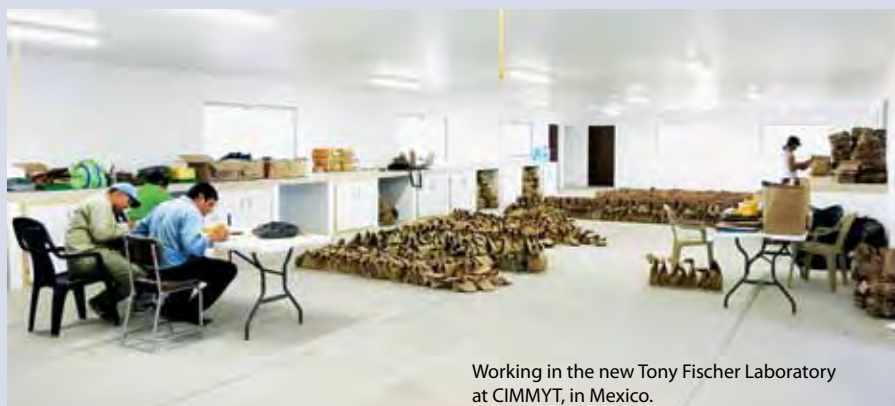
The appointment of the new advisory board members will help keep governments, business and the wider Australian community focused on the opportunities presented by the transformation of Asia, the Prime Minister's announcement said.

NEW LABORATORY HONOURS TONY FISCHER

Dr Tony Fischer AM FTSE, Coordinator of the ACT Committee of the Crawford Fund and regarded as the pre-eminent Australian crop physiologist of his generation, was honoured recently with the naming of the new Tony Fischer Laboratory at the International Maize and Wheat Improvement Center (CIMMYT) in Mexico.

Dr Fischer was awarded the 2007 Farrer Memorial Medal, which honours distinguished service in Australian agricultural science, and delivered the 2007 Farrer Oration 'Improvement in Wheat Yield: Farrer, Physiology and Functional Genomics', which focused on the past successes of Australian wheat breeding and the challenges of the future.

"Dr Fischer is well known internationally as a wheat cropping scientist," said CSIRO Plant Industry Chief, Dr Jeremy Burdon FTSE, at the time. "He is rightly recognised as a pre-eminent Australian crop physiologist who has made an outstanding contribution to agricultural research in Australia, particularly here at CSIRO Plant Industry, as Director of the Wheat Program at CIMMYT, as an influential research manager at the Australian Centre for International Agricultural Research (ACIAR) and now again as an Honorary Fellow with CSIRO Plant Industry."



Working in the new Tony Fischer Laboratory at CIMMYT, in Mexico.

ATSE CLUNIES ROSS
AWARDS DINNER 2013
Celebrating innovation in technology
MELBOURNE



The Academy congratulates the
2013 ATSE Clunies Ross Award winners

Mr Ian T Croser AM Technical Director, CEA Technologies Pty Ltd

Dr Simon Poole Director, New Business Ventures, Finisar Australia

Dr Steven Frisken Chief Technology Officer, Finisar Australia Pty Ltd

Dr Tony Radford Non-Executive Director, Modern Baking Ltd, Nucleus Network

Dr Jim Rothel Formerly of the CSIRO Division of Animal Health, CSL Ltd and Cellectis Ltd

Dr Paul Wood Adjunct Professor at Monash University, Non-Executive Director, Nexvet Biopharma Ltd

Dr Stephen Jones Formerly Chief Technology Officer, Cellectis Ltd

The 2013 ATSE Clunies Ross Awards were made possible
through the generous support of the following sponsors:

ATSE Clunies Ross Awards were proudly hosted by:



and generously supported by:

PLATINUM



MONASH University



ansto

Nuclear-based science benefiting all Australians



SILVER



UNSW
THE UNIVERSITY OF NEW SOUTH WALES

BRONZE



**THE UNIVERSITY
OF QUEENSLAND**
AUSTRALIA



**THE UNIVERSITY OF
NEWCASTLE**
AUSTRALIA



Leighton
Holdings

The Awards are an initiative of the Australian Academy of Technological Sciences and Engineering (ATSE). They are the only Australian headline awards for science and technology which highlight the hard work, extraordinary risks and long-term commitment needed to achieve, through commercialisation, the practical marketplace impact of applied science and technology.



The 2014 ATSE Clunies Ross Awards are now open Nominations close 31 July 2013

For more information about the nomination process or to download a nomination form, visit www.atse.org.au/cluniessrossnominations

USING ALGAE TO FUEL THE WORLD

In the search for clean energy, microalgae may be one of our most important allies. Professor Ben Hankamer and his team from UQ's Institute for Molecular Bioscience are developing microalgae systems to produce renewable fuels for the future.

He has launched the Solar Bio-fuels Research Centre to test the most effective way of using green algae cells and photobioreactors to produce bio-fuels such as biodiesel, aviation fuels and hydrogen. If this process proves suitable to be replicated on a large-scale, it has the potential to help alleviate the world's constantly growing demand for fuel, food and clean water.

These advances are made possible through the combination of our world-class facilities and leading researchers. Imagine the difference having access to all of this could make to you.

YOUR UQ. YOUR ADVANTAGE.



GROUP OF EIGHT



facebook.com/uniofQLD



THE UNIVERSITY
OF QUEENSLAND
AUSTRALIA

youruq.com