VOL. 9 | NO. 3 | APRIL 2023

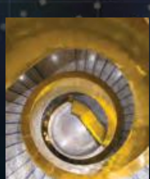
create

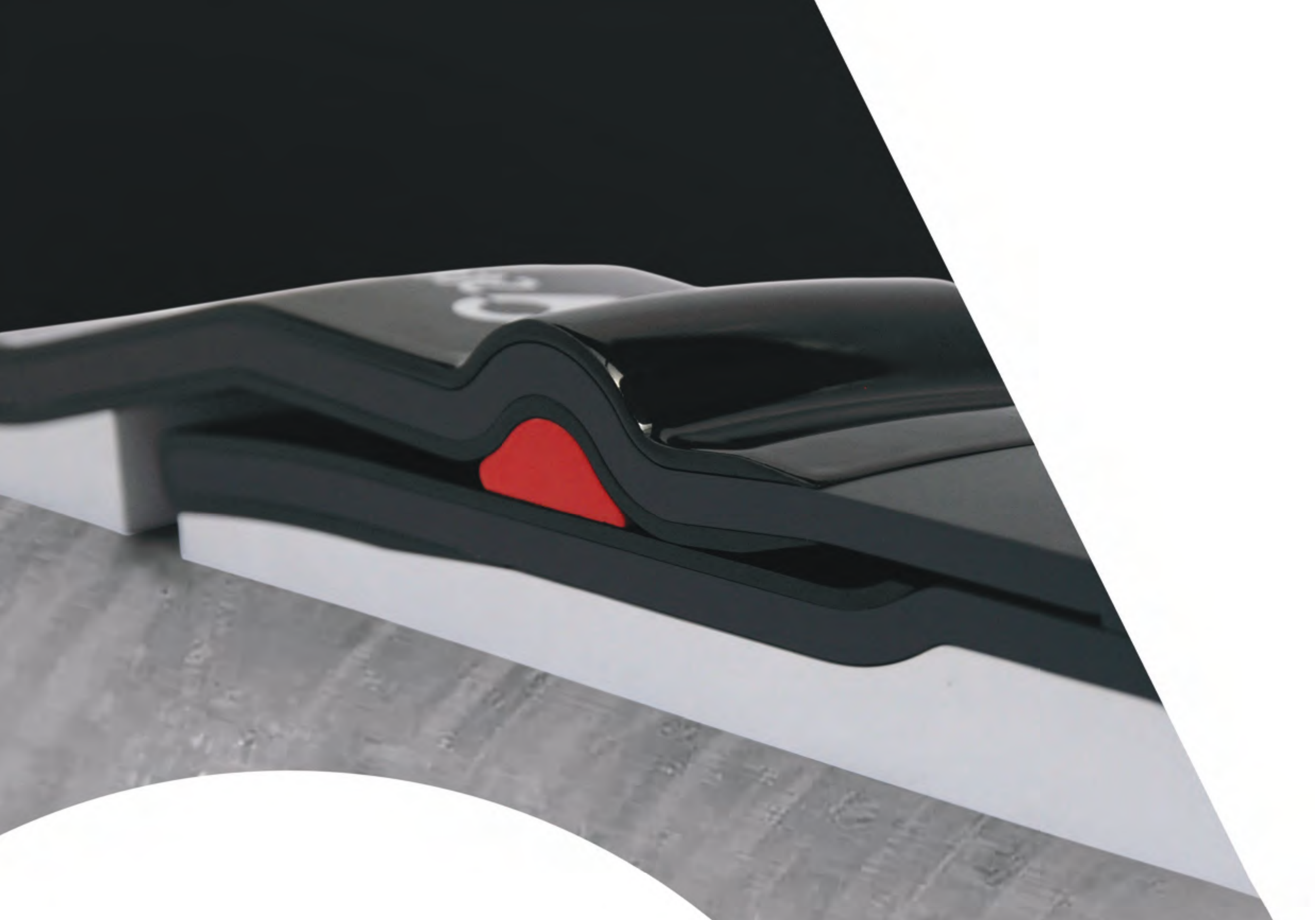
ENGINEERING IDEAS TO REALITY

ENGINEERS AUSTRALIA

THE QUANTUM PIVOT

AUSTRALIA DIVES INTO COMPUTING'S NEXT REVOLUTION





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EVERY ISSUE

NEWS

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Check out the *create* website — your best resource for the latest engineering news and information from Australia and the world.

Yesterday and tomorrow

AUSTRALIA'S RICH ENGINEERING HERITAGE PROVIDES A BASE FOR THE CREATIVITY AND TECHNOLOGICAL INNOVATION THAT WILL GUIDE THE NATION'S FUTURE.

WELCOME TO the April edition of *create*. We are pleased to bring you an issue that looks forward and back, with an eye on engineering heritage and a look ahead to opportunities to advance and learn from history.

The history of engineering is a rich one and, here in Australia, we have a wealth of built environment and cultural artefacts in our recent past and stretching back thousands of years to the innovation of First Nations peoples.

Indeed, the ingenuity of Indigenous engineering has been recognised with an Australian-first UNESCO World Heritage listing and legislative review is underway to update protections for First Nations' cultural heritage.

The destruction of the Juukan Gorge rock shelters was a catalyst for change, and Australians have a growing expectation that corporations working among culturally significant elements of the built and natural environment will engage in authentic consultation with traditional custodians and community stakeholders.

Heritage protection and conservation of more recent elements of the built environment, such as the Sydney Opera House and Old Parliament House, is a stream of the engineering profession that is in strong demand. We look at the challenges and engineering solutions required to preserve such architectural icons.

It has long been acknowledged that Australia is over-represented among inventions that changed the course of history. But not everything had the longevity and impact of homegrown advances like WiFi and the Cochlear implant.

In fact, without a specific interest in the history of computers, most people wouldn't know Australia was an early player in the development of the computer age with CSIRAC in 1949.

Read on to discover how CSIRAC was a breakthrough that perhaps never received its due place in history.

But Australia now finds itself in the race for the next horizon of the technological age: quantum computing.

The stage is set for spin-offs and startups to capitalise on the research Australian universities have produced and we look forward to our engineers adding their expertise to the mix.

It's an exciting time to be an engineer. For Engineers Australia, that means building on our strategies to champion the profession and inform debate in key policy areas. Developments in the defence, maritime and aerospace sectors open avenues for engineering skills and accreditation, and opportunities are not slowing down. In fact, they are accelerating with the drive for efficiencies in energy, use of resources, mitigating climate change and the burgeoning circular economy.

We hear from Circular Australia's first Chief Circular Engineer, Professor Ali Abbas, about the challenges and potential of engineering waste out of products and processes to minimise our environmental footprint.

It's a sector that is certainly taking the lessons of the past and using them to create a better future.

"Australia now finds itself in the race for the next horizon of the technological age: quantum computing."

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Back in the game

GLOBAL ASSET MANAGEMENT CONSULTANCY AMCL IS LEADING THE WAY IN BRINGING RETIRED ENGINEERS BACK INTO THE FOLD — ON THEIR TERMS AND IN THEIR OWN TIME.

NOT LONG after he had retired from his role as General Manager Asset Management with Essential Energy, Paul Brazier received a job offer from an AMCL Operations Director he'd employed many years earlier as a cadet engineer.

"The tables had turned," Brazier says.

"He had a small project he thought I might be interested in consulting to. And AMCL, like all engineering businesses, had a resourcing shortfall."

That project led to another and another. Along the way, Brazier was very clear that he only wanted to work around one-quarter of the time he did as a full-time employee. Plus, he wanted none of the pressure that came with managing large teams, relentless deadlines and long hours.

ABOVE: Paul Brazier returned to engineering as a part-time consultant.

However, he also recognised the enormous benefits of working as a senior executive consultant on interesting projects.

"What it gives, as well as extra pocket money – which wasn't the motivator – is a social opportunity," Brazier says. "I work with colleagues and clients from all over the country and overseas.

"It's also about using the skills you build up over many years

"IT'S ABOUT USING THE SKILLS YOU BUILD UP OVER MANY YEARS AND FEELING USEFUL, KNOWING YOU'RE CONTRIBUTING TO A PROJECT AND, AT THE SAME TIME, LIFTING THE SKILLS OF YOUNGER ENGINEERS."

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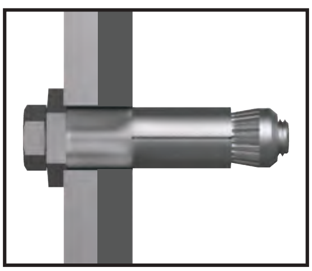

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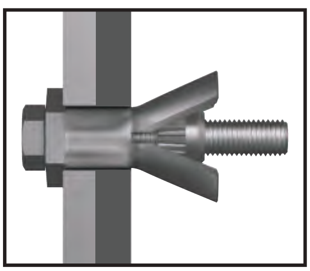

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and feeling useful, knowing you're contributing to a project and, at the same time, lifting the skills of younger engineers."

The intergenerational collaboration program, designed by Sandra Diethelm, AMCL's Associate Director Strategy and Growth, focuses partly on the pairing of highly experienced, semi-retired engineers with younger talent.

The younger professionals will do the heavy lifting, and at the same time they will benefit enormously from the advice and mentorship of their more experienced colleagues.

"It's no secret that there's far more work in the market than firms can deliver," Diethelm says.

"The problem is not in attracting the work, it's in getting the people who can do it.

"One solution is semi-retired, 55-plus consultants. They have a tremendous amount of wisdom from decades of experience. But they don't want to come back to the workplace, and they don't want a role that makes them responsible for major projects, for meeting deadlines or for working night shifts. They will not come back under those conditions."

So Diethelm designed a program in which the burden of responsibility was removed from the older engineer, but where they could still enjoy the opportunity to be an important part of the project.

Part of the glue that holds the senior executive consultants together with their full-time colleagues at AMCL is the fact that they're invited to all internal social events, including remote Friday drinks, which is work time and paid hours, as it is for full-time staff members.

They're also flown to a central location for a six-monthly get-together – the most recent was in Melbourne – for two or three days.

Robert Bruce CPEng, recipient of the NSW Service Medallion, was Manager Asset Initiatives (Sydney Trains) at Transport for NSW before his retirement in 2018.

Having spent most of his career in rail, he left full-time work with a massive level of insight and knowledge.

"A lot of people say, when they retire, that they're just going to play golf," Bruce says.

"But that's not meaningful and I want to do more with my life. My career-learnt experiences and knowledge acquisition could still be utilised."

Bruce had plans to travel with his wife, and did so until travel was interrupted by the COVID-19 pandemic.

His colleagues talked about taking on consulting work after retirement. When they accepted such work, it often transformed into a full-time commitment for them.

For Bruce, that wasn't an attractive option.

Then he was contacted by AMCL.

"I realised that even after we're retired, we still have value to add to the profession," Bruce says.

"All senior engineers' experiences are unique and can still be of value.

"I'm getting a lot out of utilising my skills. It's really interesting to work with skilled people from around Australia and the world who have different perspectives and experiences. I'm really enjoying it." ●

CHRIS SHEEDY

"A LOT OF PEOPLE SAY, WHEN THEY RETIRE, THAT THEY'RE JUST GOING TO PLAY GOLF. BUT THAT'S NOT MEANINGFUL AND I WANT TO DO MORE WITH MY LIFE."

ABOVE (from top): Sandra Diethelm, AMCL; Robert Bruce worked most of his career in rail. ABOVE RIGHT: Zhen Wei Ooi, AMCL.

BENEFIT OF EXPERIENCE

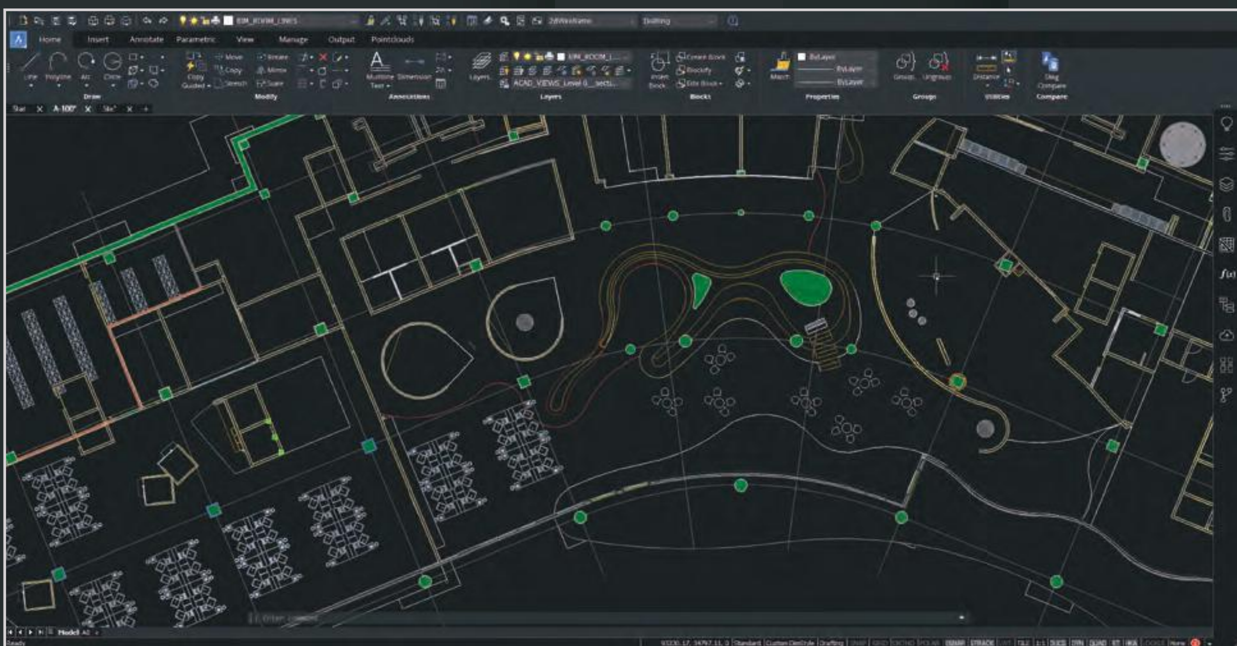
Zhen Wei Ooi, a consultant with AMCL in Malaysia, is one of the younger engineers benefiting from the company's pairing program.

Having graduated in 2019 and worked for three years in the oil and gas sector, Ooi began working with AMCL in mid 2022. The work she has been involved in since joining has mostly been in the electrical sector, including a project based in Canberra.

"We were conducting a gap and maturity assessment for an energy business, helping them to assess against the Australian Standard," Ooi says.

"One part of the process was interviewing people within the client company. I worked with Colin Lambert, one of our Senior Consultants who had a vast amount of experience I could draw upon.

"I have learned a lot from Colin. I wouldn't be able to have this sort of knowledge otherwise, not without several years of working in the sector. And I feel it's a mutual thing. He is helping me, and I'm helping him in areas like data analysis."



WORDS BY **CHRIS SHEEDY**

BETTER THAN NEW

INNOVATION IN CONSTRUCTION OFTEN ARISES WHEN ENGINEERS FACE NEW CHALLENGES. THAT'S THE CASE WHEN REVITALISATING AND RENOVATING CULTURALLY SIGNIFICANT, HERITAGE-LISTED BUILDINGS, WHICH CAN PROVIDE A POWERFUL TEST OF AN ENGINEER'S FLAIR.

THE RECENT build of Western Australian Museum Boola Bardip – a dramatic design that links contemporary structures with historic buildings at the Perth Cultural Centre – had several graduate engineers and graduate construction management personnel involved in the complex project.

The outcome has been such a positive one that it's had a powerful effect on their careers.

So says Peer Ahamed, Construction Manager at MultiPlex and winner of a WA AIB Professional Excellence Award for his work on the St John of God Murdoch Hospital in Perth. Ahamed was a Project Manager on the Boola Bardip build, responsible for procurement and delivery of the project.

"From the graduate who was just getting exposure, to the project manager, to the construction manager and everybody else, every one of us had a lot of learning during this project," he says.

"Particularly in terms of stakeholder management, design, procurement of special materials – some parts of this

project were a real eye-opener for us. Everybody learned so much.

"There were four engineers who were really project engineers. They were working on coordinating the design, but they also got involved with the execution of the project. That was a fantastic experience for them, and for all of us."

UNIQUE SOLUTIONS

The challenges were multifaceted.

"We have this particular site – an existing museum – which included four heritage buildings with its oldest, the Old Gaol, dating back to the mid-1800s. And so we had to combine the heritage with new construction without damaging or changing any of the existing building.

"In terms of construction engineering, we've got a 17 m long cantilever that sits on top of a heritage building, housing one of the exhibition halls. That is an enormous structural element which, logistically, was so difficult. Plus, we only had two streets that we had access to, to do the work."

As described on the website of Perth engineering firm BG&E, which provided structural and civil engineering services on Boola Bardip, the column-free gallery spaces are elevated 15 m above the ground over clear, external pedestrian areas.

"WE WERE DOING NEW CONSTRUCTION WITHOUT DAMAGING OR CHANGING ANY OF THE EXISTING BUILDING."

ABOVE (clockwise from top left): WA Museum Boola Bardip; a cantilever over Hackett Hall.

"Gallery floors [were] designed for total imposed loads of 14.5 kilopascals and 120 kilonewtons concentrated loads with stringent deflection and vibration acceptance criteria," the BG&E case study says. "Gallery floors comprise composite steel floors spanning 20 m on two two-storey-high fabricated structural steel trusses. These floors are supported by fabricated steel trusses, located within wall lines over storey heights and vary in depth, of between 7 m and 15 m."

There was no such thing as a simple solution on the project, Ahamed says.

When additional structural members were required and the team had to go into the fabric of the heritage building, slots of brickwork had to be opened up without causing any damage.

The structure then had to be temporarily held in place while the structural members were inserted, then the brickwork painstakingly replaced without any evidence of the work being done.

For the structural work to enable the construction of roof trusses spanning up to 45 m, instead of birdcage scaffolding, the team developed a scaffold on wheels that was guided along a train track of sorts.

"Much of our innovation followed a trial-and-error process," Ahamed says.

Ahamed believes engineering work on or around a culturally significant building needn't cost too much more, in terms of dollars or time, compared to a similar non-heritage project – as long as the project brief is clearly priced within specifications and there are no changes. It might require more resources, but what changes is the detail in the planning.

"There are a lot of things to be managed," he says. "On the resources side, there is a slight increase compared to normal commercial buildings. For a similar, non-heritage job I might have about 17 staff, but on this project I had about 22. So, it's a slight increase, but not a drastic one."

THE VALUE IN HERITAGE

Engineers go to a lot of trouble to ensure heritage buildings remain in their intended state. That's important, says Michael Taylor FIEAust CPEng (Ret), Chair of Engineering Heritage Australia's national committee.

Every state, as well as the Commonwealth, has heritage councils and heritage organisations, Taylor says.

"Heritage and the story of the past is so important because you can learn so much from it," Taylor says. "People want to know where things came from and how they came to be what they are today. It's very valuable.

"At Engineering Heritage Australia, we tell history too. We're involved in trying to recognise and help conserve those items that demonstrate our history.

"There is moveable and immoveable heritage – buildings, bridges and dams are immoveable. But tractors and steam engines and aircraft are moveable. You can put moveable items together in a museum, but immoveable items must be preserved in place."

HISTORY OF DEMOCRACY

For that reason, in 1988 when Australia's Parliament House became Old Parliament House, the building was not simply locked up and forgotten. A plan was put in place for its upkeep.

More recently, when it was partly repurposed as the Museum of Australian Democracy, the work done to create the exhibition spaces had to respect the requirements of this National and Commonwealth heritage-listed building under the EPBC Act..

"The Museum of Australian Democracy is only approximately a third of the building's footprint," says Chris Grebert, Head of Facilities, Capital Projects, Heritage and Security at Old Parliament House. "We're guided by our Heritage Management Plan 2021-2026. Working with engineers is not as simple as getting a BIM model and working from that. The engineers often work with our heritage team and sometimes conservators to design what is almost always an alternate solution."

For example, a project that involved retrofitting LED lighting into chandeliers that had been installed in 1927 had to consider heat factors because of the age of the plaster around the lights.

Heat sinks had to be mounted in various locations, adding time and cost to what is usually considered a relatively simple and straightforward job.

"OUR JOB IS TO DO AS MUCH AS NECESSARY TO CARE FOR THE PLACE BY DOING AS LITTLE AS POSSIBLE."

ABOVE (from top): Inside the new WA Museum; Michael Taylor, Engineering Heritage Australia.

The Heritage Management Plan guides decision-making on a daily basis in every individual part of the building. An action committee reviews, discusses and amends projects that are beneath a significant impact threshold.

The committee's role can include referring projects to the Department of Climate Change, Energy the Environment and Water, seeking public consultation. This all takes time.

"The South East Wing, when it was refurbished back in 2008, involved a full referral to the department," Grebert says. "It [takes] approximately a year to do that full referral, and all the spaces required a heritage impact assessment. Then, guidance is developed around how to actually do the work.

"Finally, it goes to tender, with contractors needing to follow unique guidelines. Pieces might have to be retained, taken off safely, documented, then put back on. Then a conservator must do the conservation work to bring it back as close as possible to original."

The other guide for engineers and construction professionals is the Burra Charter, published by Australia's International Council on Monuments and Sites. The charter promotes a cautious approach to change.

"Our job is to do as much as necessary to care for the place by doing as little as possible," Grebert says. "That's why I describe a lot of the work as 'alternative solutions'. We have a lot of non-compliance due to the age of the building. Sometimes there just isn't much we can do to fully achieve compliance with the restrictions we have."

When the exhibition spaces for the Museum of Australian Democracy were being planned, it quickly became clear that

Old Parliament House was not intended as an exhibition space.

Unlike galleries, theatres and other arts complexes – which often have flexible spaces designed around the high likelihood of changing demands on those spaces – the building was designed with a very different purpose in mind.

For a recent Museum of Australian Democracy exhibition, for example, the challenge became how to build a space within a space: a box within a box.

What was originally the Opposition Party Room now had to contain a fully supported metal structure with a false floor that protected the original timber floor.

Engineers were contracted to design the structure, including the articulation through the false floor of all power and other services required to run the exhibition. Vitally, the work had to be fully reversible.

"That's one of the real challenges," Grebert says.

"After this exhibition is finished, all of it must be able to be deconstructed so the room can go back to being the Opposition Party Room again, with its leather lounges and the bookshelves and so forth."

ABOVE: Repairing the roof of Old Parliament House.

RIGHT: Retrofitting Old Parliament House chandeliers with LED lights. BELOW: Chris Grebert, Old Parliament House.

THE HOUSE WINS

One of Australia's most culturally significant buildings, the Sydney Opera House regularly tosses up challenges for engineers.

Historically, and up to the present day, many of those engineers have come from Arup, whose founder, Ove Arup, was heavily involved in the design of the UNESCO-listed building.

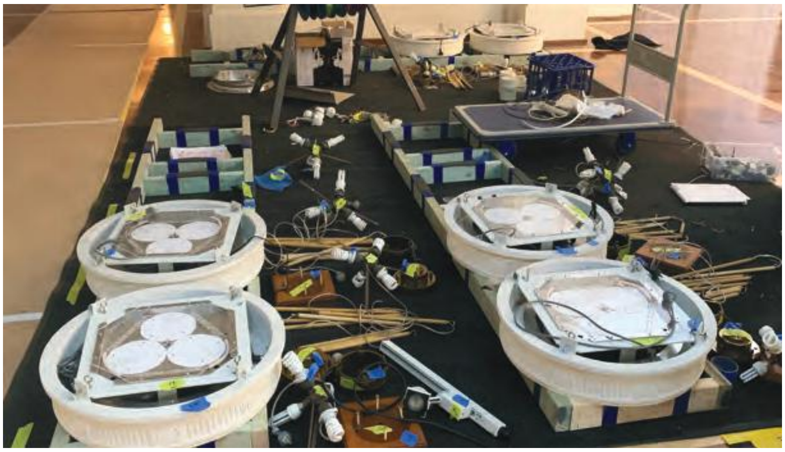
One of those Arup engineers is Alistair Morrison CPEng, Principal, Australasian Fire Engineeing Lead, and relationship manager between Arup and the Sydney Opera House.

"With significant landmark buildings like the Opera House and the Australian Museum, they have differing needs that change over time," Morrison says.

"Our role as consultants is to understand the problems they're facing by inquiring about the issues they're experiencing and listening to what their needs are and outcomes they're looking for.

"Arup is a big organisation that doesn't just do traditional engineering advice. We do all types of consultancy and advisory services. So we are able to connect our organisation, or the right people within our organisation, to solve those problems."

"AFTER THIS EXHIBITION IS FINISHED, ALL OF IT MUST BE ABLE TO BE DECONSTRUCTED SO THE ROOM CAN GO BACK TO BEING THE OPPOSITION PARTY ROOM AGAIN."



"THOSE INNOCUOUS SORTS OF CHANGES CAN BE QUITE AN ENGINEERING CHALLENGE."

Challenges within significant architectural buildings are constant, Morrison explains – not just because of varying internal needs but also, because those buildings must continue to perform in a dramatically changing environment.

The uses of the building and how it functions are often influenced by issues completely outside the control of its managers.

"There's continual pressure, particularly on performing arts venues – whether it's the Opera House or the Walsh Bay Arts Precinct," Morrison says.

"You have a changing audience expectation in the performing arts, as the interpretation of the world around us continually changes. That adds increasing demand on the buildings to adapt to the changing artists' needs. These days, flexibility is key."

One such example of improved flexibility at the Sydney Opera House was the Concert Hall renewal project. The project consisted of a complex upgrade of cutting-edge staging and theatre systems, enhanced acoustics and improved access for people with mobility needs.

"One of the features of the Concert Hall renewals were upgrades to the winching systems and motors," Morrison says.

"There was significant increase in loads that needed to be accommodated within the existing structure. The lead structural engineers Xavier Nuttall enabled a fourfold increase in the capacity of the ceiling structure for the motors and equipment."

The sustainable approach taken by the Arup team meant that the existing structure could be retained, reducing materials and minimising heritage impact

"These were substantial upgrades that had structural implications, spatial constraints and a number of changes to the design of the theatre," Morrison says. "It all meant we had to re-evaluate the safety and fire strategy."

Another recent project involved the transformation of the business offices on the north-west of the building to what is now called the Centre for Creativity.

IMAGE: ANNA KUCERA

ABOVE: Renovating the Sydney Opera House Concert Hall.

Heritage for engineers

Heritage and conservation engineering is now a recognised area of practice in the engineering profession, says Michael Taylor, Chair of Engineering Heritage Australia's national committee.

"These are the engineers who have the skills and knowledge to actually conserve things," he says.

"If you're going to do the things that this story is talking about, if you're going to carry out work on the Sydney Opera House or the WA Museum or Old Parliament House, the knowledge area around how to maintain those things in the future is heritage engineering.

"That has developed as a new area of engineering practice, one that is recognised by Engineers Australia as the heritage and conservation engineering area of practice."

The first steps in the Burra Charter process which, Taylor says, are often overlooked, are to understand the place and assess cultural significance

In this plan, the engineer, likely in consultation with various other stakeholders, figures out what is important, what is worth conserving, and why.

"What is the story that this thing you're conserving is telling us all?" he asks.

"Only once you know what you're trying to do, and why you're trying to do it, can you work out the techniques, or how to do it."

ABOVE: Alistair Morrison, Arup.

What was once a relatively bland office space is now adapted for flexible multimedia and educational experiences.

"Those innocuous sorts of changes can be quite an engineering challenge, particularly with structures where we've had to look at the impact on load paths as a result of opening up the space," Morrison says. "We looked at how changes integrate with the existing exit paths within the building to ensure safety is maintained and minimise changes required outside the project scope. ●

ANCIENT LEGACIES,

WORDS BY **SUSAN MULDOWNEY**

RESOURCE EXTRACTION HAS SOMETIMES HAD DISASTROUS OUTCOMES FOR THE CULTURAL HERITAGE OF INDIGENOUS AUSTRALIANS. WHAT CAN ENGINEERS IN THE MINING SECTOR DO TO BEST WORK WITH TRADITIONAL OWNERS?

IT STOOD for 46,000 years in the Pilbara region of Western Australia, the only inland site with evidence of continuous human occupation since the most recent Ice Age.

Then, on 24 May 2020, mining giant Rio Tinto blasted eight million tonnes of high-grade iron ore from Juukan Gorge, destroying the sacred Indigenous heritage rock shelter.

Although the detonation was legal under laws of the time, it caused immeasurable cultural loss and grief for the gorge's traditional owners, the Puutu Kunti Kurrama and Pinikura (PKKP) peoples.

And it sparked public outcry, a joint federal parliamentary committee investigation and serious questions about how companies can best work with Indigenous communities to protect culturally significant sites during mining operations.

These are important questions for engineers, whose skills are in high demand across Australia's mining industry.

What do you need to consider when mining in culturally significant sites? How can you navigate the challenges to ensure the protection of Indigenous heritage? And what are engineers' ethical obligations?

STRIKING A BALANCE

Australia's $470 billion mining industry has long been a

NEW DIRECTIONS

cornerstone of the economy: it operates 350 mines and employs about 264,700 people.

While the value to Australia is clear, its cost to cultural heritage is now being closely re-examined after the tragedy at Juukan Gorge.

The final report into the gorge's destruction, by the Senate's Joint Standing Committee on Northern Australia, found that Rio Tinto's actions demonstrated "the profound lack of care for Aboriginal and Torres Strait Islander heritage in this country".

It also highlighted serious deficiencies across Australia's Aboriginal and Torres Strait Islander cultural heritage legislative framework, and noted that the tragedy might be a catalyst for change.

The committee found that Rio Tinto's "poor communication with the PKKP" was a key element in the chain of events that led to the destruction of the Juukan caves. But it also noted that legislation designed to protect cultural heritage has, in many cases, directly contributed to damage and destruction.

The federal government has accepted the committee's recommendations to legislate new cultural heritage protections and to review the Native Title Act.

A spokesperson for Federal Resources Minister Madeleine King told *create* that legislative change must strike the right balance and that "protecting the environment and supporting industry is not mutually exclusive. The resources industry is of vital importance to our economy – it creates jobs and export earnings, funds schools [and] hospitals and is responsible for the high standard of living all of us enjoy.

"At the same time, the government is strongly committed to working with traditional owners and custodians to properly protect the history of the oldest living civilisation in the world. This includes developing new national standalone legislation to protect First Nations' cultural heritage."

MINING FOR CHANGE

While the details of the new legislation remain to be seen, many mining companies are taking a proactive approach to reviewing and improving their cultural heritage practices.

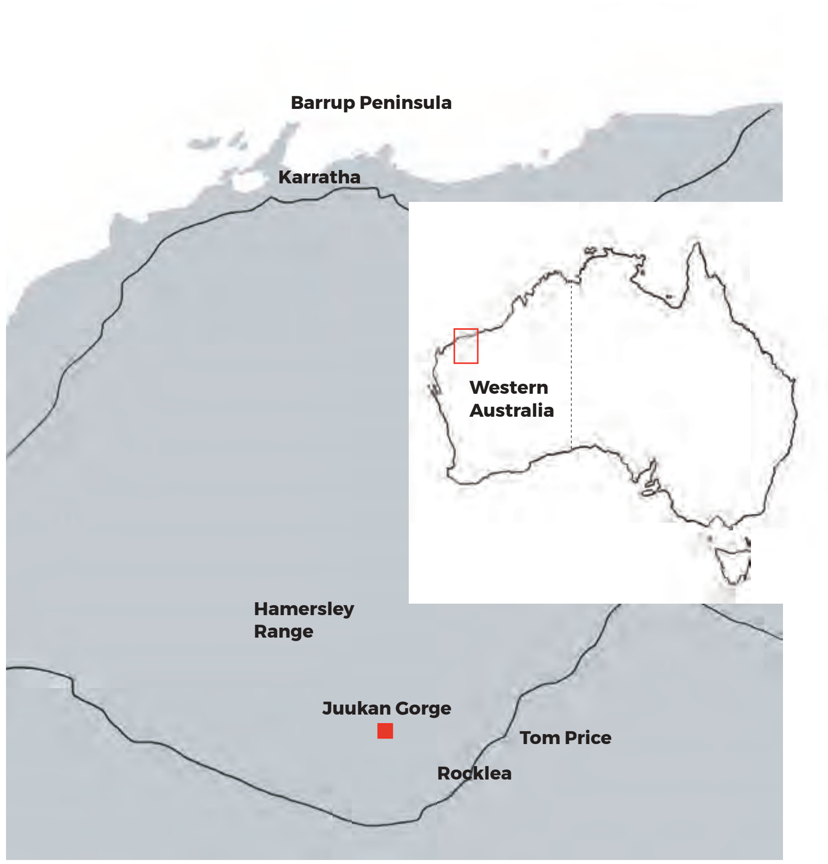
"The key to protecting Country and culture is for companies and traditional owners to have relationships built on mutual respect and trust," says Burchell Hayes, Chair of the PKKP Aboriginal Corporation.

A spokesperson for oil and gas giant Woodside says the Juukan Gorge incident prompted the company to review the risks associated with its own current and future activities, "to ensure that our management is thorough, transparent and underpinned by close engagement with Indigenous stakeholders and communities".

Woodside, which has operated for more than 35 years in ›

LEFT: Puutu Kunti Kurrama and Pinikura (PKKP) land in Western Australia. RIGHT: Location of Juukan Gorge on PKKP land.

"PROTECTING THE ENVIRONMENT AND SUPPORTING INDUSTRY IS NOT MUTUALLY EXCLUSIVE."



Murujuga – formerly known as Dampier Island – in Western Australia's Burrup Peninsula, acknowledges that its cultural heritage impacts were managed differently in the past, and that those practices no longer meet community expectations or the standards the company sets itself.

During the design and construction of Woodside's Karratha Gas Plant (KGP) in the 1980s, for instance, traditional owners were excluded from heritage processes.

"Instead, the Western Australian government, through the WA Museum, managed the heritage assessment and site clearances on behalf of the North West Shelf Project," explains Woodside's spokesperson, adding that 1832 Indigenous Australian petroglyphs were relocated from the KGP site to a compound at Hearsons Cove.

"Our approach matured with the design and construction of Pluto LNG in the mid-2000s. The traditional custodians were central to the heritage management process. They participated in comprehensive cultural heritage surveys and helped Woodside to develop our cultural heritage management plans.

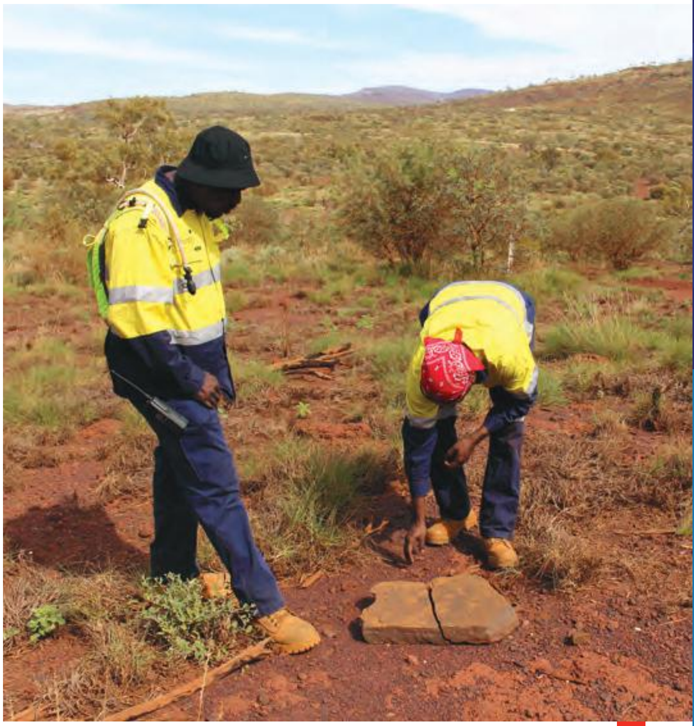
"Most importantly, their engagement – and the cultural heritage survey outcomes – prompted an engineering redesign of the initial Pluto liquefied natural gas plant to both avoid and protect the most significant heritage sites, including 92 per cent of the recorded rock art.

"The rock art and other artefacts that could not be avoided were safely relocated to a nearby natural setting with the guidance of traditional custodians."

However, controversy surrounding Woodside's operations remains; recent protests over its Scarborough natural gas project show the ongoing challenge of balancing mining operations with cultural heritage protection.

A group of traditional owners of Murujaga travelled to Geneva in July 2022 to address an expert panel of the United Nations Human Rights Council in an effort to prevent gas industry expansion bordering World Heritage-nominated rock art.

"THE KEY TO PROTECTING COUNTRY AND CULTURE IS FOR COMPANIES AND TRADITIONAL OWNERS TO HAVE RELATIONSHIPS BUILT ON MUTUAL RESPECT AND TRUST."



ABOVE (from left): Burchell Hayes, PKKP Aboriginal Corporation; Traditional Owners examine the impact of the destruction.

The significance of Juukan Gorge

Prior to its destruction in May 2020, a sacred site in Juukan Gorge was one of the oldest in the Pilbara region.

Archaeological records, such as bone pits that catalogued changing fauna, date back 46,000 years.

The final report to the Australian Senate described the Juukan Gorge tragedy as "just one example of countless instances where cultural heritage has been the victim of the drive for development and commercial gain".

In its submission to the Senate committee, Rio Tinto noted that prior to the destruction, new information on the significance of the Juukan rock shelters became available to the PKKP and Rio Tinto — but that it "is clear that various opportunities were missed to re-evaluate the mine plan in light of this material new information"..

In July 2022, with Traditional Owner oversight, Rio Tinto commenced re-excavation on Juukan Gorge 2 at the request of the Puutu Kunti Kurrama and Pinikura people as part of the broader Juukan Gorge project. Reparation discussions are ongoing.

However, Woodside says it has undertaken extensive archaeological and ethnographic surveys together with traditional owners, and that these surveys "have confirmed that the Scarborough project will not impact any onshore areas outside our current industrial footprint and will not impact any rock art".

THE ENGINEER'S ROLE

Dr Anne Hellstedt, Technical Excellence Leader – Australia and Asia Pacific, Australia, at global engineering management consultancy Mott MacDonald is Chair of Engineers Australia's National College of Leadership and Management Board.

She says engineers have both an ethical and professional responsibility to show respect for culturally significant sites.

"This includes working together with traditional owners when making decisions, and also playing a role in influencing the mechanisms for this to happen," she says.

She cautions that engineers must not allow this to become a "check-the-box" exercise to merely provide evidence of engagement with traditional owners.

"It's about having meaningful dialogue to reach decisions through consultation and collaboration," she says.

At companies like Woodside, all employees working on site participate in a cultural heritage induction, and the Murujuga Aboriginal Corporation provides additional cultural awareness training for Woodside staff on their traditional lands.

"Engineers need to listen and learn from Indigenous Australia so they can really understand the significance of these extraordinary places," says Hellstedt. "There's also a lot they can learn from Indigenous engineering."

ADDRESSING CHALLENGES

Woodside's spokesperson says the biggest engineering challenge in mining operations is ensuring there's enough flexibility in its design to accommodate cultural heritage requirements as they are identified.

"The appropriate management of Indigenous heritage sites varies from place to place, and site to site. For instance, in one case, the best practice – informed by traditional custodians – may be to fence off an area to prevent accidental entry, while in another, it will be essential that access is maintained for traditional custodians."

Often, the best approach is "early consultation with traditional custodians, and a sound understanding of the cultural values", he adds.

Hellstedt notes that the clean-up and remediation of legacy mines is also a challenge and a significant issue for Indigenous Australians.

"There are challenges at both ends of a mine's life cycle," she says.

"Again, the way to address these challenges is for engineers to work with the traditional owners, to communicate effectively and to not make assumptions."

CO-MANAGEMENT SOLUTION

In the years since the destruction of the rock shelters at Juukan Gorge, Rio Tinto CEO Jakob Stausholm says the company has been "changing the way we work in every part of our business".

One of the most significant changes is the signing of an agreement with the PKKP Aboriginal Corporation in May 2022, which sets out how it will work in partnership on a co-management approach to mining activities on PKKP country.

RIGHT: A Woodside gas processing plant. BELOW: Dr Anne Hellstedt, Mott Macdonald.

"ENGINEERS NEED TO LISTEN AND LEARN FROM INDIGENOUS AUSTRALIA SO THEY CAN REALLY UNDERSTAND THE SIGNIFICANCE OF THESE EXTRAORDINARY PLACES."

ABOVE: Rock art site on Burrup Peninsula, Western Australia.

Burchell Hayes, Chair of the PKKP Aboriginal Corporation, says the Juukan Gorge traditional owners support the new mining model, and stresses that co-management is not "an afterthought, or regulatory tick-the-box".

"It will apply to every aspect of a mine life cycle, from the planning to the closure and rehabilitation," he says.

"It requires mutual obligation and shared responsibility; the miner and the PKKP people must be committed to the best outcomes for it to work successfully."

Hayes adds that a co-management model makes

> **"THE PRINCIPLE OF CO-MANAGEMENT IS SIMPLE: WE WORK WITH THE MINING COMPANY TO PROTECT CULTURE, AND IT GIVES US AN EQUAL SAY IN WHAT HAPPENS ON OUR COUNTRY."**

clear "how we both communicate and resolve differences.

"It gives our people a greater role to work on the ground, monitoring and engaging with the mining people," he says.

"And it sets out what we, as traditional owners, want to achieve from what happens on our country: protection of culture and environment, and economic and social opportunity."

Hayes says that the corporation and its members decided to rewrite and rebuild the relationship with Rio Tinto in the aftermath of what happened at Juukan Gorge

"A major step forward in that relationship is an agreement for co-management of mining," he says. "The principle of co-management is simple: we work with the mining company to protect culture, and it gives us an equal say in what happens on our country." ●

ADVANCING INDIGENOUS ENGINEERING

Australia is home to one of the world's finest examples of ancient aquaculture and hydraulic engineering. In 2019, the Budj Bim eel traps, in the traditional Country of the Gunditjmara people of south-western Victoria, became the first Australian UNESCO World Heritage site to be listed exclusively for its Aboriginal cultural values.

The site dates back at least 6000 years to when Gunditjmara engineers developed and managed the hydraulics required to farm and harvest fish.

They comprise a vast network of weirs, dams and stone canals to manipulate water levels in various lake basins.

Some of the channels are hundreds of metres long and were dug out of basalt lava flow. The structures force eels and other aquatic life into traps as water levels rise and fall.

The canals also appear to have been used to create holding ponds to keep eels fresh until they were needed for food.

In 2011, Engineers Australia Victoria Division erected an Engineering Heritage National Marker for the Budj Bim Aboriginal Hydraulic Works, and members of Engineers Australia's National College of Leadership and Management Board were given a tour in 2018 by a traditional owner.

"A site like Budj Bim shows there's a lot engineers can learn from Indigenous engineering practices," says Hellstedt. "It became clear from our guide that the engineering thinking comes from caring for Country, and that the benefits flow from that. The observational skills when it comes to solving problems in the environment are just extraordinary, and I think there's so much power in that."

In universities across Australia, engineering faculties are also promoting the value of Indigenous engineering. The Bandalang Studio, an Indigenous knowledge systems space at the Australian National University, creates opportunities to embed Indigenous insights into core engineering modules.

Engineers Australia's Reconciliation Action Plan is exploring relationships with educational institutions, she says.

"We want to encourage Indigenous peoples to pursue a career in engineering," Hellstedt says. "But we also want to raise awareness of Indigenous engineering and how we can incorporate this knowledge into our day-to-day practice of engineering."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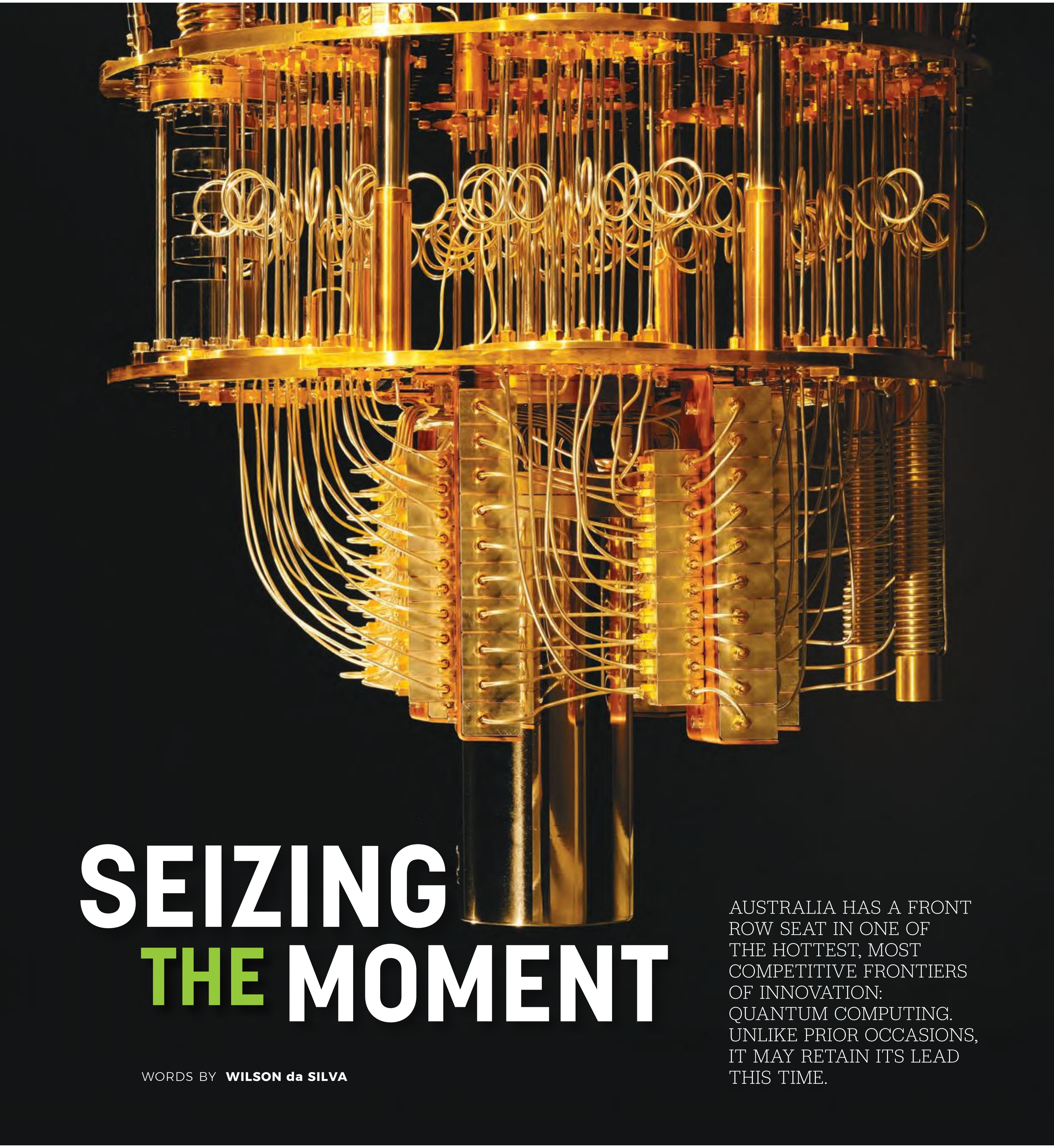


SEIZING THE MOMENT

AUSTRALIA HAS A FRONT ROW SEAT IN ONE OF THE HOTTEST, MOST COMPETITIVE FRONTIERS OF INNOVATION: QUANTUM COMPUTING. UNLIKE PRIOR OCCASIONS, IT MAY RETAIN ITS LEAD THIS TIME.

WORDS BY **WILSON da SILVA**

FEW PROBLEMS in transport engineering are as complex as managing a busy port.

Take Fremantle Ports: it juggles 12,500 trucks, 400 train paths and up to 15,000 containers each week, making the efficient flow of cargo critical.

This requires a wickedly intricate orchestration of all moving parts – marine side, quayside and landside – so that the right container is in the right terminal when needed, the right container is loaded on to the right ship, and the right truck enters the gates at the required time.

To manage this, supply chain operators rely on Monte Carlo simulations, a class of computational algorithms for demand modelling and integrated transport optimisation that can take days to calculate. And when things change – due to delays from weather, breakdown or traffic – the model becomes useless.

But this type of combinatorial optimisation is perfect for quantum computers, which can solve certain problems exponentially faster than existing "classical" computers.

Even though they are in their infancy, quantum hardware systems are now available that, coupled with classical computers, could crack the problem. And that's what Fremantle Ports is exploring.

"The beauty of quantum optimisation is that it can be done much faster, and the model can be adjusted in real time to take account of changes," Dr Cathy Foley, Australia's Chief Scientist, told attendees at the recent Quantum Australia conference.

Reporting on a previous visit, she marvelled at Fremantle Ports' ambition: "They're working on putting together a consortium among shipping lines, the container terminal and trucking companies to try to make this happen."

According to Foley, it's just one example of how the promise of quantum computing is seeping into all sorts of industries at an unexpected pace.

"In 2023, 'quantum' has entered the lexicon," she says.

"The government is very cognisant of the transformative potential of quantum technologies, as well as the need to ensure we make the most of this moment."

Australia has all the components to make the most of quantum computing, she says: excellent foundations built on decades of patient fundamental research, a lively research

LEFT: A quantum computer produced by IBM.

"THE BEAUTY OF QUANTUM OPTIMISATION IS THAT IT CAN BE DONE MUCH FASTER, AND THE MODEL CAN BE ADJUSTED IN REAL TIME TO TAKE ACCOUNT OF CHANGES."

ABOVE: Professor Michael Biercuk, Q-CTRL (left) and Dr Cathy Foley, Australia's Chief Scientist, speak at the Quantum Australia 2023 conference.

IMAGES: GRAHAM CARLOW/IBM; SYDNEY QUANTUM ACADEMY

community, an energetic cluster of start-ups creating novel solutions and applications – and governments keen to catalyse success.

"We're in a sweet spot," Foley continues. "And we have momentum."

Quantum computing is the next big technological revolution, likely to reap enormous benefits in the decades ahead – but it is also one of the most competitive frontiers of innovation.

Today, Australia has an enviable lead. But we've been here before: in 1949, at the very dawn of the computer age, Australian engineers were among the first to build a fully digital computer – CSIRAC. But we let that lead slip away.

KEEPING AHEAD

However, this time, Australian governments, researchers and industry are determined not to repeat history.

"At last count, we have in this country around 20 quantum-related companies," Ed Husic, Federal Industry and Science Minister, told the conference. "And the number is growing as Australian innovators make new discoveries and identify ways to commercialise them. Our firms are branching out overseas, and global heavyweights like Google are partnering with our research institutions to push the quantum envelope.

"We've long had an outsized impact on quantum research, and people who had their training in quantum in Australia are now in leadership roles – in research, industry and government, both here and abroad."

Husic promises that the Federal Government's National Quantum Strategy will be "the beginning of a conversation, not a punctuation mark. This is a critical opportunity for the country. We believe in the quantum ecosystem, and its role in national prosperity."

The line-up of heavyweight speakers at the conference suggests Australia is being taken seriously these days, with industry players such as IBM, Google, Microsoft, Amazon, venture capital firms IQT and Blackbird, as well as the US's Quantum Economic Development Consortium and the UK's National Quantum Computing Centre all taking part.

"Stop having small ambitions," says Professor Michael Biercuk, founder of the University of Sydney spin-off Q-CTRL, a $70.8 million quantum software startup

that counts Airbus, Salesforce and Main Sequence Ventures as investors.

After decades of research and more than $1 billion in government funding, the local quantum sector is at a tipping point, he says, and many Australian companies could become global leaders: "We have an opportunity to be everywhere in the value chain."

Nevertheless, Foley admits this is "difficult science, right at the edge of human capability".

UP TO THE LIMIT

While creating computers that operate on the principles of quantum mechanics – the physics of how matter and energy behave at subatomic level – has long been recognised as enormously powerful, it is a devilishly complex undertaking.

Unlike today's "classical" computers, which process information in binary bits – zeroes and ones – quantum computers use "quantum bits", or qubits, which can exist in multiple states at once.

Known as superposition, this allows a multitude of computation strategies – some exponentially faster, some simultaneous – far beyond modern computers. Another property, entanglement, allows quantum computers to process data in parallel.

"AT LAST COUNT, WE HAVE IN THIS COUNTRY AROUND 20 QUANTUM-RELATED COMPANIES, AND THE NUMBER IS GROWING AS AUSTRALIAN INNOVATORS MAKE NEW DISCOVERIES."

ABOVE (from left): Ed Husic, Federal Industry and Science Minister, speaking at the Quantum Australia 2023 conference; a panel discusses the role of government in the quantum ecosystem.

Although a nascent technology that is still delicate and unstable, quantum computers are already being used to simulate chemical and molecular interactions to help discover new drugs or novel materials.

As they scale up over the next decade, quantum computers will revolutionise cryptography, financial modelling and chemical engineering; easily solve complex optimisation problems; and accelerate some machine learning algorithms used for artificial intelligence.

It's this promise that's attracting so much investment: the global market is already valued at US$10.3 billion and growing fast.

Thanks to enormous investments by governments and commercial companies, the market is predicted to reach US$125 billion by 2030.

Modelling by the CSIRO in 2022 predicted quantum computing will generate $2.2 billion in Australian revenue by 2030 and nearly $6 billion by 2045, creating 8700 new jobs by 2030 and 19,400 by 2045.

The list of well-heeled Australian start-ups today is indeed impressive.

Among them is Diraq, which spun out of the University of New South Wales (UNSW) last year with $20 million in funding. While existing quantum computers have fewer than 100 qubits, Diraq's ambition is to put billions on a single chip within a decade.

And because it relies on the same CMOS fabrication technology as today's computers, fellow researchers don't bat an eyelid at Diraq's goal.

"People often think of landing on the Moon as our greatest technological marvel," Andrew Dzurak, Diraq's founder and a Professor of Quantum Engineering at UNSW, tells *create*.

"But I personally think today's CMOS microchips – with billions of operating devices integrated together to work like a symphony – are mankind's most important technical achievement. They have revolutionised society, industry and our way of life. Quantum computing will be equally astonishing." ●

IMAGES: SYDNEY QUANTUM ACADEMY

WORDS BY **WILSON da SILVA**

FORGOTTEN HERO

IT WAS A MARVEL OF ITS TIME — ONE OF THE WORLD'S VERY FIRST COMPUTERS — BUT FOR DECADES REMAINED A FORGOTTEN RELIC. TODAY, CSIRAC IS RECOGNISED AS ONE OF THE GRANDFATHERS OF MODERN COMPUTERS.

IN NOVEMBER 1949, CSIRO scientists in Sydney independently created what is now recognised as only the fourth digital stored-program computer in the world: CSIRAC.

It came hot on the heels of other "first generation" computers created in the UK and the US only a year earlier.

Using vacuum tubes instead of microchips, the noisy behemoth filled a room and consumed enough electricity to power a suburban street. While paltry by today's standards, CSIRAC was a stunning achievement at the very dawn of the computer age.

"It had a presence like Stonehenge, a scale that was impressive – big grey cabinets filling a room, humming like a power station," recalls Peter Thorne who, in the 1950s, at the age of 19, began working on CSIRAC; he went on to head up computer engineering at the University of Melbourne.

Before CSIRAC, a "computer" was a job: someone who wrangled equations on a mechanical calculator. Complex calculations would be split into many parts and distributed to individual "computers": row after row of mathematics graduates – mostly women – who would labour over arithmetic for hours, sometimes days, to complete a single task.

"CSIRAC was 1000 times faster than that – so it was like a supercomputer in its day," Thorne says.

MODEST BEGINNINGS

Compared with today's computers, CSIRAC was Lilliputian. Its main memory, what we would now call its RAM (random access memory), was just 2 KB – or four million times smaller than a typical laptop with 8 GB of RAM.

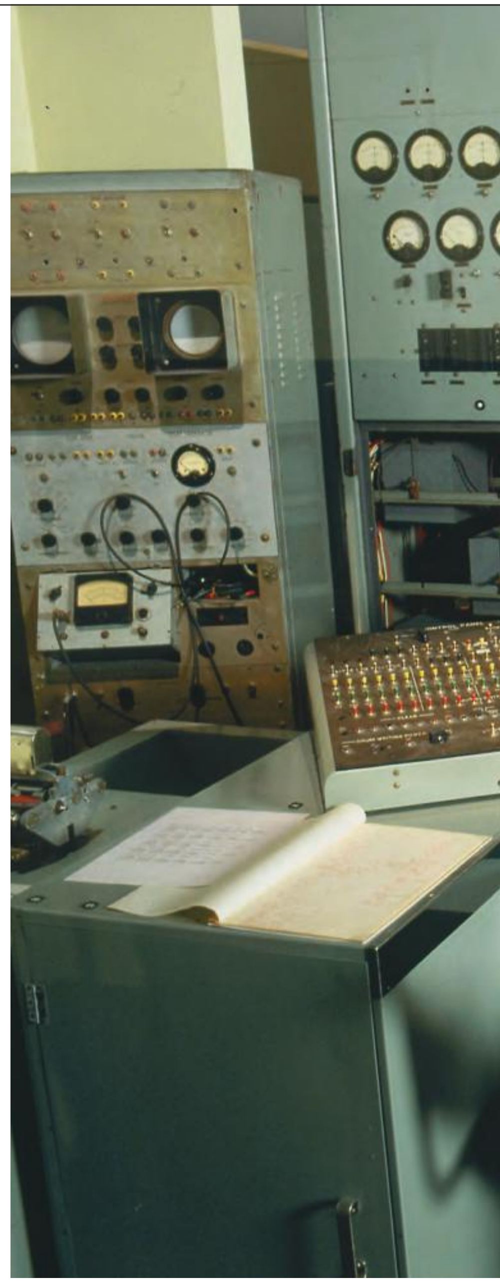
Its long-term data storage was 5 KB – or 25 million times smaller than the simplest thumb drive you can buy. And its top clock speed, or the speed at which it processed calculations, was 1 kHz, or 1000 cycles per second. Today's laptops are measured in gigahertz, or billions of cycles per second.

"It was an extraordinary piece of engineering, new and exciting. We knew we were at the beginning of something wonderful, we just didn't know how big it would be. We certainly didn't think that one day we'd have millions of times more computing power on our wrists," Thorne says, pointing to his Apple Watch.

"It's an iconic machine globally, and something Australia should be immensely proud of," says Wayne Fitzsimmons FIEAust, a former vice-president of Data General who went on to found technology companies in Australia. "It's miraculous what they were able to achieve. All the parts – valves, relays, wiring, switches, the software, everything – were made locally. It's the most Australian computer ever built."

CSIRAC's remarkable story began in Sydney in 1947, at the Radiophysics Laboratory of CSIR – the Council for Scientific and Industrial Research, the forerunner of CSIRO.

Calculations for a range of new applications, from radar to radio astronomy, had become laborious



ABOVE: CSIRAC designer Trevor Pearcey (top) and engineer Maston Beard. RIGHT: CSIRAC on display at the Melbourne Museum.

IMAGES: MUSEUMS VICTORIA; CSIRO ARCHIVES

"CSIRAC WAS LIKE A SUPERCOMPUTER IN ITS DAY."

and slow. The physicists and engineers – like others elsewhere in the world at the time – reasoned it was now practical to build a large-scale electronic calculator that could be pre-programmed to handle such hefty tasks.

So began the grand endeavour to build a massive electronic calculator. Maston Beard, a research engineer at the laboratory, teamed with Trevor Pearcey, a physicist and mathematician who had worked in the UK for many years developing shortwave and microwave radar.

In 1946, Pearcey began to design a large electronic computation device with a stored memory, which he called an "automatic computor". Finally, in early 1948, construction began with Beard in charge of engineering and Pearcey the design.

The moment of truth came in November 1949, when the first test program was run: a long multiplication routine.

And it worked.

To its creators it was a marvel, able to operate more than 1000 times faster than the best mechanical calculators of the time.

MODEST BEGINNINGS

RAM: 2 KB or four million times smaller than a typical laptop with 8 GB of RAM.

LONG TERM DATA STORAGE: 5 KB or 25 million times smaller than the simplest thumb drive.

TOP CLOCK SPEED: 1 kHz or 1000 cycles per second. Today's laptops are measured in gigahertz, or billions of cycles per second.

GIANT-SIZE

The jubilant team called its metal colossus the CSIR Mark 1, later renamed CSIRAC, for "CSIR Automatic Computer".

When fired up, it covered 40 m^2 of floor space, weighed 2.5 t and consumed 30 kW of power. Twenty years before computer monitors were invented, CSIRAC was using cathode-ray tubes – or small televisions – to display its internal workings.

It had no mouse or floppy disks: instructions were written on punched paper tape, and then "uploaded" via a feeder wheel.

A photo-electric detector would read each line of 12 holes on the spool of paper, row by row. An operator would sit on a ponderous grey metal console covered with toggles, switches and meters.

Once the hour-long testing procedure had been completed, and the paper "software" loaded, CSIRAC would fire up. Its row after row of metal cabinets covered in dials and gauges would come alive. Coloured lights, dotted in rows along its panels, would blink on and off as it processed its task.

Inside the cabinets, jumbles of thick wiring, mercury switches and vacuum tubes would do their job. When it was fully operational, CSIRAC had 2000 vacuum tubes in its innards – the glass-enclosed valves found in old radios.

Despite this early lead, the CSIRO decided that computers were "outside its purview" – a decision which left designer Trevor Pearcey deeply disappointed. In his view, Australia had thrown away a chance to lead the world in digital computing.

"We were living off the sheep's back in those days, so the potential wasn't recognised," says Fitzsimmons.

CSIRAC was moved to the University of Melbourne, where it was used for a decade before being decommissioned and going into storage.

To be fair, vacuum tube computers like CSIRAC were quickly overtaken by the arrival of transistors in the 1950s, which ›

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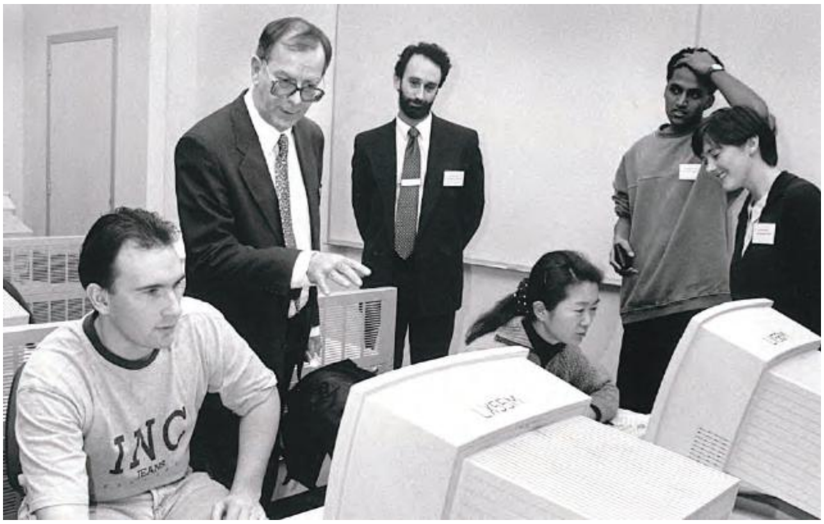


LEFT: Peter Thorne (centre) former head of computer science at the University of Melbourne.

made digital electronic computers easier and faster to build.

These led to microchips, which triggered the dizzying climb up the scale of Moore's law, where computer processors double in speed every two years.

Hence, while CSIRAC had a long operational life, it did the same amount of processing in 14 years that a smartphone can do in about a minute.

QUANTUM OF SOLACE

Today, a new chapter in computer technology is being written thanks to an explosion of investment by governments and venture capital in quantum computing.

While Australia may have missed an opportunity at the birth of the computer age with CSIRAC, the same cannot be said of quantum computing.

There's globally renowned research coming from Australian universities, and notable local start-ups, like Q-CTRL, which makes devices and software to improve the performance of quantum hardware; Silicon Quantum Computing, focusing on single-atom qubits for information processing; and Diraq, which relies on spin qubits and existing microchip technology used by today's classical computers.

"If these Australian companies make it, it'll be fantastic," says Fitzsimmons. "And we're right there at the beginning – there's strong backing and lots of money flowing in. So, it's very positive."

"I SEE PEARCEY AND THE CSIRAC STORY AS AN INSPIRATION OF WHAT AUSTRALIANS CAN DO."

Thorne agrees.

"We're giving it a much better shot this time," he says.

"Government and industry have a more sophisticated view of the significance of high technology and its potential. But it's still a hard road to hoe because this is an area that's exceptionally competitive."

Fitzsimmons is now chair of the Pearcey Foundation, created in 1998 in memory of CSIRAC's designer and which annually recognises innovation excellence in Australian information technology with a series of awards, debates and orations. He recalls meeting Pearcey in the 1960s, when Fitzsimmons was starting out in computer sales.

"He was an oddball guy, but a completely original thinker," recalls Fitzsimmons. "In 1946 he was already envisioning what he called an 'automatic encyclopaedic service delivered via a national teleprinter or telephone system'. That's basically electronic libraries and the internet.

"I see Pearcey and the CSIRAC story as an inspiration of what Australians can do." ●

IMAGES: UNIVERSITY OF MELBOURNE ARCHIVES; CSIRO ARCHIVES; UNIVERSITY OF MANCHESTER

The first computers

The difficulty with establishing a definitive history of computers is agreeing on just what a computer is.

Some early electro-mechanical calculators were able to do large-scale calculations as far back as 1941.

It's also difficult to assign a ranking to the operational dates for many first-generation computers, since much depends on the definition of "operational". Does it mean when the first test program was run, or when the computer started routine operation? Early electronic computers were room-sized, custom-built research projects. Once the basic operations were sound, the machines were continuously improved.

This list applies today's definition of a digital computer – an all-electronic machine capable of calculating operations, where the data and instructions are held in rewritable memory:

JUNE 1948

The Manchester Baby (or Small-Scale Experimental Machine), built at the University of Manchester, is generally accepted as the first electronic stored-program computer. It is upgraded in April 1949 into a fully operational machine and renamed the Mark I.

BELOW: The Manchester Mark-1.

MAY 1949

EDSAC, built at Cambridge University in Britain, goes live and runs its first stored program.

AUGUST 1949

BINAC, or Binary Automatic Computer, was designed for Northrop Aircraft Company and runs its first stored program. It is generally considered the first stored-program computer in the United States, although was limited in scope and never fully functional.

RIGHT: Pearcey with his creation.

NOVEMBER 1949

CSIRAC goes live, running its first program – a long multiplication routine.

WORDS BY **MICHELLE WHEELER**

PLASTIC PROMISE

NEW AUSTRALIAN TECHNOLOGY PROMISES TO MAKE PLASTICS INFINITELY RECYCLABLE. CAN IT DELIVER FOR THE ENVIRONMENT?

IT STARTED about five years ago in Professor Colin Jackson's protein engineering lab at the Australian National University (ANU).

PhD students Vanessa Vongsouthi and Matthew Spence wanted to study plastic-degrading enzymes found in nature, hoping to be able to recycle or degrade plastic more efficiently.

"It's a funny thing," says Jackson. "It's never really something where you're, like, 'It's done!' So, there was never a 'dance around the lab' moment … [although] there were a couple that were close to it. It's more a process of continual iterative improvement."

By 2020, the team had boosted the enzymes to the point the duo was featured in the university magazine, *ANU Reporter*.

The article was seen by Paul Riley, an entrepreneur-in-residence at Main Sequence Ventures, who had spent almost a year searching for plastic alternatives and recycling technologies.

Riley approached the ANU team, and plastic recycling start-up Samsara Eco was born.

RECYCLING 2.0

Vongsouthi and Spence's plastic-eating enzymes are able to revert complex plastic polymers to their monomer building blocks, ready to be made into new products.

"It's a type of recycling called molecular recycling," says Jackson, who is now Samsara Eco's Chief Science Officer.

"Rather than just melt and reform the bottle – which is essentially how we currently do it – you use the enzymes to break the bottle back down to the molecules that it was made from in the first place."

While plastic recycling already exists, traditional mechanical processes are a low-tech solution. Plastics are typically only recycled a couple of times, often into products like roads that remove them from the circular economy.

"It actually isn't recycling, it's 'down-cycling'," says biotechnologist Dr Jestin George, Samsara Eco's Head of Communications.

"The quality is too low for a lot of applications. What that means is, even though we've had recycling for a long time, something like 82 per cent of new plastics on the shelves are made with no recycled content. It's still just virgin plastic."

Unlike mechanical recycling, George said Samsara Eco can extract the colour from plastics. The technology can also handle multi-layered products, such as food packaging that is coated with a different type of plastic.

The technology can also recycle polyester fabrics, the polyurethane found in upholstery and carpet underlay, and polycarbonate, such as CDs and screens, George says.

Samsara Eco is now poised to partner with a global fashion brand on new plastic textiles.

One thing the company can't recycle at the moment is soft plastics – the sort that can be easily scrunched into a ball, such as plastic bags and bread bags. A solution to this problem has been in demand since the collapse of the REDcycle program in November 2022.

"In theory, we can design enzymes for every plastic," George says. "But in reality, there are some that are on our work order."

Recycling some products – such as the bioplastic PLA – should be straightforward, but the company hasn't tried them yet, George adds.

"Then there are ones that we think we might be able to do, but they are very challenging at a chemical level – the ideas our scientists have might not work. And those are things like polyethylene and polypropylene and PVC."

The company has also made strategic decisions not to pursue recycling plastics like polystyrene, which is being banned around the world.

"There will be no feedstock, so it doesn't actually make sense for us to do that one," George says. "And that's great news … we want to see these plastics being eradicated."

ABOVE: Paul Riley, Main Sequence Ventures (left), and Professor Colin Jackson, ANU.

"RATHER THAN JUST MELT AND REFORM THE BOTTLE, YOU USE THE ENZYMES TO BREAK THE BOTTLE BACK DOWN TO THE MOLECULES THAT IT WAS MADE FROM IN THE FIRST PLACE."

ENZYME LIBRARY

After Samsara Eco's launch, the company was quick to garner support from ANU, Woolworths and CSIRO's Main Sequence innovation fund.

In November, the start-up announced it had raised $54 million in a Series A funding – cash that will be used to grow the engineering team and expand its library of plastic-eating enzymes.

LEFT: Riley (left) in the lab with PhD student Vanessa Vongsouthi.

BREAKING IT DOWN

Samsara Eco's technology uses enzymes to attack complex plastics and revert them to their original chemical building blocks — like removing individual bricks from a house and using them to build a new dwelling.

"Plastic is a polymer," says, Samsara Eco's Chief Science Officer Professor Colin Jackson. "It's made up of a chain of monomers that are joined together. The enzyme [cracks] this chain to break it back down to the chemicals that were used to produce it in the first place. These chemicals can then be isolated, and then used to make brand new plastic."

Different enzymes can be used to target different types of plastic, including traditionally difficult-to-recycle products such as plastic fibres and mixed plastics.

Samsara Eco believes it can develop enzymes for any type of plastic, not just the ones scientists are working on today.

"Part of our technology is actually a proprietary algorithm," says Dr Jestin George, Samsara Eco's Head of Communications.

"Our scientists ... can mine the data that exists about all these organisms that have all these amazing evolutionary capabilities, and then design new-to-nature enzymes that don't exist. That's also why we can do different types of plastics."

"IT SHOULD RESULT IN A MASSIVE INCREASE IN THE AMOUNT OF PLASTICS THAT ARE RECYCLED, AND IT SHOULD REDUCE THE AMOUNT OF FOSSIL FUELS THAT WE NEED TO USE TO MAKE THE PLASTIC."

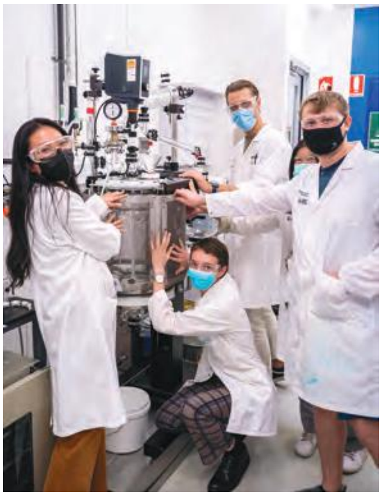
Jackson says enzymes found in the wild are interesting, but not really suited to industrial applications. They have evolved to help the bacteria eat plastic.

"But those conditions aren't the same as the conditions that we'd want to use in a factory to do this," he says. "So the main challenges have been around how do we engineer the enzyme to be more stable, so it can last longer in our reactors? How can we engineer it to be more active on the particular plastics that we want it to work on? And how can we engineer it so that we can make a large volume very cheaply?"

Another goal is ensuring the process has a low carbon footprint. It's been a challenge for other advanced recycling technologies, which can be expensive and come with a high carbon cost.

George says the carbon footprint of Samsara Eco's recycled PET comes in well below that of virgin plastic.

"We've made design and innovation decisions along the way that have always had that carbon footprint in mind," she says. "It has to be infinitely recyclable and circular, and it has to have a low carbon footprint. Otherwise, there's no point in doing it."



ABOVE: Plastic feedstock ready for recycling.
LEFT: Samsara Eco staff in the lab.

Samsara Eco has big goals. George says it will start producing recycled plastics for customers for the first time this year, with an aim of recycling 1.5 million t of plastic by 2030. The company plans to open a large-scale infinite recycling facility in regional New South Wales this year.

It's also pursuing policy change, including a minimum target for recycled plastics. The company has also been engaging with peak bodies, including the Australian Council of Recycling and Australian Fashion Council.

Jackson is excited to be working on a genuinely new technology.

"Once we get it working, it should result in a massive increase in the amount of plastics that are recycled, and it should reduce the amount of fossil fuels that we need to use to make the plastic," he says.

George says there's some eight billion tonnes of plastic waste on Earth – enough to supply the world's need for plastic more than 20 times over.

"It is really not acceptable to be making plastics from fossil fuels anymore," she says.

WORDS BY **KIM THOMSON**

ENGINEERING TO WIN

THE ENGINEERING TEAM AT THE AUSTRALIAN INSTITUTE OF SPORT PRODUCES A DIVERSE RANGE OF CUSTOM GEAR THAT ATHLETES TAKE TO PINNACLE SPORTING EVENTS. HERE'S HOW THEY GET IT DONE.

WHEN ANDY Richardson was studying aerospace engineering, he'd never heard of the job "sports engineer".

These days, he's Sports Engineer Lead at the Australian Institute of Sport (AIS), where he works with a team of eight other engineers on projects ranging from wheelchair seats and racing gloves to custom handlebar extensions for triathletes.

Richardson joined the AIS in 2018, after a 10-year stint in motorsports and time in the high-performance automotive industry. He describes getting across the 20 sports for which the AIS makes equipment as a fairly large learning curve.

"It still is!" he tells *create*. "Nearly every project we do is new and different."

But the rewards of the job are pretty special.

"[It's really satisfying] knowing that we've been able to produce something that supports an athlete and improves their performance," he says.

HIGH-TECH EQUIPMENT

Richardson's team works mostly with para-athletes who need highly customised gear.

"We make custom equipment to improve their comfort, reduce fatigue, and improve their overall performance," he says.

"IT'S REALLY SATISFYING KNOWING THAT WE'VE BEEN ABLE TO PRODUCE SOMETHING THAT SUPPORTS AN ATHLETE AND IMPROVES THEIR PERFORMANCE."

In the preceding week, the team had a practice session with wheelchair tennis player Heath Davidson, who was trying out a new custom chair that he will soon take on tour. Led by Senior Para-sport Engineer Matt Crawford and funded by Tennis Australia, the project has been close to a year in the works.

"The position of the seat is really important when it comes to agility and change of direction and speed – so Matt worked with Heath and his coach to develop that seat position," says Richardson.

Knowing the position of the seat, Crawford could delete the seat mounts and fully integrate them into the titanium frame, as well as reduce the diameter of the titanium tubes on the frame to reduce weight, one of the primary design objectives.

"He also gave some advice on a lighter, more stiff wheel set to buy, and a lighter custom footplate for Heath for his feet and shoes," Richardson adds.

He says understanding each athlete's particular needs is vital, and describes projects as very collaborative.

"As engineers, we need to continually be mindful about our limitations and qualifications," he says.

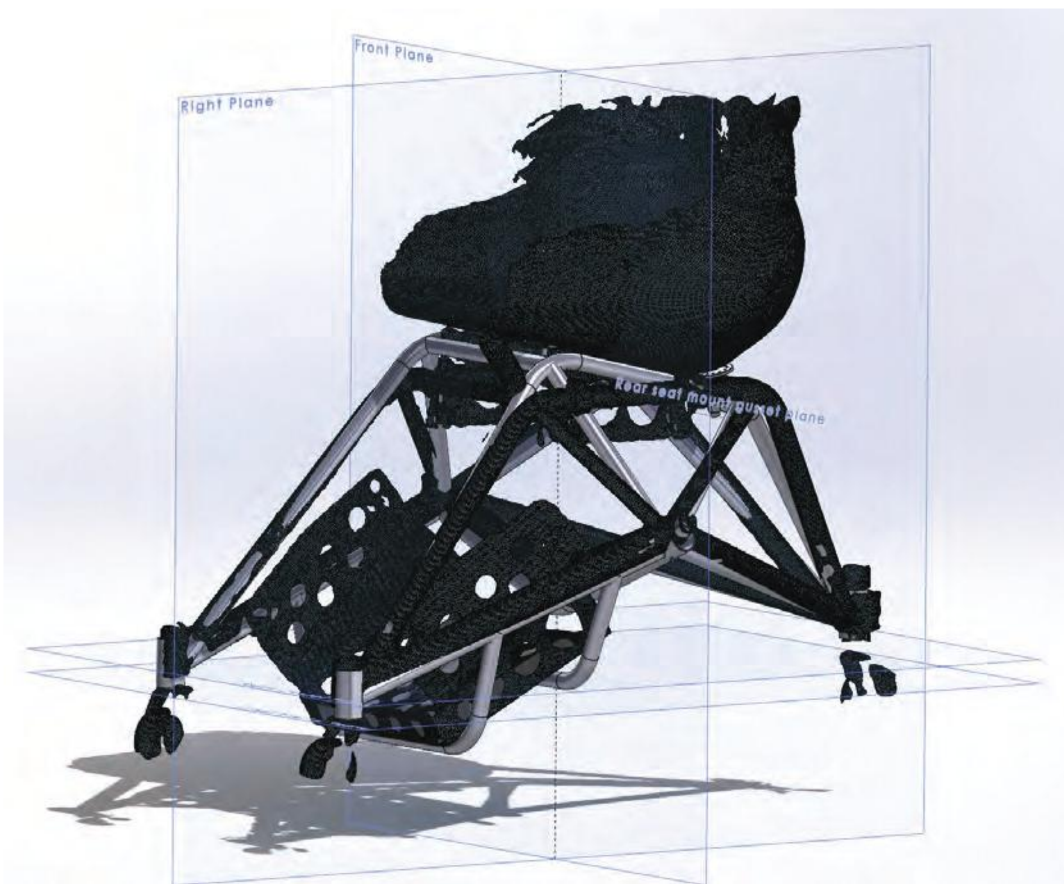
"So when it comes to engagement with different athletes and different capabilities, we need to be mindful of other relevant experts to collaborate with – experts such as orthotists, sports physiotherapists, physiologists, and so on."

One example involves athletes who are paraplegic or quadriplegic and need a custom seat or an interface designed for them.

"We need to understand the risk of pressure injury, because they may not have skin sensitivity," Richardson says.

"If there's a pinch point – or a pressure point – from the device that we develop, there's a risk that the athlete won't feel that and

BELOW: An original frame (left) and its new, lightweight counterpart.



they'll be injured and be unable to compete through that injury."

NEW GEAR FOR TOKYO

The AIS team had more than 100 pieces of equipment in play at the Tokyo Olympics and Paralympics.

One challenge it needed to overcome before the Games was for triathletes: they were slipping off their individually customised handlebars in humid conditions.

"I'd been struggling to find a solution for athletes who were having their forearms slip around on the bar extensions in the heat," says Richardson.

After a conversation with Dr Paul Collins, a mechanical engineer and former associate professor in design and product development at Deakin University who heads up engineering at AusCycling, Richardson's team came up with a novel solution.

"He suggested that we 3D-print TPU [thermoplastic polyurethane] patterns on to a neoprene fabric

substrate ... to provide grip for that interface between the athlete and the equipment – so that in the hot, sweaty conditions at Tokyo, the athlete wouldn't slip off the equipment," Richardson says.

OUT IN PLAY

It's still a thrill to see his gear being used by athletes at high-level sporting events, Richardson says.

"I actually went to the Olympics," he says.

CLOCKWISE FROM ABOVE: Cyclist Emma Jeffcoat uses bar extensions at the Tokyo Olympics; the Australian triathlon team's custom-designed bicycles: testing in Monash University's wind tunnel.

"WE'VE HAD INSTANCES WHERE EMERGING ATHLETES HAVE HAD SUCH DISCOMFORT IN THEIR WHEELCHAIRS, FOR EXAMPLE, THEIR TIME TO TRAIN HAS BEEN LIMITED TO 15 MINUTES."

Added value

One thing that has had a big impact on how the team works is 3D printing.

The AIS first adopted additive manufacturing in 2016, and now has a dedicated room with 10 printers, including a metal printer and machines that can print with continuous filament carbon fibre.

"We use 3D printing quite prolifically with our equipment, and it's no longer 3D printing for check fitting or prototyping; they're functional components that we send to pinnacle events now," sports engineer Andy Richardson says.

"The biggest change is the design mindset that we have to shift to with 3D printing, because almost any anything, any form, any shape, is achievable."

"To be on the phone talking with my family so that they could see the athletes and the equipment that we've developed on TV at the Games was pretty special."

And noticing a big improvement in an athlete's performance is always satisfying.

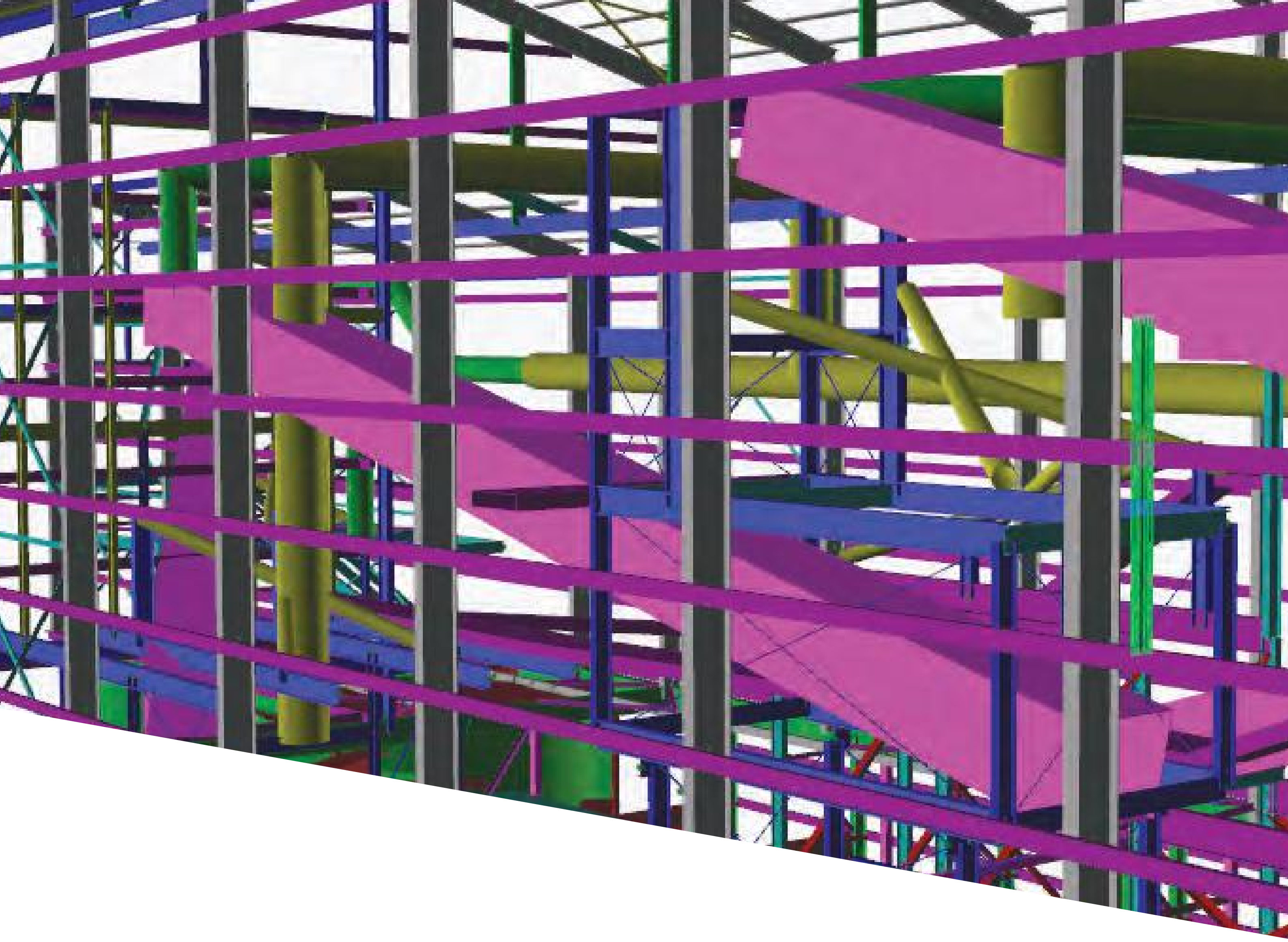
"We've had instances where emerging athletes have had such discomfort in their wheelchairs, for example, their time to train has been limited to 15 minutes," he says.

"We've been able to come up with custom seats and protective devices for them and subsequent training sessions have instantly jumped up to an hour long."

This was the case for wheelchair racer Robyn Lambird.

"We engaged with Robyn in about 2019. The coach approached us with this problem that Robyn was not comfortable, was in pain in the chair," says Richardson.

"Robyn went on to win a medal in Tokyo." ●



WORDS BY **JEN WALKER**

SQUARING THE CIRCLE

CREATING A VIBRANT CIRCULAR ECONOMY WILL REQUIRE A DEEP OVERHAUL OF THE WAY WE DESIGN AND MANUFACTURE PRODUCTS, AND EVEN HOW WE THINK ABOUT INNOVATION — AND ALI ABBAS IS LEADING THE CHARGE.

THE CIRCULAR economy will provide fertile ground for engineers, but according to Circular Australia's first Chief Circular Engineer, Professor Ali Abbas, the profession needs to enhance its understanding of what "circularity" means to make the most of the opportunity.

In fact, awareness is his top priority in his new role.

"People think they know what a circular economy is," he says.

"But ask 100 people, you'll get 100 different answers. So there is this important piece in getting people to properly understand and comprehend the circular economy – that it is much more than recycling. It is more around what I call this mantra of design, manufacture and reuse."

Abbas believes design is fundamental to all engineering disciplines, and that engineers need to work more closely with those outside the profession to

WHO IS ALI ABBAS?

Current positions:
- Chief Circular Engineer, Circular Australia
- Professor of Chemical Engineering, University of Sydney
- Director, Waste Transformation Research Hub, University of Sydney
- Founder and Director, Scimita Ventures
- Founder and Director, Trofica

Education:
- Bachelor of Engineering, University of Sydney
- PhD, Chemical Engineering, University of Sydney

Selected awards:
- PSE Model-based innovation prize
- Australia-Harvard Fellowship
- Academy of Technological Sciences and Engineering (ATSE) Fellowship
- Sydney Research Accelerator (SOAR) Fellowship

to solve problems, but need to be very conscious that, when doing so, they are not creating secondary problems that will hinder the transition to a truly circular economy.

He uses solar energy as an example, suggesting customers should lease solar panels and batteries instead of owning them or the critical minerals and materials they are made from. Customers should only need to focus on "energy as a service" rather than on the associated hardware.

"The circular design of the technology of the product, and the circular business model, go hand in hand," he says. "Without that connection, we will always end up back in the linear economy."

Manufacturing is another sector Abbas believes is set to boom in the circular economy.

"It's going to create innovations, new industries in reuse, and potentially new industries for managing those materials flowing back from the renewable sector – for example, end-of-life solar panels, end-of-life batteries and battery materials, and end-of-life electrolyser material," he says.

TRACK RECORD

Abbas isn't short of ideas. The chemical engineer is also the founding director of the University of Sydney's Waste Transformation Research Hub; co-founder of Scimita Ventures, which seeks to redesign innovation itself through a marriage of science, engineering and entrepreneurship; and founder of Trofica, which commercialises agricultural technologies to capture traditionally wasted nutrients and transform them into new foods and bio-products.

He also has a track record of translating research and ideas into real world solutions quickly.

Scimita, for example, was born out of a frustration with research and development being bogged down by bureaucracy, with the resulting innovations being misaligned with the real world.

"There's a lot of potential in Australia to do great things. I am of the view that more of the research we do in universities should be translated into greater impacts on society," Abbas says. "I'm becoming more and more critical of research that doesn't do that. I like to do it rapidly and translate it into something meaningful, whether it has commercial value or impacts people in terms of training or developing their skills in bringing the technology out to be developed in society."

Abbas says he asks hard questions of his university research team at the beginning of a project: "Where is this going? What impact will this have on society?"

His experience in research commercialisation and industry engagement, he adds, has informed his research, innovations

> **"THE CIRCULAR ECONOMY IS MUCH MORE THAN RECYCLING. IT IS MORE AROUND WHAT I CALL THIS MANTRA OF DESIGN, MANUFACTURE AND REUSE."**

ensure waste is designed out of products and processes from the start. Design, manufacture and reuse, he believes, should be more strongly linked through information flow.

"We need to open up the conversation much more to social scientists, and also to non-technical fields, so we can have a conversation around behavioural aspects, policy aspects and the human experience, so we can get these pieces aligned."

SECOND-ORDER PROBLEMS

Abbas, a Professor of Chemical Engineering at the University of Sydney, says engineers like

OPPOSITE: Professor Ali Abbas (left) is Circular Australia's inaugural Chief Circular Engineer.

Circular Australia is an independent not-for-profit company that aims to accelerate Australia's transition to a circular economy by 2030. Abbas joined the organisation at the end of 2022.

Lisa McLean, its CEO and Managing Director, says the company is excited to work with Abbas, "who is bringing fresh ideas and new approaches to traditional engineering practices and driving innovative design thinking for the new circular economy".

Coates

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1. Stronger, yet lighter than conventional systems

Conventional propping systems are often costly and inefficient due to their low capacity-to-weight ratio and bolted module-to-module connections. Quadshore 150 uses lightweight, high-strength steel elements to provide extra-high load-bearing support of up to 170 tonnes. The working load limit-to-weight ratio of a 3m assembly is at least 1.7 times higher than conventional systems.

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Quadshore's patented boltless connectivity eliminates the need for consumables. As a result, assembly and disassembly time is at least 60% quicker than conventional systems with the same capacity. A range of end sections means adjustments are faster and easier, too. These include an unloading jack that enables the screw jack to be disengaged with zero manual effort.

3. Safer due to less manual handling

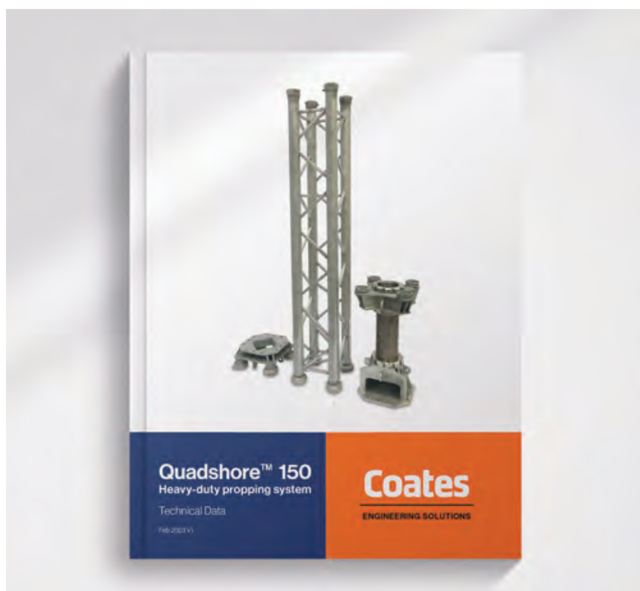
Conventional propping systems pose challenges around safety due to the need for manual handling and heavy machinery or equipment to unload and install it. As Quadshore 150 is considerably lighter with no bolted connections between its modular beams and a smaller site footprint, Coates expects the number of lost time injuries reported by customers will be dramatically reduced.

4. Reduced costs for labour, transport and consumables

Compared with a conventional propping system, Coates estimates that Quadshore 150 will reduce transport costs due to its lighter weight and higher capacity, which means less equipment, machinery and labour are required on site. The boltless design will also result in significant cost savings on consumables throughout the entire lifecycle of the product.

5. Lower carbon footprint due to less transport

Quadshore 150 is more environmentally sustainable than conventional propping systems in a number of ways. As it is made with higher-grade steel, there is less material used in its manufacture and less energy is required for its transportation. Boltless connections mean less waste of any kind of steel componentry.



Learn more

To request a copy of the Quadshore 150 technical brochure, or to book a Lunch & Learn session for your team, email engineeringsolutions@coates.com.au or call (02) 8796 5000.

"WE ARE MOVING TOWARD CIRCULAR ECONOMY TARGETS. WE ARE CREATING AWARENESS, GOVERNMENTS ARE LISTENING, AND WE HAVE THE TECHNOLOGY TO INNOVATE."

and technology development, supporting researchers to progress their work from publication into the commercial world.

Abbas says his appointment to Circular Australia allows him to "find that sweet spot where I am able to bring my passion for science and knowledge to connect with real world impact. I'm grounded in research fundamentals, but at the same time I'm able to help people, and the environment, by creating meaningful solutions."

CIRCULAR ENTHUSIASM

Abbas's passion for circularity arose about a decade ago, when he was an academic looking to solve problems around process engineering.

"We sought feedback from industry and local government, and they were telling us they had so much waste – various quantities and types – and they didn't know what to do with those potential resources," he says.

This prompted Abbas to create the university's waste transformation hub in 2015, a facility that supports the waste sector and other industries to create processes, technologies and solutions to address wastewater, carbon, plastics, organic waste streams and electronic waste.

The hub now funds itself through industry partnerships and contracts.

"I listen very closely to industry, to understand the pain points and work out how we can help them resolve those issues," Abbas says.

ABOVE: Abbas believes circular thinking must be integrated at a systems level.

"We are very industry and solution-focused in our approach, but we adopt systems thinking, and that's core to the Waste Transformation Research Hub approach.

"Systems thinking is about understanding scale: from the atomic scale in our fundamental research, all the way up to systems – such as, for example, chemical processing plants and how to engineer those – and then all the way through to 'systems of systems' where we are developing engineering solutions for the design and operation of new NSW Government SAPs [special activation precincts].

"We are now looking at place-based circular economy solutions inside these SAPs in regional NSW, building training capability in the regions to support the scaling that's required for these new circular industries and technologies."

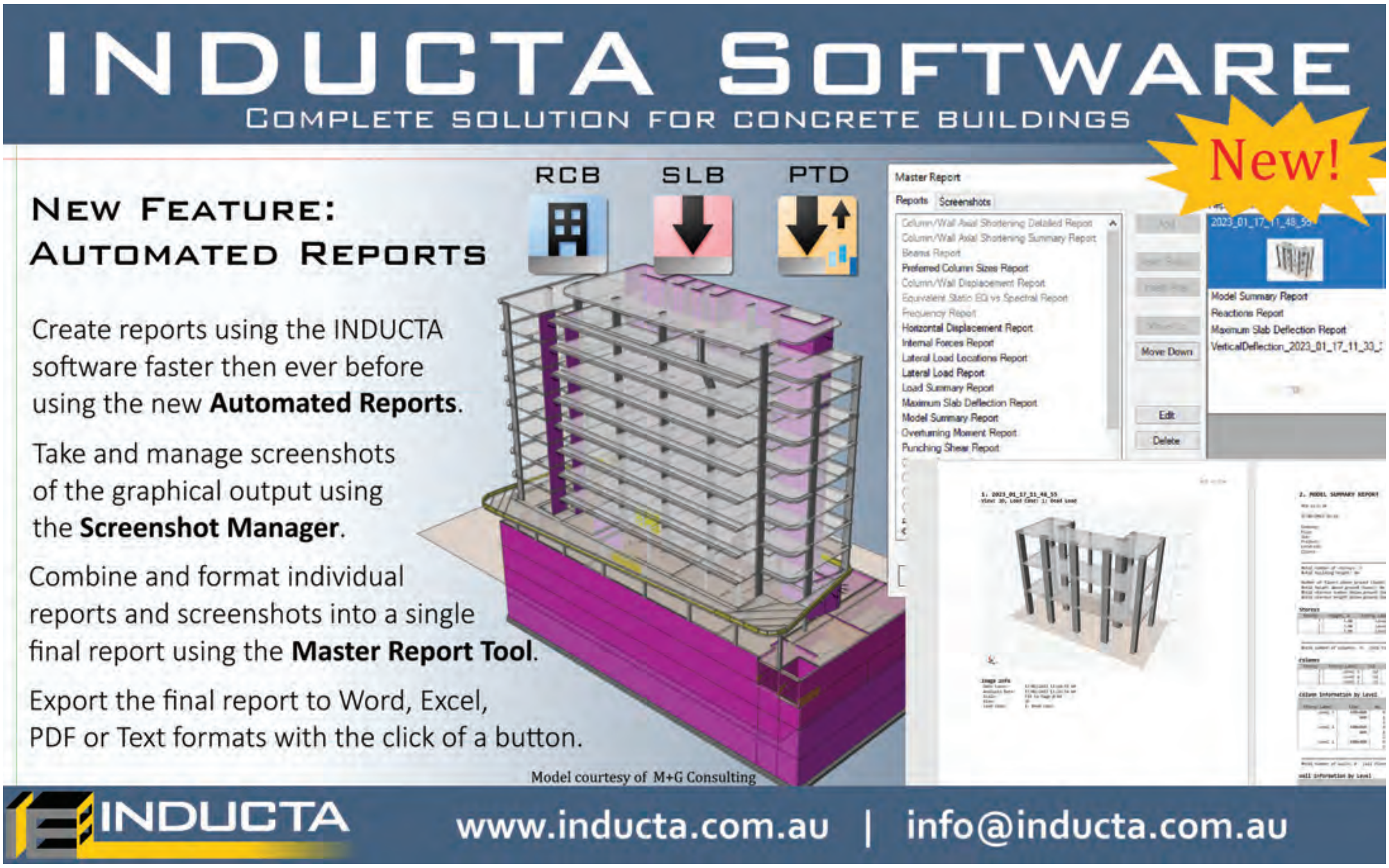
Abbas believes there is a risk of draining brain power from regional areas, as engineering students come to city universities, and often don't want to return.

His solution is to extend the work of the Waste Transformation Research Hub to regional NSW to allow students to access training and industry to access development – potentially creating secure jobs based on circular economy principles.

Collaboration between research, industry and government is vital to the success of the circular economy into the 2030s.

"It's fertile ground for engineers," he says. "There are a lot of excellent opportunities to innovate and create solutions, and my hope is that we capture those opportunities properly and avoid going back into a cycle of designing solutions that end up being problems, as we are seeing in the linear economy.

"The good news is that we are moving toward circular economy targets. We are creating awareness, governments are listening, and we have the technology to innovate." ●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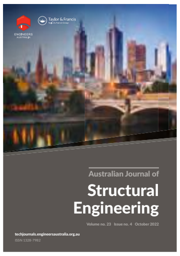
HIGHLIGHTS FROM AUSTRALIA'S MOST UP-TO-DATE ENGINEERING RESEARCH



ENGINEERING GRADUATE ATTRIBUTE ATTAINMENT MEASUREMENT MODELS

Journal: *Australasian Journal of Engineering Education*
Author: L. Ngu, C.C. Sia, M. Lee, R. Lakshmanan, J. Lai & T. Ling

—

This research aims to determine whether the indicative model that uses an indicator approach can significantly represent graduate attribute (GA) attainment. This research also explores assessment selection differences in GA attainment, using four measurement models, namely the indicative, explicit, GA assessment and culminating models, to measure GA attainment.

FE MODELLING PROGRESSIVE COLLAPSE ASSESSMENT OF STEEL MOMENT FRAMES

Journal: *Australian Journal of Structural Engineering*
Authors: M.A. Abid, A.El Ghoulbzouri & L. Ikharrazne

—

Progressive collapse is the failure of primary structural components produced by natural or abnormal events that may result in a total or partial collapse of a structure. This study sought to demonstrate the impact of bending moments, plastic hinges status and their rotations, displacements and ductility on structural enhancement and reduction of damage triggered by the failure of a primary structural component.

SECRECY SUM-RATE BASED ILLEGITIMATE RELAY SELECTION

Journal: *Australian Journal of Electrical and Electronics Engineering*
Author: V. Ozduran

—

This study presents the secrecy performance of sum-rate-based illegitimate relay selection policy for the two-way relay-assisted network. It considers two-hop multiple half and full-duplex two-way illegitimate relay networks and a limited number of friendly jammers, affecting the illegitimate relays. Results show that a large number of friendly jammers do not severely affect the system secrecy performance if they are located relatively far from the illegitimate relay terminal.

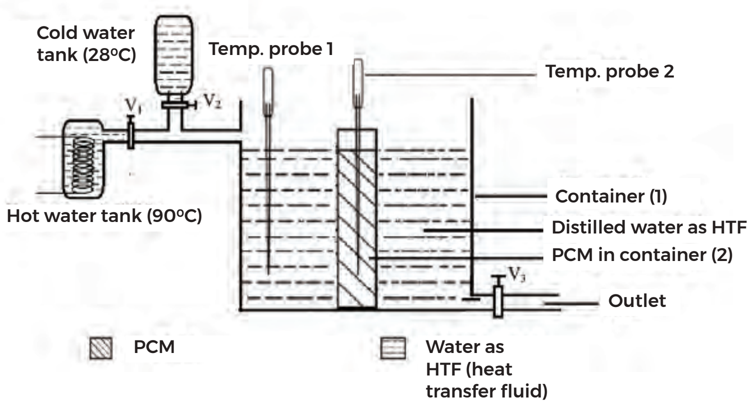
Experimental analysis for thermo-physical properties of phase change materials during accelerated thermal cycling

—

Journal: *Australian Journal of Mechanical Engineering*
Authors: O.A. Babar, V.K. Arora & P.K. Nema

Phase change materials (PCM) are widely used in thermal applications due to their latent heat storage capabilities. The use of PCMs has increased the thermal efficiency of these systems. The thermal stability of PCMs — the number of times that a PCM can be used for repeated melting and solidification — plays a key role in the selection of materials for a particular thermal application. This paper investigated thermochemical degradations of five paraffin waxes during 750 accelerated thermal cycles to determine their suitability as PCMs in solar dryers.

BELOW RIGHT: Schematic diagram of set up for heating and cooling cycle of phase change materials.



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CONFERENCES & EVENTS | APRIL – NOVEMBER 2023

19-21 JUN 2023
CONFERENCE ON RAILWAY EXCELLENCE 2023 (CORE)

Location: in-person *Melbourne*
Website: *core2023.org*
The premier technical conference in Australasia's rail industry calendar is celebrating 25 years in motion. This year will highlight the technological and industry developments that are increasing and enhancing the effectiveness of rail.
Register now

15-18 AUG 2023
AUSTRALASIAN COASTS AND PORTS

Location: in-person *Sunshine Coast*
Website: *coastsandports2023.com.au*
"Working together: 50 years of coasts and ports" is the conference theme for 2023. The conference will bring together professionals to focus on the technological, scientific, policy, planning and design issues related to our diverse and developing coasts.
Register now

07-08 SEP 2023
RISK ENGINEERING CONFERENCE 2023 (RISK 2023)

Location: in-person *Brisbane*
Website: *engineersaustralia.org.au/risk2023*
The conference theme for the 10th International Risk Engineering conference is "Risk Engineering for a Resilient 2030". It will bring together a wide range of engineering professionals and disciplines practising engineering-related risk management, risk analysis and risk-based decision-making processes when undertaking engineering activities.
Abstracts open

11-13 OCT 2023
SEVENTH WORLD ENGINEERS CONVENTION

Location: in-person *Prague, Czech Republic*
Website: *wec2023.com*
This event will bring together engineers, scientists and technical specialists as well as industry executives, policymakers, educators and students from around the world to exchange views and mobilise their crucial international role in contributing to solving the most critical global problems of humanity.
Abstracts and registration open

29-30 NOV 2023
CLIMATE SMART ENGINEERING CONFERENCE 2023 (CSE23)

Location: in-person *Melbourne*
Website: *engineersaustralia.org.au/cse*
Now in its third iteration, CSE23 will return in-person with a full technical and plenary program. Abstract submissions close this month. Don't miss your chance to inspire the profession to be at the forefront of achieving net-zero emissions.
Early bird registration open.
Submit abstracts by 12 April 2023

Celebrating Earth Day

21 APRIL 2023
EARTH SAVING TECHNOLOGY

Location: webinar
Website: *engineersaustralia.org.au*

In recognition of Earth Day, join Engineers Australia to learn how engineering nature-based solutions (NbS) is key to bringing the planet back to health. NbS projects simultaneously address the disappearance of key biological species while considering climate change adaptation, mitigation and resilience. This session will outline how AI-based technology is helping restore the planet's ecosystem.
Register now

AUSTRALIAN CONSTRUCTION ACHIEVEMENT AWARD

03 May 2023

Location: in-person *Melbourne*
Website: *acaa.net.au*
The Australian Construction Achievement Award (ACAA) recognises the best construction projects, delivered by the nation's very best construction companies. Finalists will be honoured, and a winner announced, at the ACAA black-tie gala dinner in Melbourne at Crown Palladium.
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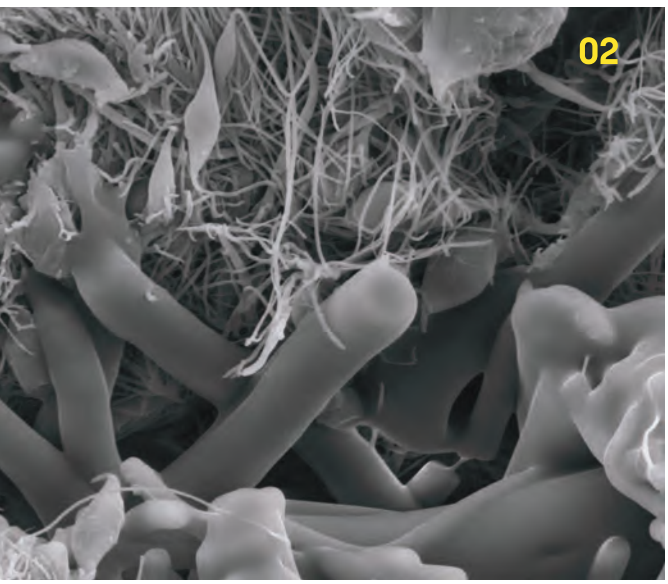
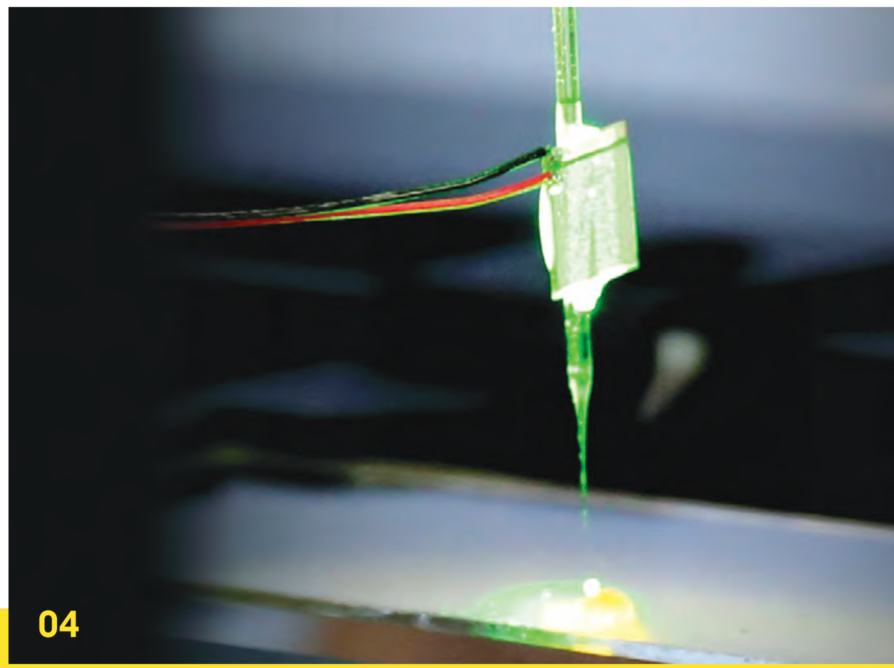
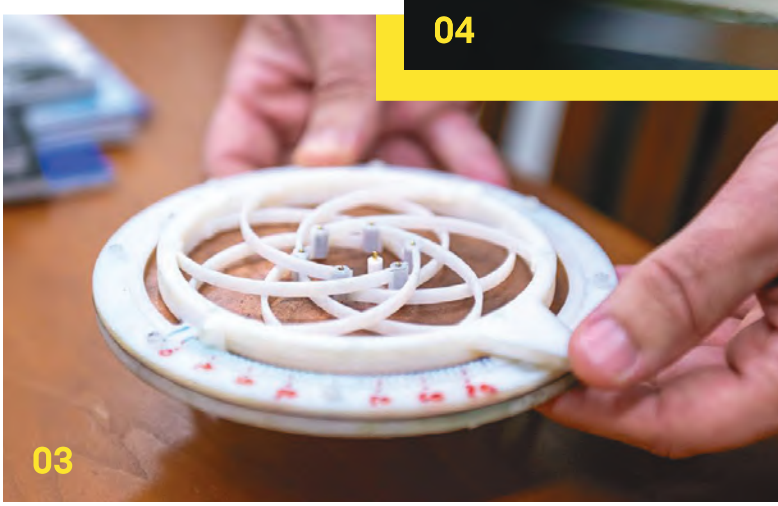
THE LATEST DEVELOPMENTS FROM AROUND THE WORLD.







01

"Smart" walking stick

A subject tests a "smart" walking stick that helps visually impaired people discern between different products. Image: Nico Goda

A team at the University of Colorado Boulder has combined a camera and computer vision technology with the very analogue technology of the walking stick to produce a smart device designed to help blind and vision-impaired people. The smart walking stick maps and catalogues a space and then guides its user via vibrations and spoken directions. "AI and computer vision are improving, and people are using them to build self-driving cars and similar inventions," says doctoral student Shivendra Agrawal. "But these technologies also have the potential to improve quality of life for many people." A smart walking stick could, for instance, be used to help people select an optimal seat in a café or choose among different products at a supermarket. The team cautions the technology is not designed to supplant the need to consider accessibility when designing spaces, but to help improve the independence of people with vision impairments.

02

Laminate material

Layers of polylactic acid (top) and ethylene vinyl acetate interact to produce electricity. Image: University of Melbourne

Engineers at the University of Melbourne have created a new laminate material that increases the amount of electricity they generate from movement by up to 400 times. Composed of repeating chains of tiny fibres of ethylene-vinyl acetate and polylactic acid, the material is structured in alternating microscopic layers; electricity is generated at the points of movement between the layers. "We altered the size and texture of these fibre layers and ordered them in very specific ways to optimise the friction and contact electrification, and ultimately generate the maximum charge," says Dr Peter Sherrell and Professor Amanda Ellis. "Since we can always introduce more interfaces by using thinner fibres, this type of energy generation is very scalable." The technology could be useful at small scales, such as providing energy to smart watches or pacemakers, but could also be used to monitor minor seismic activity or to power sensors in remote locations by drawing energy from vibrations in the ground.

03

Reconfigurable antenna

The reconfigurable antenna uses electromagnetic simulation software and 3D printing. Image: Jeff Xu/Penn State

Pennsylvania State University researchers have developed a reconfigurable antenna that is far more robust than conventional equivalents, with help from a compliant mechanism — the kind used in a binder clip. "Compliant mechanisms are engineering designs that incorporate elements of the materials themselves to create motion when force is applied, instead of traditional rigid body mechanisms that require hinges for motion," says doctoral student Galestan Mackertich-Sengerdy. "Compliant mechanism-enabled objects are engineered to bend repeatedly in a certain direction and to withstand harsh environments." This allows the antenna to change its operating frequencies as its arms bend, permitting more robust operation. Reconfigurable antennas are used in advanced communication network systems, such as 6G, because they can adjust their properties in real time.

04

Miniature robot arm

An oscillating glass needle acts as a tiny robotic arm, mixing liquids and moving particles. Image: ETH Zurich

Thanks to work conducted at Swiss university ETH Zurich, tiny robots designed to carry liquid through capillaries have been equipped with moving arms — akin to the manipulators on a far-larger factory robot. The robots can be used in microfluidic systems that have previously been difficult to automate and mean that future versions will not need to be custom designed for their specific application. The arm consists of a thin glass needle that oscillates with the help of a piezoelectric transducer. Altering the frequency of the oscillations creates vortices that can be changed and controlled. As a result, one single device can be used to mix and pump liquids as well as trap materials. "Until now, advancements in large, conventional robotics and microfluidic applications have been made separately," says Professor Daniel Ahmed. "Our work helps to bring the two approaches together."

Mohsin Bhatti
CPEng, Transformer Specialist
Hitachi Energy

MOHSIN BHATTI DESCRIBES ENGINEERING AS THE "BEST PROFESSION" — AND IT HAS CERTAINLY TAKEN HIM TO SOME UNEXPECTED PLACES.

WHEN THE 300 m-long cruise ship *Costa Luminosa* broke down, it was sailing hundreds of kilometres offshore from Cairns.

Stranded at sea, the vessel needed an expert to evaluate the situation and formulate a course of action.

Electrical engineer Mohsin Bhatti was working on an offshore mine site at the time, and he sprang into action. A helicopter carried him out to the troubled ship and he set to work.

"I had a look, did some diagnostics testing and did some verification," the Hitachi Transformer Specialist tells *create*. "I came to the conclusion that they could operate the ship at 20 per cent of the designated speed, and somehow they managed to manoeuvre the ship from that position to Singapore. We provided them with rapid response services by overhauling the existing transformer and installing a new one with similar voltage and class rating."

Bhatti's work does not always involve such dramatic heroics, but he loves it anyway.

"I'm very proud of being an electrical engineer," he says.

"I have gained years and years of experience, and I've become a globally certified industrial expert in my core competency."

Bhatti's role with Hitachi involves designing, developing and testing high-voltage transformers. It is specialised work that requires a great deal of expertise, but Bhatti has also found that trade skills can come in handy in his field.

That's why as well as being an electrical engineer, he's also certified as an electrician.

"I can go anywhere in Australia or New Zealand and do my electrical work, whether it's access to the substation or testing or energy industry relevant conversation," he says. "If I'm managing those multimillion-dollar assets in a substation, I want to make sure that safety has not been compromised and I'm safe to enter. So, for this reason, we need all the parameters and relevant monitoring details that I need to do on those asset inspections."

Bhatti is also a Chartered engineer, a qualification that he has found accords him a great deal of respect within the community, as well as helping him progress in his career.

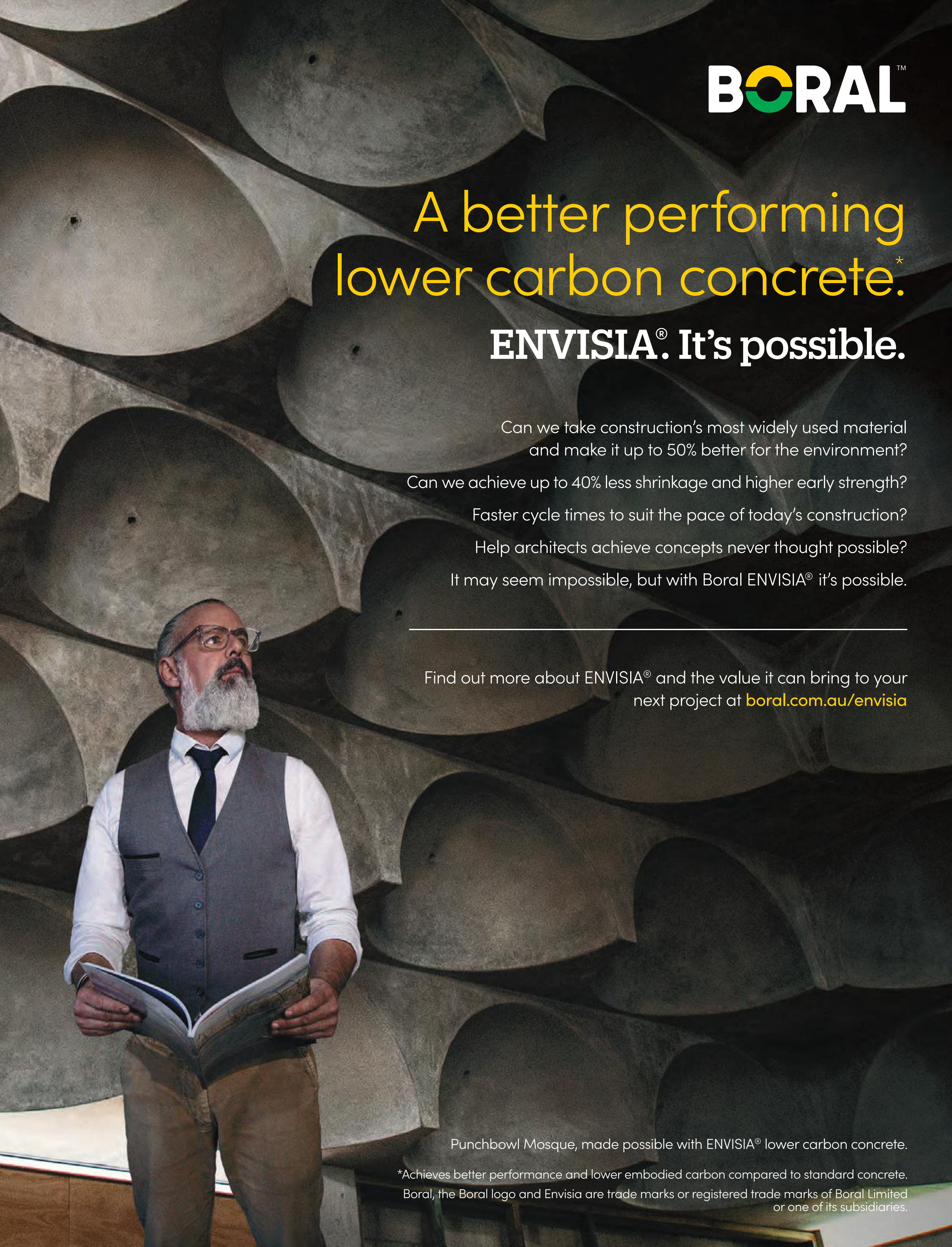
"Having the Chartered credential in a board meeting or C-suite meeting, where we have to discuss profit and loss from a technical perspective, puts me in a recognised and standout position," he explains.

"That gives me added value for myself and the organisation." ●

03 TIPS FOR SUCCESS

1. Be passionate about what you do.
2. If you love your work, everything else – money, reputation, career opportunities – will follow from there.
3. Look at engaging in community-based engineering work to build your skills.

IMAGE: CHARLES C. MEYER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