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ENGINEERS AUSTRALIA

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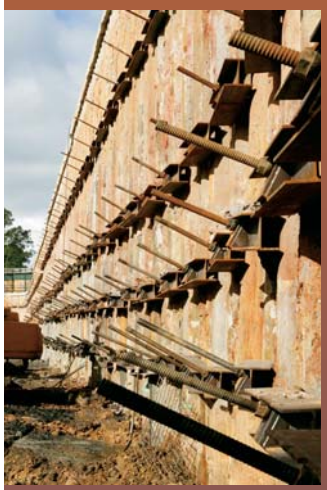

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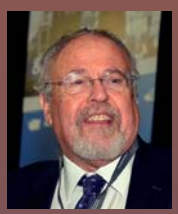
Phil Oxley, Mott MacDonald

"The Application of Dynamic Analyses for Testing of Non-Uniform Deep Foundations"
Samuel Paikowsky, Ph.D., Professor, University of Massachusetts Lowell



"Driven Displacement Pile Ground Improvement for Liquefaction Mitigation"
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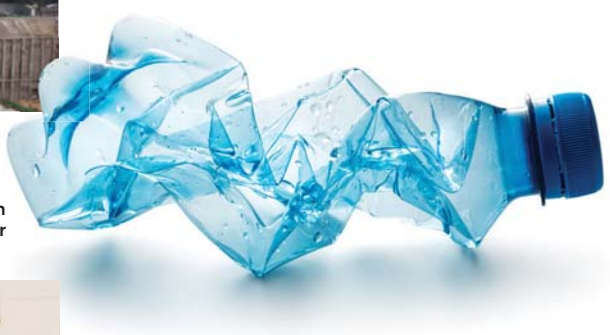

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Eye on the future

IN A TIME OF CHANGE, ENGINEERS ARE PREPARING FOR NEW FRONTIERS, NEW RESPONSIBILITIES AND NEW WAYS OF WORKING.

Time has flown and we find ourselves in a change of season and the final quarter of the calendar year. We are in the midst of a significant moment in history, with the passing of Queen Elizabeth II and ascension to the throne of King Charles III.

There has been much commentary on the impressive legacy of Queen Elizabeth, a 70-year reign through eras of political turmoil, pandemic and the evolution of the technological age.

A most enduring lesson from the Queen's life is that of service. Regardless of personal views about the monarchy or whether Australia should be a republic, Queen Elizabeth set an extraordinary example of sustained commitment.

Though it is a solemn time, there is optimism towards King Charles, a committed environmentalist with a keen interest in sustainability and the transition to clean energy.

Our cover story this month details the steep task ahead of Australia's first space commander, Air Vice-Marshal Catherine Roberts. It's AVM Roberts's role to put in place the systems, resources and relationships to assure Australia's access to space for ourselves, our allies and industry partners.

That's no small task, considering we are a little late to the party in terms of the maturity of our domestic sector and our involvement in the development of regulations and protocol around the use and protection of assets in space.

However, Australia has a significant geographical advantage in the space race, with burgeoning infrastructure already in place in our remote northern regions.

We then take a look at the integral role of ethics in engineering, a concept so critical to the profession we have established a micro-credential course, "Applying ethical decision-making practices to engineering projects".

"Australia has a significant geographical advantage in the space race, with burgeoning infrastructure already in place in our remote northern regions."

It is widely understood that it is not always easy to do the right thing. In truth, the ethical choice is often not the easy choice, nor the most popular.

But times are changing and engineers are shifting the balance away from what is easiest or fastest or cheapest to what is the right outcome for the organisation, its stakeholders and the environment.

This is where deep consideration of ethics is most valuable; when we examine any bias of self-interest, social context, profit or weight of expectation that might colour our decision-making. It takes moral courage to do the right thing, as enshrined in the Engineers Australia Code of Ethics and listed among the competencies for Chartered status.

Also in this issue is an important discussion on mental health in engineering. Leading organisations understand that positive attitudes towards mental health are a part of organisational culture that is so pervasive as to influence workflow and personnel policy as well as being a key part of work health and safety strategy.

Mental wellness at work is not any one person's responsibility; it is modelled from the top, a feature common among organisations rated as employers of choice.

Today's flexible working life blurs the lines between home, the office and the job site, and with more people working in isolation, forward-thinking organisations are finding more resourceful ways of keeping their people connected and well at work.

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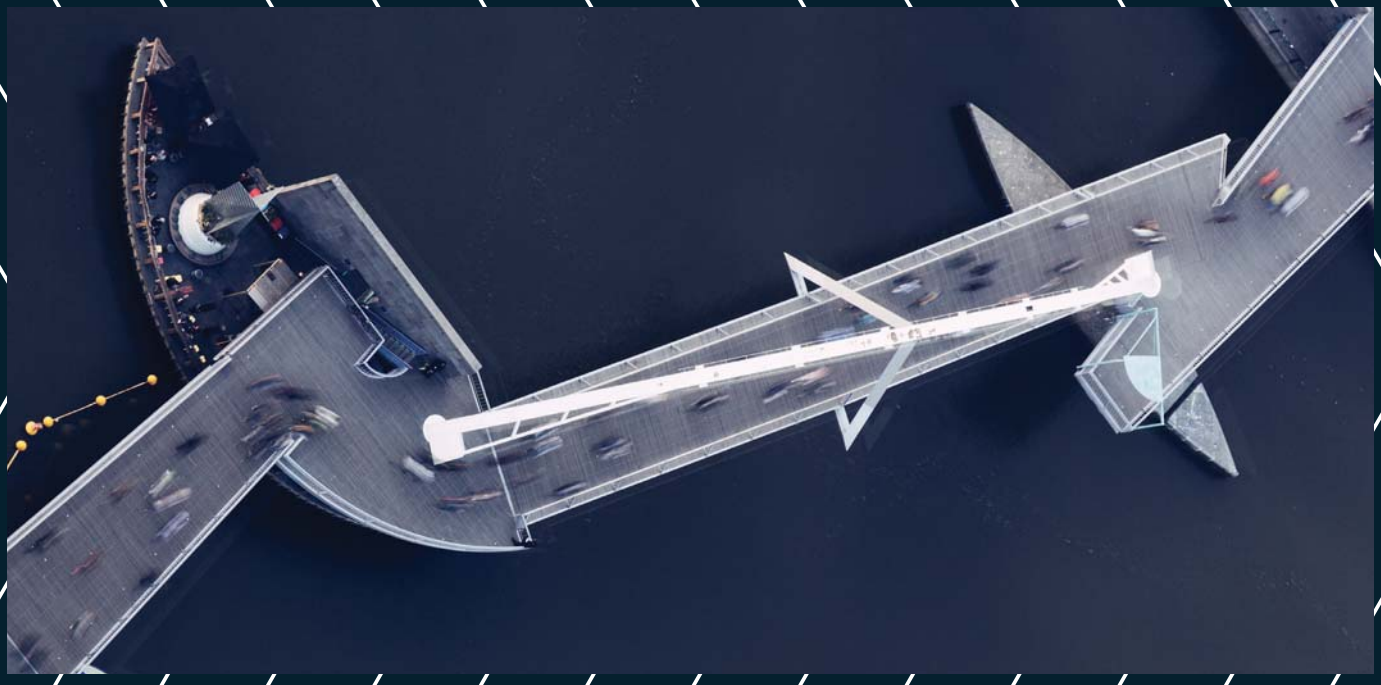

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All sorted

CSIRO ENGINEERS HOPE A NEW SMART BIN WILL MAKE RECYCLING EASIER AND MORE EFFECTIVE.

THE CSIRO'S Ending Plastic Waste Mission has a formidable challenge: it is aiming for an 80 per cent reduction in plastic waste entering the Australian environment by 2030.

NSW alone generates 800,000 t of plastics every year, with just 10 per cent being recycled. The wide range of plastic waste materials poses unique challenges for the recycling process. The contamination of one type of plastic by another can also cause serious processing problems.

For the past year, electronics engineer Dr Wei Ni has been part of the CSIRO Ending Plastic Waste Mission, working with the University of Technology Sydney (UTS) to develop a smart bin that can sense and separate different types of waste containers.

For National Science Week this year, Ni and his team demonstrated a prototype of the Smart Bin that can sort waste into metal, glass, and high-density polyethylene (HDPE) and polyethylene terephthalate (PET) plastic.

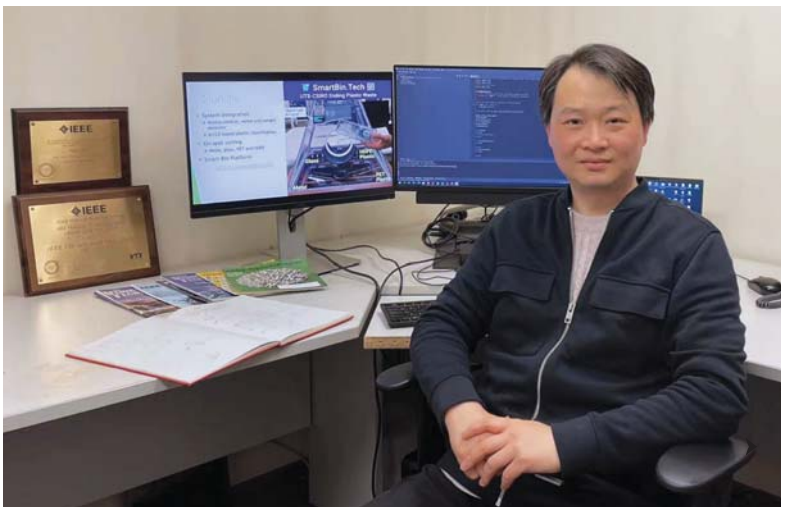
To sort waste at the point of capture, the device incorporates Internet of Things, sensing, robotics, artificial intelligence and infrared spectroscopy technologies.

"When a container or bottle is put into the bin, our weight sensors will first check if it is glass, which is substantially heavier than the rest. If it's not, the object moves to the next stage where sensors will check if it is a metal can," says Ni, who holds the title of Principal Research Scientist at CSIRO.

The next stage uses AI-based image processing to determine whether the plastic bottle is PET, typically used for beverage container bottles, or HDPE, typically used for shampoo bottles.

"We have different sensors to assess a container over multiple steps until we find the right category for it," says Ni.

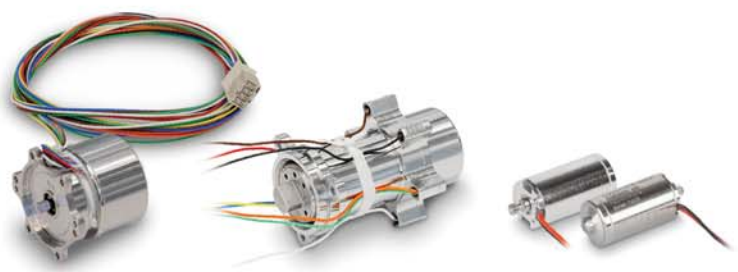
"A robotic arm inside the bin will spin around and find and place the bottle or can in the correct sub-recycle bin."



RIGHT: Dr Wei Ni, CSIRO.

"A ROBOTIC ARM INSIDE THE BIN WILL SPIN AROUND AND PLACE THE BOTTLE OR CAN IN THE CORRECT SUB-RECYCLE BIN."

maxon motors on Mars



DC motors from maxon have been used in virtually all successful robot missions on Mars. More than 100 of these drives are already on the Red Planet including the Perseverance rover and the helicopter drone Ingenuity.

Ingenuity Helicopter
Ingenuity made history when the first powered, controlled flight took off in the extremely thin atmosphere of the Red Planet. Subsequent flights of incrementally farther distances and altitudes have also been a success. There are six 10mm brushed DCX micromotors used to control the tilt of the rotor blades, which determines the direction of Ingenuity's flight. The drone weighs 1.8 kilograms, is solar powered, and is designed to take aerial photographs. This experiment primarily tested the concept for further drones of this kind.

Perseverance Rover
Perseverance rover's mission is to collect soil samples for analysis on Earth later, including looking for signs of previous life. maxon's precision DC motors and gearheads are in numerous mission-critical tasks. They power the small robotic arm in the rover which moves the valuable samples from station to station. The motors are based on our standard industrial products: a flat, brushless DC motor and a planetary gearhead with a diameter of 22mm. maxon's brushless DC motors are also used for sealing and depositing the sample containers.

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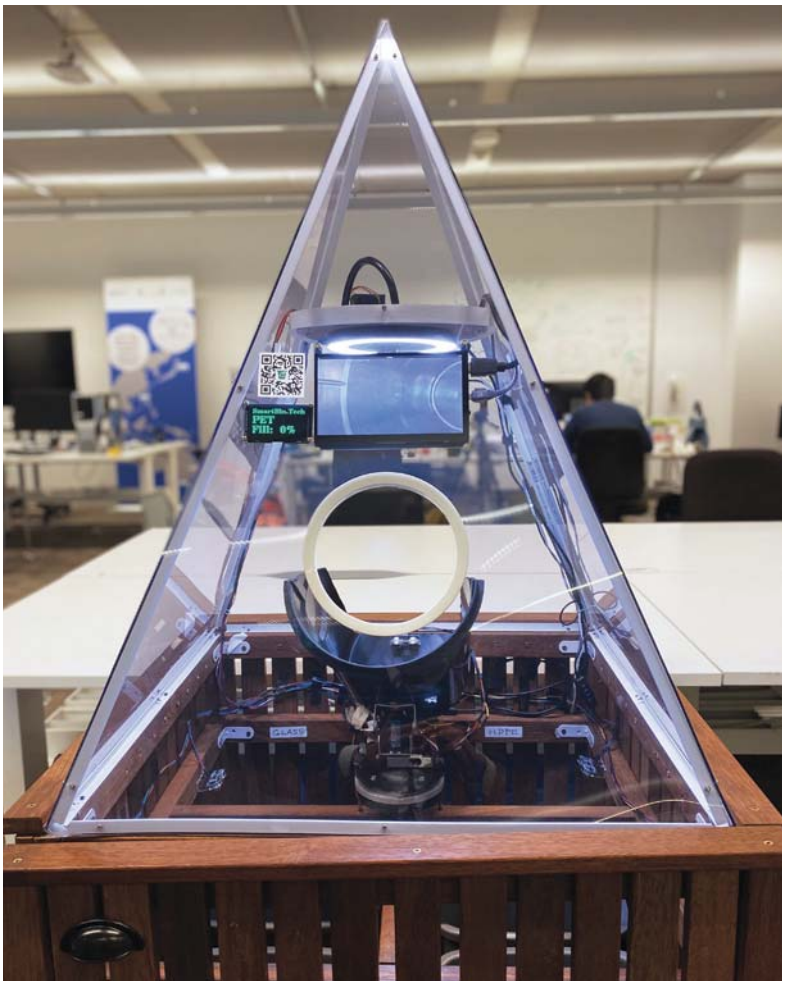

Disposable data

The CSIRO Smart Bin's waste data could be used to generate new insights and Dr Wei Ni is keen to explore this aspect.

"When I look at what I put into my household bin, it could expose my lifestyle, diet, medication, whereabouts, health condition," says Ni.

His plan is to use the latest differential privacy method to protect and anonymise the data, so the information remains useful while protecting the privacy of whoever throws waste into the bin.

ABOVE (from left): The Smart Bin, displayed at the University of Technology Sydney; Ni (left) inspects the technology with some students.

The prototype's results have been encouraging.

"We achieved close to 100 per cent accuracy during the testing stage," says Ni.

He is also working on a solution to deal with instances when incorrect items are added to the bin.

"There is a potential for us to create another sub-bin inside the bigger Smart Bin. Anything which cannot be categorised into glass, metal, PET or HDPE could end up in the fifth bin. This could be our next step."

This initiative also has the objective of supporting the transformation of waste into a resource. Victorian small business Casafico already manufactures commercial construction materials from recycled glass, newspaper and polystyrene, much of which is sourced through an online waste exchange marketplace.

"One big purpose of this Smart Bin is to educate," says Ni.

"We want to demonstrate the recycling concept and allow people to see what's happening inside the process. This will promote recycling awareness in the community and also improve social responsibility."

Ni himself learned from the process.

"I personally was not aware of the difference between PET and HDPE until I went on this journey," he says.

"WE NEED TO TREAT PLASTIC LIKE A RESOURCE AND A COMMODITY, RATHER THAN AS WASTE."

"In a small monitor on top of the glass, you will see how an item is categorised. We hope the general public will understand that plastics are actually different and need to be recycled in different ways. Only by doing that will waste products become assets and generate additional value rather than being a burden for our society and the environment."

Dr Deborah Lau, Lead for the Ending Plastic Waste Mission, believes we all need to change how we use and how we think about plastic to achieve the mission's ambitious goal.

"We need to treat plastic like a resource and a commodity, rather than as waste," she says. ●

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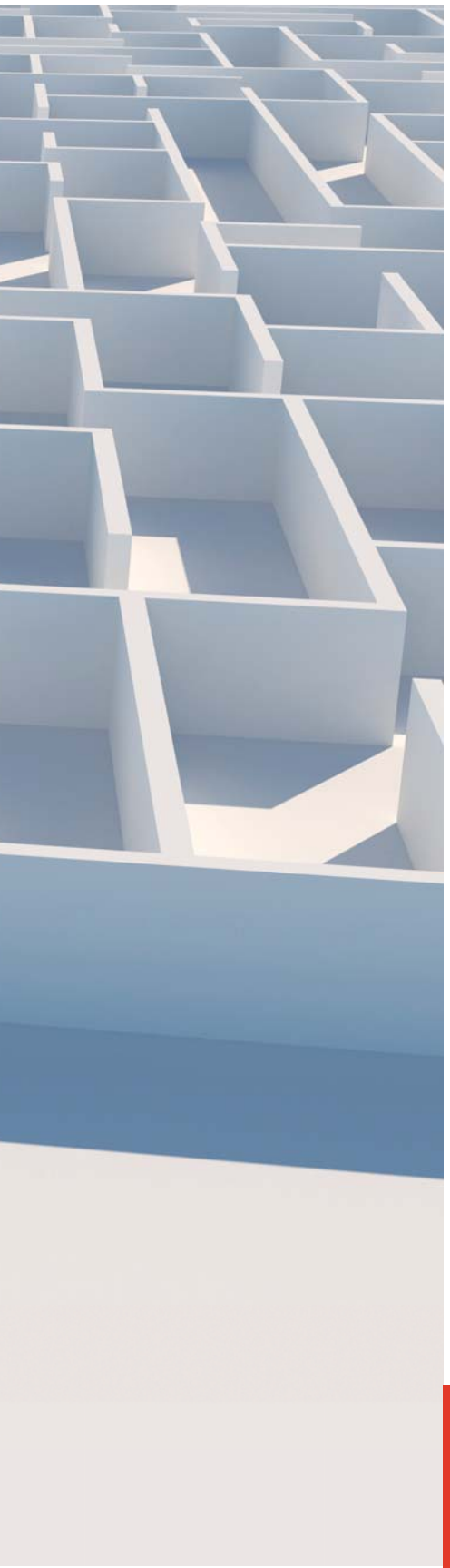
WORDS BY **CHRIS SHEEDY**

TOUGH CHOICES

WHAT DOES AN ETHICAL DILEMMA LOOK AND FEEL LIKE IN ENGINEERING? AND WHAT SHOULD ENGINEERS DO WHEN THEY RECOGNISE ONE?



THERE'S GREAT responsibility that comes with being a member of a profession that Australians regard so highly, says Nick Stanton FIEAust CPEng, Director of I2I Collaborative Executive Solutions.

"As engineers, we're deeply involved in integrity and trust," says Stanton, who also facilitates the learning component of Engineers Australia's Ethical Practice micro-credential.

"We're maintaining that every day through engineering activities. We achieve it by making good and right decisions based on our code of ethics. Unethical work is not tolerated."

The decisions engineers make must be consistent with the expectations of Australian society, he says. Increasingly, engineering organisations are also experiencing pressure from within to ensure ethical decision-making.

"AS ENGINEERS, WE'RE DEEPLY INVOLVED IN INTEGRITY AND TRUST. WE'RE MAINTAINING THAT EVERY DAY THROUGH ENGINEERING ACTIVITIES."

ABOVE: Nick Stanton, Director, I2I Collaborative Executive Solutions.

And so, when the public hears of residential buildings with serious engineering defects, and of residents abandoned by developers who have hidden behind corporate veils and phoenixed into other forms, it reflects on the entire profession.

Avoiding such issues comes back to making decisions with integrity, Stanton says. And that, in the end, is all about ethics.

"People say it's easy to do the right thing. Actually often it's not," says Stanton, who is also a retired military officer and a recipient of the Conspicuous Service Cross for leadership and innovation.

"When you're making a decision, ask yourself if there is integrity or self-interest behind what you considered before you arrived at that decision? Was your decision vulnerable to bias or to being undermined?

"In engineering there are so many different stakeholders. You can be swayed by so many other factors without even realising it."

How does an engineer ensure they're making the right, ethical decision? It begins, Stanton says, with a deep knowledge of yourself.

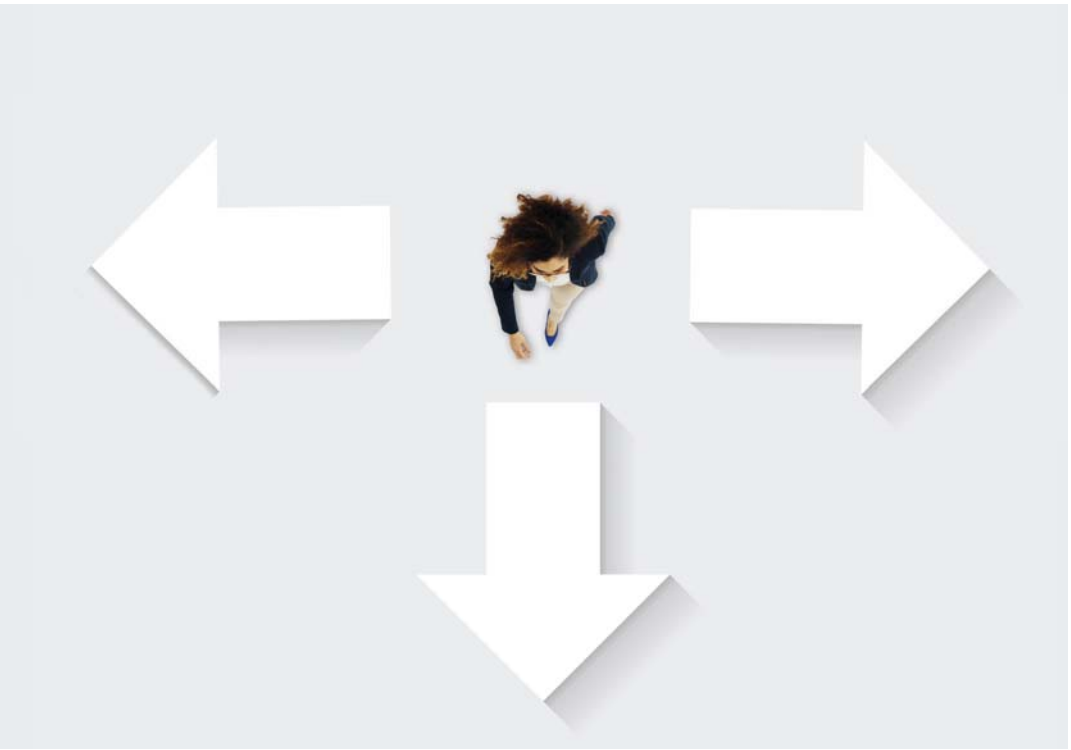
"It starts with you," he says. "We all have particular strengths and weaknesses. We all have particular biases, whether we know it or not. We have particular alignments that could be because of our upbringing, our schooling, our friends or family.

"So the first thing we do in teaching ethics is help people understand themselves. Then they need to understand the influence of the sense of obligation or duty they might feel.

"You've heard of the saying that the customer is always right? Well, if that was true, why would they need us? If the customer or client is so clever, why would they need engineers?"

The engineer cannot transfer ethical responsibilities to the customer, Stanton says.

Similarly, they should never ignore a problem with a design simply because they're not ▶



connected with that part of the project.

That is why dealing with ethical issues is one of the 16 engineering competencies for Chartered status, and why Engineers Australia members are all bound by the Engineers Australia Code of Ethics.

At the same time, Stanton says, an engineer shouldn't "die in a ditch" because of somebody else's decision that raises personal ethical questions.

"The classic question I get from junior engineers is how can they take on management when they recognise a potential unethical decision," he says.

"If the decision was not yours, you should communicate your concerns, letting people know why you believe it's an ethical concern.

"It can be extremely stressful to find the moral courage to say, 'This is not right'. It takes a lot of courage. We need engineers to do that, but keep things in perspective and don't threaten to resign. How can you make things better if you're no longer involved?"

GUT FEELING

Your gut will often let you know about an ethical dilemma, says Melissa Kirby, Legal Director at Sharpe & Abel, a law firm that consults to engineers and technical professions.

Kirby agrees that standing up for one's beliefs can be stressful, which could explain the physical reaction.

"People usually get a feeling in the pit of their stomach that tells them something isn't right," she says. "That's simplistic, but there's research to back it up, that knot in your stomach."

ABOVE: Melissa Kirby, Legal Director, Sharpe & Abel.

"IN ENGINEERING THERE ARE SO MANY DIFFERENT STAKEHOLDERS. YOU CAN BE SWAYED BY SO MANY OTHER FACTORS WITHOUT EVEN REALISING IT."

Ethics should be the starting point and the ending point of a decision, Kirby says.

"In terms of ethics in engineering, it means starting from the point of what is the right thing to do, as opposed to starting from what is the most profitable thing to do," she says. "Lawyers have ethical requirements. Doctors have ethical requirements. It is absolutely possible to be ethical and profitable."

Ethics is also the end point, Kirby explains, because engineers should be able to look back and know they've done the right thing and made the right decisions.

Part of avoiding ethical dilemmas, says Melbourne Law School Professor Katy Barnett, a consultant with Sharp & Abel, involves having an overriding ethical duty to a higher body or cause.

For lawyers, that is a duty to the court.

"That stands above our duty to our clients," Barnett says. "It means that even if something is going to go against our client, we have a duty to report it to the court.

"A conflict of interest is where you're pulled two or more ways – client demands, what you think is right, the need to make profit, etc. Lawyers are always interrogating whether we have a conflict of interest and whether, when we're working with clients, it is going to conflict with our ethical duties."

Engineers should do the same, Barnett believes.

An engineer's equivalent of a lawyer's duty to the court might be a duty to engineering principles, or to the profession.

Guidelines towards such a duty can be found in Engineers Australia's Code of Ethics.

THINKING STRAIGHT

Because engineering is a complex realm, it means engineers work in an environment of tension, says Dr Kourosh Kayvani FIEAust CPEng, Partner at HKA and Engineers ▸

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"It's not just technically complex, but also societally and commercially," Kayvani says. "As engineers, we are responsible for designing and building the infrastructure upon which our human progress rests. That responsibility, however, is not discharged purely through our technical knowledge and capability.

"Ethical thinking and decision-making is also an integral part of being a professional and of being trusted by society to deliver their built environment."

Kayvani offers the high-profile problems encountered in high-rise apartment buildings in Sydney and Melbourne during recent years as examples.

"WE ARE WANTING TO BE MORE AND MORE PROACTIVE ABOUT THE ENFORCING OF ETHICS, RATHER THAN SIMPLY HAVING OUR CODE OF ETHICS THERE AS A GUIDE."

"These problems happened in well-established areas of engineering," he says.

"So why did they happen? What role did ethics play? What do we say no to? Some engineers might say they were only responsible for a certain part of the project but, if they were aware of the problem, what was their ethical duty?

"Can an engineer accept a commission when the client says they don't have budget for the engineer to oversee the implementation of the design?

"If your client demands a leaner and cheaper design, but you feel you're compromising safety and long-term performance, do you have an ethical obligation to protest?"

Kayvani suggests the engineering profession should take the lead from the medical and legal professions, with ethics training as part of the curriculum, followed up by ongoing training.

The Code of Ethics guides professional conduct, specifically demonstrating integrity, practising competency, exercising leadership and promoting sustainability. But Engineers Australia is not a regulator.

"We don't have the power to say you're not allowed to practice," Kayvani says. "We are wanting to be more and more proactive about the enforcing of ethics, rather than simply having our Code of Ethics there as a guide. But this is a hard problem.

"The soft part is about taking a position and being an advocate of quality and integrity. The hard part is oversight and audits and reacting for the profession when there's a compliance breach.

"That's about ensuring ethical behaviour, and it's becoming increasingly important for the profession and for society." ●

ABOVE (from top): Dr Kourosh Kayvani, HKA; Professor Katy Barnett, Melbourne Law School.

COMMUNICATE YOUR CONCERNS

It's vital for ethical decision-making that engineers regularly communicate and openly discuss their ethical concerns, says I2I Collaborative Executive Solutions Nick Stanton.

"Just because you think you're right, it doesn't mean other people aren't also right," he says. "They may not see what you see and you may not see what they see. You have to communicate and work as a team."

Along the way, Stanton says, an organisation's ethical standpoint will begin to reflect the views of its people, attracting more individuals with similar values and further strengthening the firm's ethical frameworks.

"Plenty of ethical people stand by and allow unethical things to happen," he says.

"In the end, for engineers, it's all about communication and the courage to deal with ethical issues."

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WORDS BY **JONATHAN BRADLEY**

REACH FOR THE STARS

As the economic and strategic importance of Australia's space sector grows, it is becoming ever more important to secure access to space and ensure national priorities. The nation's newly formed Defence Space Command has been established to safeguard these interests, and one engineer has been charged with getting the organisation off the ground.

WHEN AUSTRALIA announced its intention to establish its own Space Command in March 2021, RAAF Air Marshal Mel Hupfeld told ABC News that the country was "three or four years behind" in its defence force space capabilities.

As the Space Command's inaugural Commander, aeronautical engineer Air Vice-Marshal Catherine Roberts has the task of overseeing that catch-up.

Roberts, who began in the role this past January, tells *create* that her goal is to establish foundations that would allow the Space Command to pursue its long-term vision.

"Which is to assure our access to space across whole government and in concert with our allies and international partners and industry," she explains. "It's about the physical capabilities and it's about the people that make that work. They're the two fundamental things that I want to make sure we have right, and so we're on the right trajectory."

Roberts is enthusiastic about the challenge; she describes the job of getting the Defence Force more involved in space as a "great opportunity" but also acknowledges the difficulties and demands of the task before her.

This includes expanding Australia's space capability in terms of domain awareness, communications, intelligence, surveillance and reconnaissance.

"We're going to have to do it really quick, otherwise we'll just continue to be a consumer of space and we won't be able to protect our assets in space," she says.

"To do it quickly means that [Space Command] gets to field low-technical readiness level technology really quickly and look at all sorts of different commercial arrangements as well."

FINDING SPACE

Roberts sees Space Command as having a vision that will unfurl on a scale of decades, though she is aware her personal role is to focus on the next few years.

In some ways, however, she has been preparing for the job her entire life.

Roberts was three years old when NASA's Apollo 11 mission made its lunar touchdown.

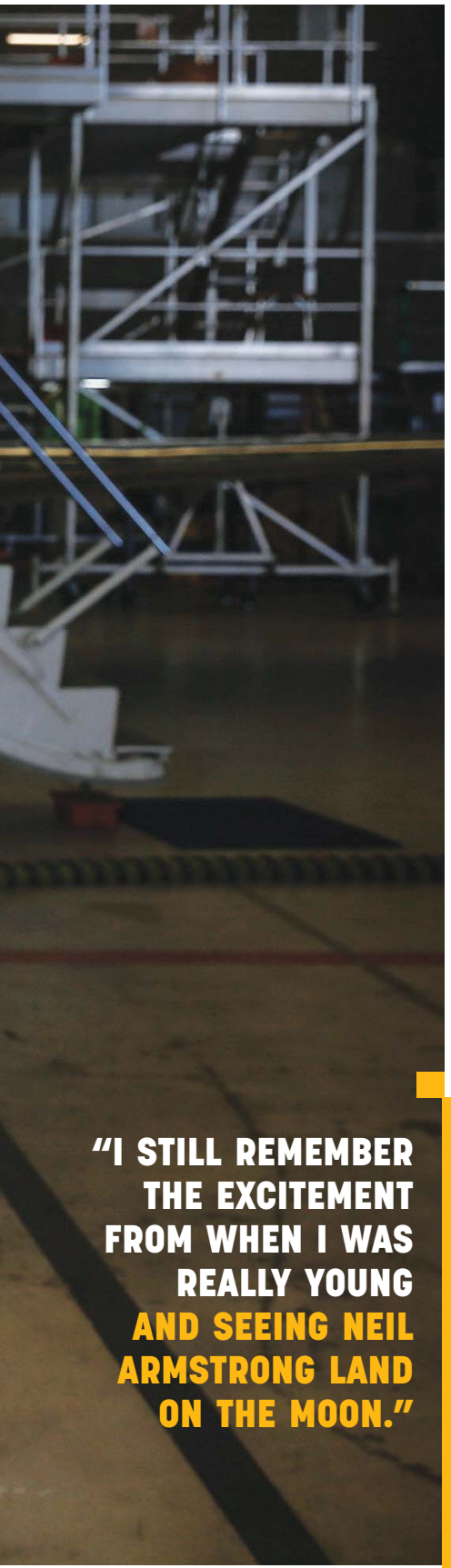
"I still remember the excitement from when I was really young and seeing Neil Armstrong land on the moon," she says.

That didn't mean she dreamed of becoming an astronaut herself. When she was growing up, Australia's participation in the space sector was minimal, with most of the action happening in the United States. Even the few Australian astronauts, such as Andy Thomas who, like Roberts,

RIGHT: Australia's Head of Space Command Catherine Roberts.

"WE'RE GOING TO HAVE TO DO IT REALLY QUICK, OTHERWISE WE'LL JUST CONTINUE TO BE A CONSUMER OF SPACE AND WE WON'T BE ABLE TO PROTECT OUR ASSETS."

IMAGE: CPL VERONICA O'HARA © DEPARTMENT OF DEFENCE



"I STILL REMEMBER THE EXCITEMENT FROM WHEN I WAS REALLY YOUNG AND SEEING NEIL ARMSTRONG LAND ON THE MOON."

RIGHT: Roberts remembers being inspired by the Apollo 11 mission.

grew up in South Australia, seemed very remote.

"They were in America, they weren't in Australia, and there was no clear path to actually become something like that. I didn't understand back then the fact too that anyone can go to space. You could be an engineer, you could be a psychologist, you can be a geologist," she says.

"I wasn't thinking that I would necessarily be involved in space, but I knew that I'd be doing things that were related."

But Roberts did know she wanted a career where she could make a significant contribution to

the world. Talented at maths and science, when she finished high school, she sought a challenge.

"That was my motivation," she says. "It was a choice between medicine or engineering – and engineering was slightly harder to get into at that point in time."

And of the engineering options available, aeronautical engineering seemed the toughest, so that's where she set her sights.

As she anticipated, the study was challenging – "helicopter aerodynamics," she recalls, "oh my goodness; I never want to do that ever again" – but it also involved subjects that have once again become relevant to her career, such as rocket design.

To study aeronautical engineering at RMIT, Roberts joined the Royal Australian Air Force, which was at the time quite a different organisation to the one that exists today.

"When I joined the Air Force, women couldn't be pilots," she recalls. "They'd only just opened up engineering to women."

By 2019, however, she had risen to Head of Air Force Capability, conceptualising and shaping the future of the entire organisation. Among the highlights of her career along the way, she says, was bringing the Air Force's F/A-18s to Indonesia for the first time.

"That was absolutely amazing, taking our fighters overseas to somewhere they'd never been before," she says.

One of Roberts's goals for Space Command is to help support Australia's rapidly expanding space industry, focusing on companies that can produce a business model that gives them a variety of customers in space.

"We want to see a lot of innovation from industry," she says. "You can't just have defence as your only customer. You need to have a broader base than that."

Launch facilities are an example of this, Roberts says.

"I think launch is really important because it brings the ecosystem around you. If you can launch things, then all of a sudden there's more of a market for satellites that you're building," she says.

"That's something that we're talking about in the space strategic update ... we've got to be very clear on what industries we're going to go after. Because we could go after everything, but we need to go after something that's sustainable."

GREY-ZONE CONFLICTS

When it comes to space, Roberts says, Australia has a geographical advantage – and that is an important security consideration. ▸

"We're in the Southern Hemisphere. When we are looking up, we can see things that other countries can't, and that makes us quite valuable. You can tell what's going on in space in a different sector from Australia – and that really helps allies as well," she says. "We meet on a regular basis trying to do things like setting norms of behaviour in space, and then we work very closely with them on this architecture, because you can share constellations [of knowledge]."

The security challenges in space are many and varied, and it can sometimes be difficult to determine what conflict in space looks like.

One example from this past February involves a cyberattack on a ViaSat satellite's Ukrainian ground infrastructure, which coincided with Russia's invasion of the country.

"The US said that Russia hacked it, and then that destroyed the modems for Germany's wind farm generators, because they were using the comms with the commercial satellite. It also took out some other military targets," Roberts says.

"Space-enabled cyber-attacks: is that conflict? Well, it happened in a conflict, so you need to be able to prevent that from occurring."

There are also what Roberts calls "grey zone operations", such as a recent occasion when China's SJ-21 satellite was used to drag another Chinese satellite out of geosynchronous orbit.

"If they can do that, then they could take one of ours out. If they took our NBN satellite out of orbit and we didn't have NBN anymore, would that be a conflict? We certainly would be unhappy," she says. "It's pretty hard to define where that line is there. What we have to do is be able to prevent it."

In such a situation, Australia might decide to move its satellite out of the way. But there are other times when countries might move their satellites too close to Australia's for comfort.

"[These are] what we call proximity operations, and they are trying to look at potentially what we are saying, what we are receiving, interfering with that data source or intelligence," Roberts explains. "Is that a conflict? Well, no, that's just spying, you could say, but it's certainly something you have to protect against if you want to make sure that we secure our information."

Another concerning possibility relates to countries intentionally inducing the Kessler effect, whereby debris strewn in space creates collisions in low-Earth orbit that, in turn, create more collisions, affecting a region's usability.

"We talk about it in terms of responsible behaviours in space in a military sense," Roberts says.

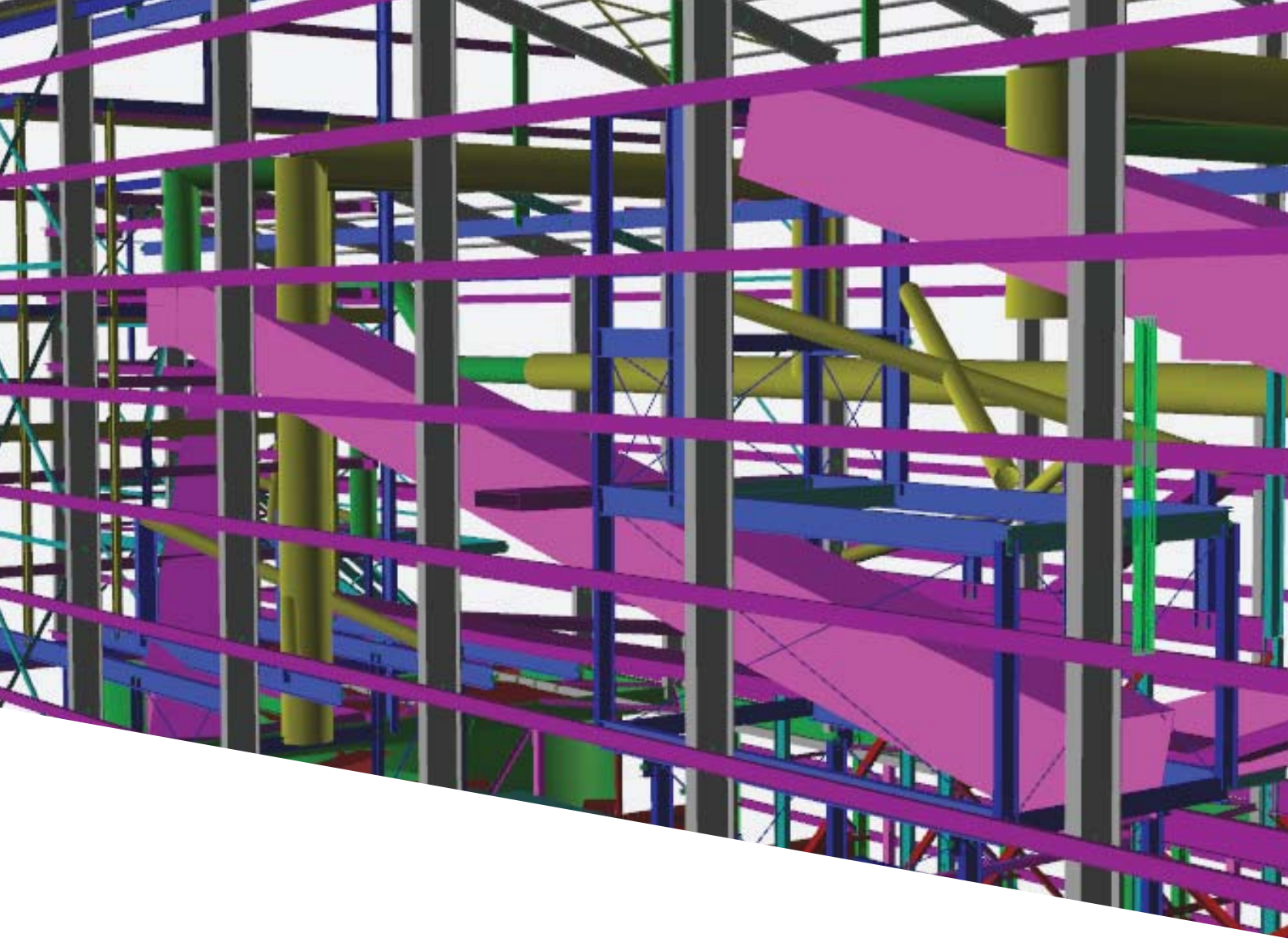
"The US just recently issued a statement saying that creating debris in space is irresponsible. But there are no rules for space: there's no [International Civil Aviation Organization], there's no law of the sea; we are on new turf."

"IF THEY TOOK OUR NBN SATELLITE OUT OF ORBIT AND WE DIDN'T HAVE NBN ANYMORE, WOULD THAT BE A CONFLICT? WE CERTAINLY WOULD BE UNHAPPY."

ALL ENGINEERS NEEDED

Professor Brian Falzon is Director of RMIT's Space Industry Hub. He believes Australia's Space Command was inevitable, and he welcomes its introduction.

"It's quite an exciting period to be in for me, because I look at what it must have felt like back at the turn of the [20th] century when the Air Force was coming



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into being," he says. "That must have seemed just as out-there and just as fantastic as we think of the Space Command now. But, of course, the Space Command here is not so much about Star Wars and having spaceships doing battle. It really is about the realisation that the space domain is actually a very different domain to what it was even a few years ago."

He sees that space domain as an increasingly congested one.

"There are actors who are not playing by the rules, as we have seen recently," he says. "How do you protect your assets? How do you protect your access to space?

"So it's an inevitability that we would have a Space Command to protect our critical infrastructure, because space is very much becoming part of our critical infrastructure. So much of what we do depends on it."

He hopes the organisation will highlight the importance of space to all forms of engineering and encourage people to study the skills the sector needs for growth.

"IT'S AN INEVITABILITY THAT WE WOULD HAVE A SPACE COMMAND TO PROTECT OUR CRITICAL INFRASTRUCTURE, BECAUSE SPACE IS VERY MUCH BECOMING PART OF OUR CRITICAL INFRASTRUCTURE."

"It's tough enough getting young people into STEM, and then to further get some of these STEM students to realise that there is a career pathway for space," he says.

"With the establishment of the [Australian] Space Agency, there seems to be a government commitment to really grow the sector and also to develop … sovereign capability.

"So that in itself creates demand for people, it creates demand for products, it creates services, etc, because even from a geopolitical perspective, we are very much in a different world to the one we were in a few years ago. We are also likely to see a strengthening partnership between the civil and defence space sectors."

Falzon says it is important to future-proof a workforce, and this is one of the core activities of the space industry hub.

"We are talking about engineering here, but when you think about it, pretty much every single profession you can think of has a space counterpart," he says.

"It's not just engineering, whether it's medicine, whether it's law, whether it's policy."

Roberts agrees, saying that even within engineering, space affects everyone from every discipline.

"Aerospace and the space elements of that – the space design – is really important," she says. "But then, if I was talking about electrical engineering, [there are] all of the things to do with the buses [the structural body and system] on the satellites."

And it doesn't stop there. Civil engineers will be important if we are to build structures on the moon. Chemical engineering is another example: rockets draw on careful chemistry for their ▸

IMAGE: CPL VERONICA O'HARA © DEPARTMENT OF DEFENCE

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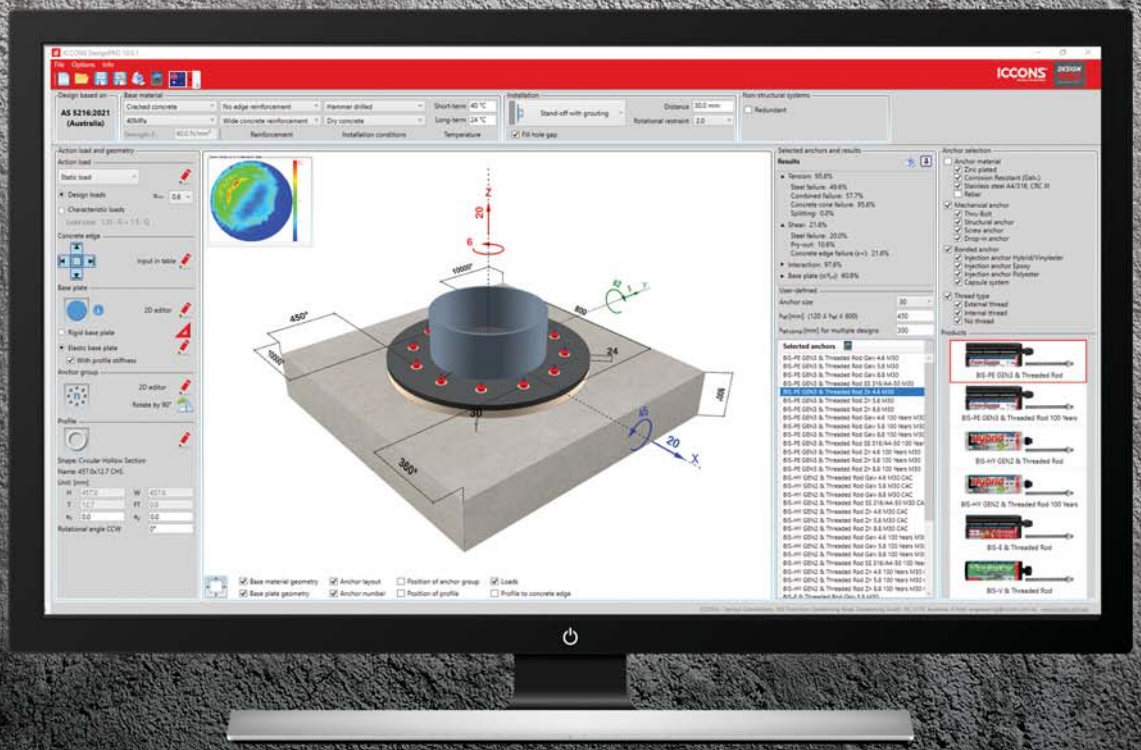

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operation, and future developments will involve making them more environmentally friendly.

"It's a whole new environment, and it requires every discipline of engineering to be successful," Roberts says.

READY FOR LAUNCH

For now, Roberts is focusing on getting everything under her command up and running. That involves a lot of challenges.

"I'm what we call an environmental commander," she says. "It's not a role I think that an engineer – an Air Force engineer certainly – has ever been in, because it's considered an operational role. So I have to raise the forces that will allow us to fight if we had to."

She also must map out what training and career paths will look like for people in Space Command.

"I need space people and I'll train them, and I don't care whether they're a pilot or they're a technician, or they're a cyberwarfare officer. I just want people with these different categories," she says. "I've got to redesign the architecture that we were planning, the constellation in space and the constellation on the ground, so that we can actually do what we need to do for Australia and with our allies too, because space is extremely contested."

Her task is to ensure physical capability and engage the people to make the organisation work.

"They're the two fundamental things that I want to make sure we have right, so we're on the right trajectory," Roberts says. "The job is massive. We have thousands of things that we want to do, but we've got to work out what we are going to do first." ●

ABOVE: Roberts displays a model of the M2 CubeSat.

IMAGE: SGT OLIVER CARTER © DEPARTMENT OF DEFENCE

LEADING THE NEXT GENERATION

Australia's Space Commander Catherine Roberts says she was inspired to go into a STEM career by her mother, who was a scientist, then worked as a teacher.

"I had this really good role model of someone who'd done something different and worked in the field," Roberts says. "She told me stories about having to go to a boys' school to do maths and science because they didn't do it at the girls' school she was at … I think that gave me the motivation to do something very different."

She has, in turn, been an inspiration for her daughters — one who is in exercise science, with the other in biosecurity — and her family now contains three generations of women in STEM.

"[There are] all those barriers that we have in terms of women in STEM from a very young age, not being encouraged to do it because it's not what girls do. Both my girls did STEM, but maybe that's because they had a role model," Roberts says.

"I think we've got to really sell the message that engineers help people."

WORDS BY **JONATHAN BRADLEY**

SUSTAINABILITY

SEWAGE CAN BE A MESSY PROBLEM FOR LOCAL COUNCILS AND UTILITIES TO DEAL WITH, BUT ENGINEERS HAVE DELIVERED A SOLUTION IN SOUTH-EAST QUEENSLAND THAT IS GREEN, COST-EFFECTIVE AND ODOUR FREE.

NEW TECHNOLOGY in operation south of Brisbane is taking the local community's sewage sludge and converting it through a gasification process into small dry pellets called biochar.

The system, developed by Logan City Council's Logan Water in a partnership with Downer, WSP and Stantec operates as a closed energy loop: it draws energy from the gas produced during the treatment process, which is reused to dry biosolids. The biochar output, which has uses in everything from agriculture to construction, can then be sold to other industries.

ABOVE: Logan City Council's biochar product sequesters carbon and can be used in agriculture as a fertiliser.

Logan Water Infrastructure Solutions Manager Mark Vaughan tells *create* the project began when the utility sought a better way to manage the biosolids stream from its largest wastewater treatment plant.

"The traditional method is to look for the best technology to remove as much water from them as possible to minimise the volume of biosolids that we've got to deal with," he says. "We were certainly heading down that path at one stage and were looking at some tools like a piston press and advanced centrifuges and things like that to try and minimise our water content. But in this project, we identified gasification as a potential option."

According to Downer Senior Design Manager Mark Thomas, 30 per cent of the treatment plant's operational budget had been devoted to costs associated with the arduous task of hauling and disposing of biosolids 300 km away. In trying to reduce those costs, the team also identified potential environmental benefits.

"We started to look into it a little bit more and worked out that not only was the haulage [impact] there but the actual carbon released from spreading or applying the biosolids to land was quite massive," Thomas tells *create*.

"It evolved into not just a reduction in those operating

costs but actually the great environmental benefit of producing a biochar, which sequesters carbon."

IT'S A GAS

With gasification as its goal, the team began building a pilot plant, assisted by a $6.2 million grant from the Australian Renewable Energy Agency.

"There's some really technical elements of the design that needed to be proven out around the heat balance and making sure that we could actually recover the energy that's embedded in the biosolids," Vaughan says. "But also, when we went into the project, we were thinking that there's some real regulatory hurdles that we needed to get over here because it's new and, what had been considered waste, we wanted to be considered a product."

The system the team put together consists of three main components: centrifuges, belt dryers and gasifiers. While the individual components of the system – gasification in agriculture, centrifuges in wastewater treatment – were already in use elsewhere in the world, the engineers were not aware of anyone who had put them together in a closed loop system.

"Right at the front, off the treatment plant, we use a centrifuge, and we need to get our material to around about 22 per cent dry solids content," Vaughan says.

ABOVE: Mark Vaughan, Logan City Council. BELOW: The self-sustaining Loganholme treatment plant.

"The next step we have are big belt driyers, which are custom-built and work by having hot water running through it. There have been ones that have thermal oil as the heating fluid."

He compares the dryer to "a big pizza oven".

"They hold a constant temperature as biosolids go through and that will dry the material. Once we have that dried material, then that's our feedstock that goes into the gasification process," Vaughan says.

"Once we put it through the gasifier's hearths, there's two products that come out. One is the biochar that will fall out the bottom of the hearth, but the second is we release a gas. That gas that goes off is burnt, and it's the burning of that gas where we ▸

"IT EVOLVED INTO NOT JUST A REDUCTION IN THOSE OPERATING COSTS BUT ACTUALLY A GREAT ENVIRONMENTAL BENEFIT OF PRODUCING A BIOCHAR, WHICH SEQUESTERS CARBON."

FROM SLUDGE

recover the heat – and that heat goes back to the dryers."

That final step is essential to ensuring the process is environmentally friendly. Although the system requires external energy to start up, once it begins operation, it is self-sustaining.

"What had previously made these dryers uneconomical or unsustainable was that they generally needed a fossil fuel to heat the heating fluid," Vaughan says.

"Whereas we are using the renewable energy – which is released from the gasification process – to actually provide that heat into the water. That's the trick that we don't believe has been done before – that we are actually taking that renewable energy and using it for the heating purpose."

ABOVE: Mark Thomas, Downer. BELOW: The biosolids biochar.

FEEL THE HEAT

Thomas says that any electrical energy the system requires is also offset.

"The heat energy is effectively neutral. However, obviously centrifuges and the dryers and the gasifiers need electrical energy for the motors that we have," he explains.

"As part of an offset project we actually constructed a 1.1 MW solar farm at the same time. That's been in operation for about 12 months now, and that offsets the electrical energy. So both the heat energy and the electrical energy, we've been able to offset both."

Capturing the heat energy involves dual mechanisms, Thomas says.

"There's two main areas that are capturing the heat. The hearth is the first component where we are actually producing the biochar – so that's effectively where the dried biosolids enters a hearth and that's where it's converted from a dried product into a char," he explains.

"All of the volatiles go into the gas stream or the air stream, and that then goes into an oxidiser. And that oxidiser is about 800 to 850 degrees. And that's where it is effectively destroying the PFAS and microplastics and any other pollutants.

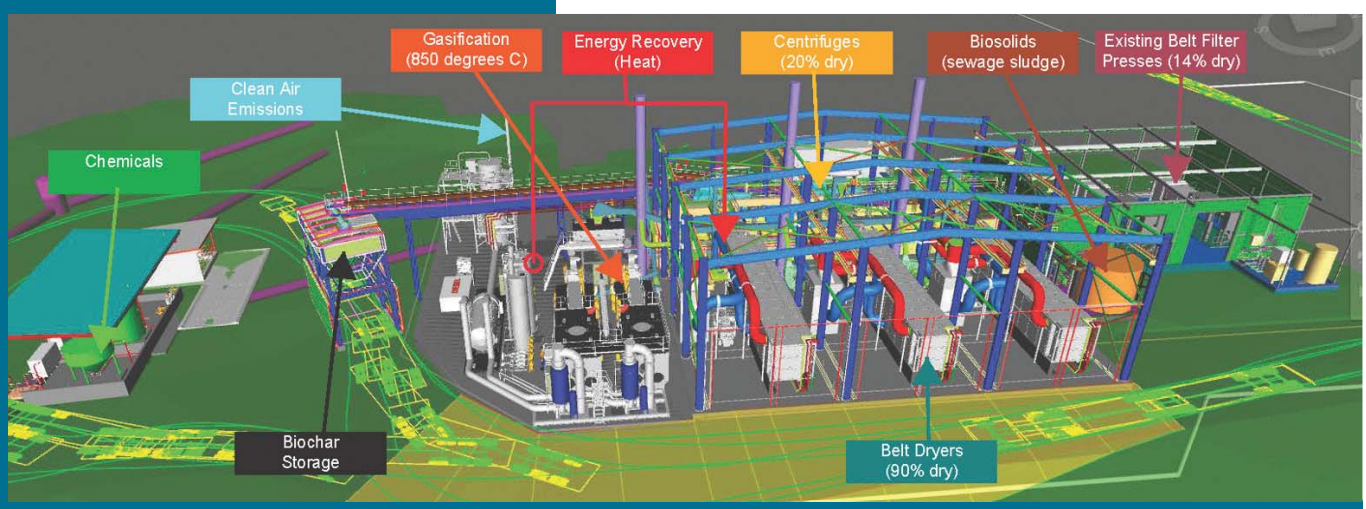
"But also that's when we're starting to capture some of that heat from that oxidiser. So we're capturing about 25 per cent from the oxidiser. Then we are going to a heat exchanger. And that heat exchanger is where we're extracting about 75 per cent of the heat from."

Vaughan says it was a challenge in itself to get the components of the system to work in sync with one another.

"THE DRYERS RELY ON THE GASIFIER TO PRODUCE HEAT, AND THE GASIFIER RELIES ON THE DRYER TO MAKE SURE THAT THE FUEL FOR THE GASIFIER IS DRY ENOUGH AND CONSTANT ENOUGH."

"Because the dryers rely on the gasifier to produce its heat, and the gasifier relies on the dryer to make sure that the fuel for the gasifier is dry enough and constant enough, you've really got to commission those two together," he says. "And that is a challenging process to get that loop right. I couldn't praise our commissioning team enough. They've been amazing in actually working through that." ●

BIOSOLIDS GASIFICATION FACILITY



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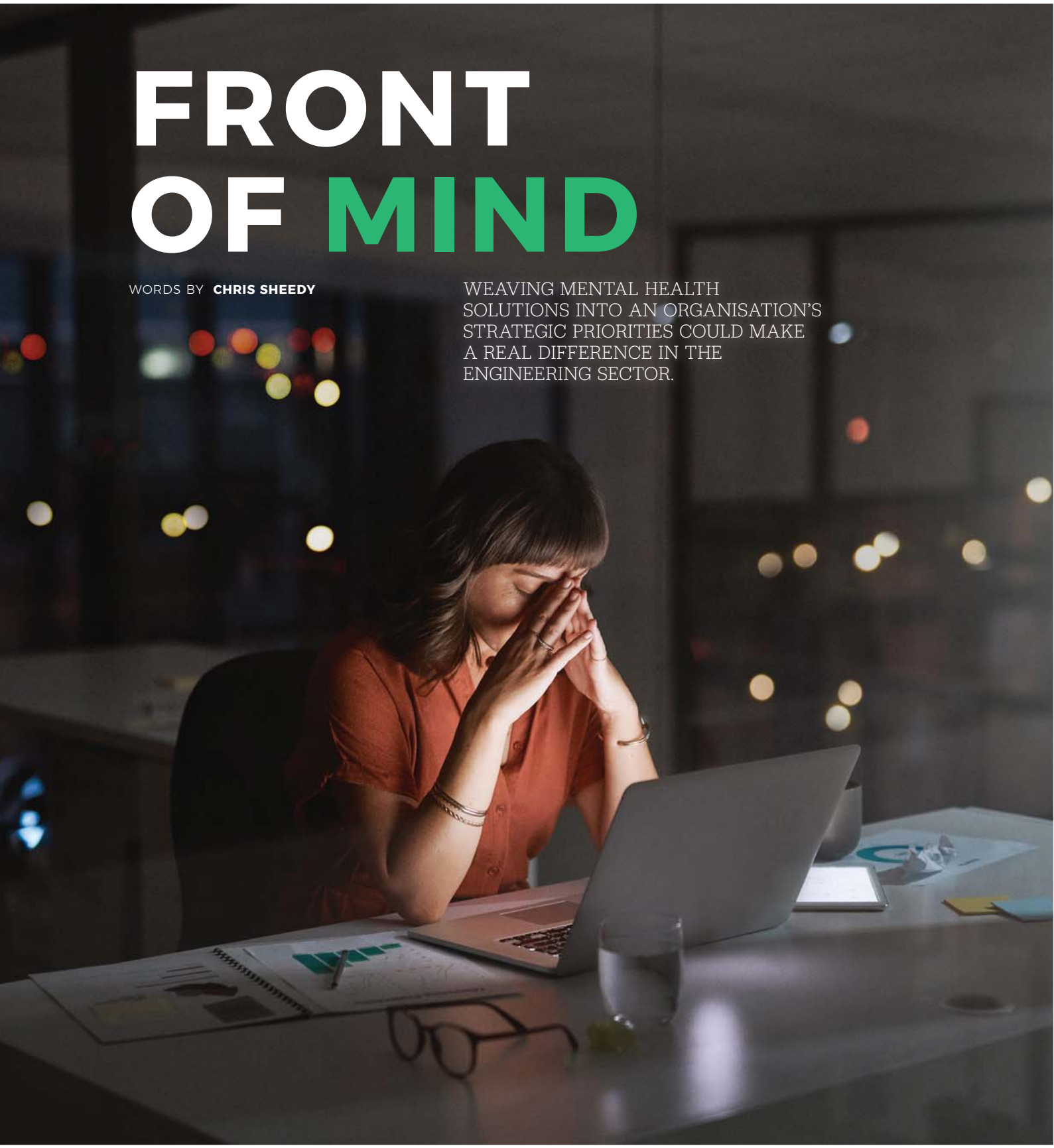
FRONT OF MIND

WORDS BY **CHRIS SHEEDY**

WEAVING MENTAL HEALTH SOLUTIONS INTO AN ORGANISATION'S STRATEGIC PRIORITIES COULD MAKE A REAL DIFFERENCE IN THE ENGINEERING SECTOR.



Warning *this article contains references to mental illness and suicide.*

A CHALLENGING MENTAL health experience in 2015 put Ricky Pena, Engineers Australia's Chief People and Strategy Officer, in a position to deeply understand similar issues faced by individuals and organisations.

Travel and work pressure in his job had combined to leave Pena feeling physically ill and reacting moodily to situations.

"The doctor told me I was at Stage 3 burnout," he says. "I asked, 'What does that mean? What comes after Stage 3?'. The doctor said Stage 4 requires hospitalisation."

Most fascinating to Pena was that he had reached such a level of burnout without himself or his workmates recognising any signals.

"This is one thing the experience taught me about mental health awareness," he says.

"We've got to equip our leaders and their people to identify some of the flags – whether it be a sudden change in mood, in approach to work or in the way they're behaving."

There have long been indicators of a "burning need for change" in the construction and engineering sector, says Martin Smith, John Holland Group's General Manager Health, Sustainability and Climate.

Smith says that reports published into high suicide rates relative to all other industries were a wake-up call that mobilised many companies to respond, but change had not been uniform across the sector.

"At John Holland we've shifted the dial, but we've got so much more to do," he says.

"We have to address structural and cultural issues that cut across the industry, including high work demands, inflexible working arrangements, long hours and consequences in terms of relationships."

ABOVE: Ricky Pena, Engineers Australia.

STRATEGIES FOR SUCCESS

Pena says he's happy that he's now seeing stronger leadership in the engineering sector around mental health.

"But still, just last year, *Harvard Business Review* said 60 per cent of employees had never spoken to anyone about their mental health status," he says.

"An Accenture study said 90 per cent of employees had never heard about the mental health experiences of their senior leaders. So we've got a long way to go to reduce stigma."

Organisations innovating in the mental health space, Smith believes, are those that are taking a strategic, integrated approach.

Rather than "something you do", he explains, mental health solutions are about "the way we work".

It is about organisational governance as opposed to departmental responsibility. It is about solutions codified into an organisation's policies and decision-making processes, rather than relying on individuals to do the right thing.

"We've positioned mental health and wellbeing as a strategic priority for the business, because it impacts things like attraction and retention," Smith says.

"In an overheated market, what you offer to your employees and potential employees becomes a point of difference."

SETTING THE PACE

Large employers have positive power in the mental health space, with the ability to maintain and improve the mental health of employees, their families and friends, and the communities in which they operate.

At the same time, these employers are fast recognising that it pays, quite literally, to ensure the mental wellbeing of their people.

"It's a win-win," says Cara Kuramoto, People Leader, Australia, at GHD. "Happy and healthy employees are much more likely to demonstrate higher levels of engagement and continued discretionary effort."

In 2020, GHD established a comprehensive global wellbeing program designed to meet the needs of all the organisation's people, with mental health being a key component.

"One of the early challenges was defining what a well-rounded, multi-faceted wellbeing program looked like, and how we implemented such a program when the majority of our workforce was working remotely," Kuramoto says.

GHD has provided a platform where its people can ▸

"WE'VE GOT TO EQUIP OUR LEADERS AND THEIR PEOPLE TO IDENTIFY SOME OF THE FLAGS – WHETHER IT BE A SUDDEN CHANGE IN MOOD, IN APPROACH TO WORK OR IN THE WAY THEY'RE BEHAVING."

access wellbeing content in their own time, at their own pace, and in a way that suits them best.

"As our world shifts to new and different ways of working, adopting this robust but flexible approach to health and wellbeing is a must," Kuramoto says.

An example is a national yoga program for employees. People can participate remotely from home or in small groups in the office.

GHD also offers its Wellbeing Speaker Series, a regular online and interactive event involving presentations by external specialists.

IN THE CONTRACT

In John Holland's Global Mandatory Requirements document, minimum requirements have been laid out for project planning and delivery.

"Projects have to budget – up-front – for the delivery of wellbeing," Smith says.

"Each project must have a health and wellbeing plan establishing how they'll manage mental health in the workplace.

"The project might be big enough to have a standalone role for a wellbeing coordinator. If so, we specify those requirements."

One of the big issues around construction is the six-day work week. Several organisations, including John Holland Group and Laing O'Rourke, are currently experimenting with ways to deliver projects on time and within budget via a five-day work week.

It all points to the fact that, while there's a long way to go, engineering and construction organisations are taking the mental health challenge very seriously. And if they don't, they lose a competitive advantage.

"In an Engineers Australia board meeting two weeks ago, the directors were talking passionately about mental health awareness and training, and what we can do to be proactive," Pena says.

"That was a very positive sign. Discussions and actions around mental health really are normalising – all the way up to the board level.

"It has become about organisational culture, rather than just support. Success will be about it becoming increasingly strategic, so it's built into everything we do." ●

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"HAPPY AND HEALTHY EMPLOYEES ARE MUCH MORE LIKELY TO DEMONSTRATE HIGHER LEVELS OF ENGAGEMENT AND CONTINUED DISCRETIONARY EFFORT."

These include contracts that outline how each project will deliver health and wellbeing throughout its life.

Mental health and physical safety hold the same level of priority.

TOP: Cara Kuramoto, GHD. ABOVE: Martin Smith, John Holland Group.

Health first

—

John Holland Group has been recognised by Mental Health First Aid Australia, alongside Lendlease and Bouygues, as a Gold Standard Mental Health First Aid Business.

The company has trained numerous staff as mental health first-aiders throughout the business, in offices and on sites. These first aiders are also taught to recognise early-warning signs.

The company also offers all employees two John Holland Days each year – above and beyond annual leave days – to be taken as paid wellbeing days.

Most important, Smith says, is the fact that the numerous mental health offerings, including processes and policies, are not specific to a location or project. They have been codified into the business, so are consistent globally and across disciplines.

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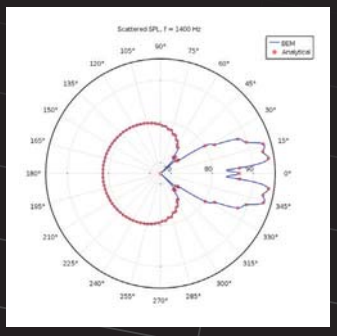

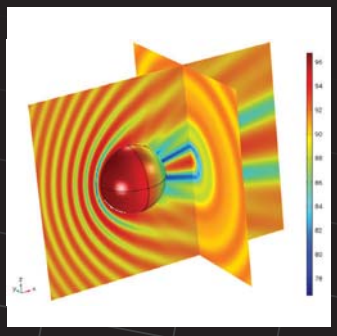

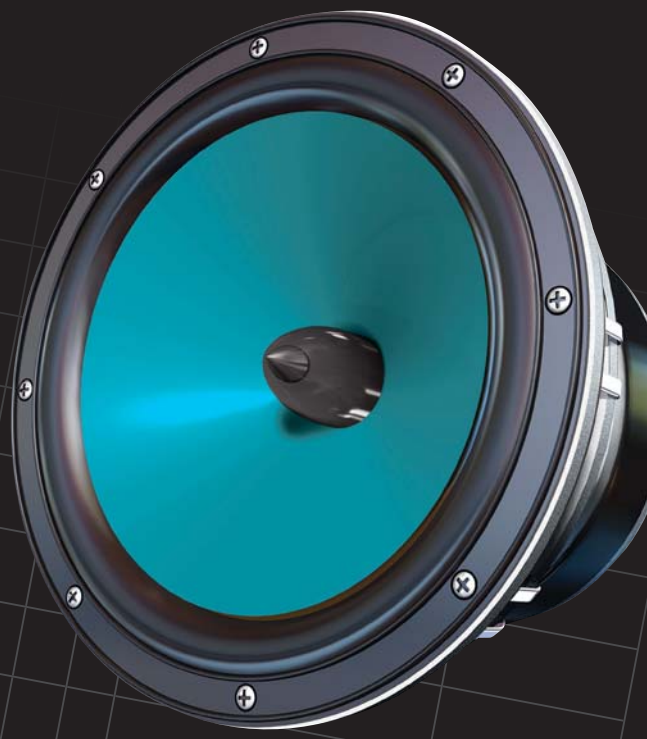

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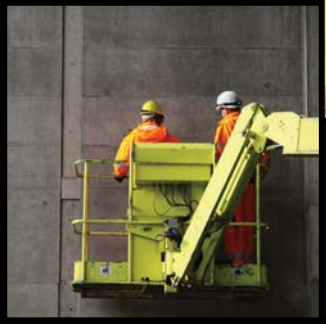

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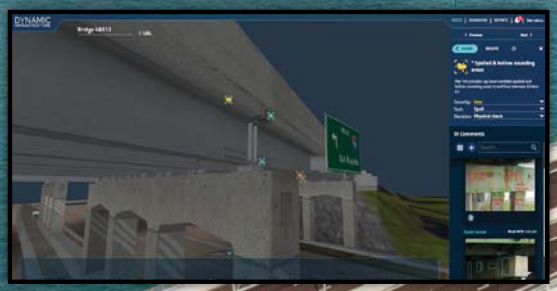

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MONITORING A CONSTRUCTION SITE'S ENVIRONMENTAL CONDITIONS CAN BE A CHALLENGING TASK. ONE NEW EASY-TO-USE DEVICE COULD OFFER BUILDERS TIME AND COST SAVINGS.

WORDS BY **KEVIN GOMEZ**

PICTURED: SiteHive Hexanode being used for baseline monitoring, along with attended noise measurements and dust deposition gauges.

RIGHT: SiteHive Hexanode deployed on site.
BELOW: Ben Cooper-Woolley, SiteHive.

CONSTRUCTION ACTIVITY in populated urban areas poses challenges ranging from stringent environmental guidelines to the need to address the concerns of increasingly vocal communities and stakeholders.

The parameters that need to be monitored on construction sites include dust, noise and vibration.

"Typically, this would be done using an agglomeration of bespoke measurement devices," says Rowan Braham, Principal Product Engineer at Laing O'Rourke. "A third-party service provider might come in to take a couple of one-off measurements at certain times during the project's delivery cycle."

It was an elementary sensor network-based remote environmental monitoring system.

Cooper-Woolley had been at Arup for several years as Digital Advisory Leader working on major infrastructure projects across the world.

Part of his remit was to look at emerging technology and how it applied to everything that Arup did.

"I was often drawn to major projects and saw very little innovation – especially in the environmental space – but regulation as well as community and stakeholder pressures were continuing to increase," says Cooper-Woolley. "The projects always needed to do more with less, and the technology just hadn't caught up."

"I WAS OFTEN DRAWN TO MAJOR PROJECTS AND SAW VERY LITTLE INNOVATION, BUT REGULATION AS WELL AS COMMUNITY AND STAKEHOLDER PRESSURES WERE CONTINUING TO INCREASE."

As part of the construction company's innovation team, Braham was focused on emerging and disruptive technologies, working with startups and research institutions.

On one of his exploratory visits to Arup, he came across some innovative work being done in the company's digital team, led by Ben Cooper-Woolley.

A NEW APPROACH

In 2019, with the germ of an idea for a solution, he joined early-stage venture capital firm Antler, where he acquired the start-up tools, some funding and a business partner. Six months later, SiteHive was born.

"We were betting on lower-cost digital sensors being able to ▶

provide measurements that were reliable and accurate enough for compliance monitoring," says Cooper-Woolley.

Traditionally, innovation and evolution of these types of sensors comes from military and industrial applications; Cooper-Woolley points to the evolution of GPS technology as an example of this process.

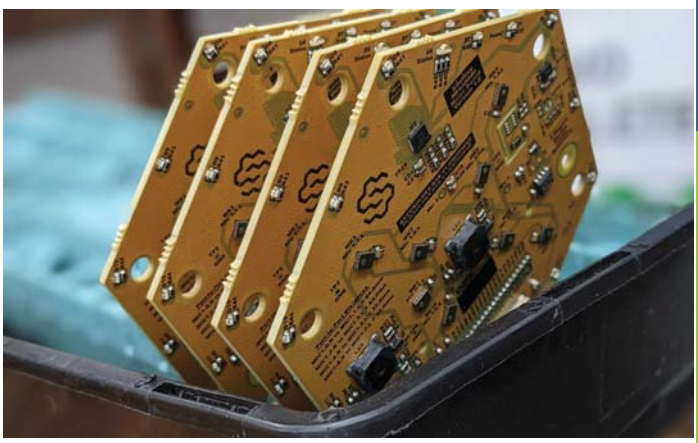
"When I was at university 20 years ago, we carried the GPS unit in a backpack with a big aerial and a large battery pack, just to get a coordinate as you moved around," says Cooper-Woolley. "At that time, it was cutting edge. Then fast forward 10 years and you have GPS in your phone."

A wave of consumer electronics, mobile phones, wearables and smart devices has pushed down the price of digital sensors while increasing their accuracy.

"But they hadn't yet come back to industry; they were pushed into the consumer domain," says Cooper-Woolley.

His strategy was to take innovations from low-cost consumer electronics, bring them into industry and provide a new type of monitoring device to address the difficulty of environmental monitoring in the construction space.

The engineering challenge was to create a device that was integrated electronically and mechanically, and then to develop a housing for it that could be deployed on construction sites without users worrying about reliability or cost.



ABOVE: SiteHive noise boards during manufacturing.

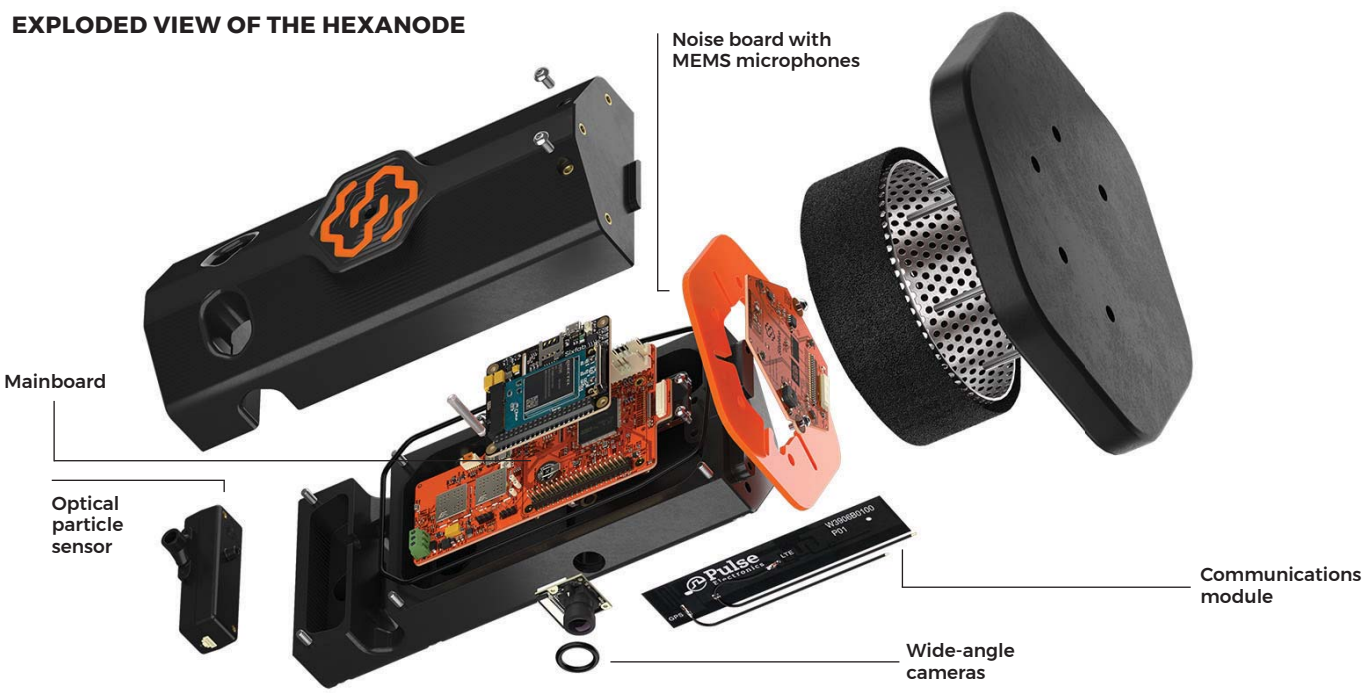
"WE WERE BETTING ON LOWER-COST DIGITAL SENSORS BEING ABLE TO PROVIDE MEASUREMENTS THAT WERE RELIABLE AND ACCURATE ENOUGH FOR COMPLIANCE MONITORING."

FULL STACK

At the top of Cooper-Woolley's device is a noise board containing 11 different micro-electro-mechanical systems (MEMS) microphones, which determine the direction and level of sound.

Below that lie two 170-degree wide-angle cameras that, when activated, take an image in ▸

EXPLODED VIEW OF THE HEXANODE



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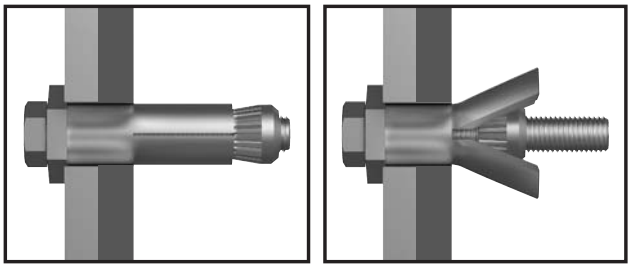

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LEFT: SiteHive Hexanode on a solar panel. BELOW: SiteHive cloud software provides access to live site data.

the direction from which a problematic sound is coming.

"When project teams are making decisions on what caused this, they can log in and immediately see an image and a six-second audio clip of exactly what happened," says Cooper-Woolley.

At the bottom of the device is an optical particle sensor that measures PM2.5 and PM10 particulate matter, the main parameters for dust measurement on construction sites. The device also measures temperature, humidity, pressure, and various atmospherics. Cloud-based software presents all key information in a dashboard that can be accessed from anywhere.

"PROJECT TEAMS CAN LOG IN AND IMMEDIATELY SEE AN IMAGE AND A SIX-SECOND AUDIO CLIP OF EXACTLY WHAT HAPPENED INSTANTANEOUSLY."

SiteHive is now used on more than 150 projects across Australia and New Zealand, and 300 of these devices have been deployed worldwide. The product has received certification from the National Measurements Institute and SiteHive recently released a new iteration of its hardware that reduced the power consumption by 70 per cent.

"Previously we put these things out with a 36 Ah battery and they'd last about a week. They're now lasting up to a month," says Cooper-Woolley.

Some challenges will have to wait, however.

"The original device actually had an accelerometer that measured vibration, but we had to remove that because measuring ground vibrations isn't very useful with a sensor that's up in the air on a 1.5 m pole," says Cooper-Woolley.

Regardless of the accelerometer challenge, SiteHive ticks a few boxes, according to Braham.

"Having a continuous monitoring solution, which can be managed and handled by onsite staff, was very attractive because it improved the efficiency of our people on the ground. I think we have statistics that say SiteHive can magnify the productivity of an environmental manager by 50 per cent," says Braham.

"That's basically because these people don't have to spend the same amount of time collecting and interrogating the data."

SiteHive also delivers a richer data stream because the data is being collected over a period of time. ●

ABOVE: Rowan Braham, Laing O'Rourke.

ON THE GROUND FLOOR

From the outset, SiteHive's technology received a positive response at Laing O'Rourke.

The construction company entered an early strategic partnership with SiteHive to help promote the use of its products internally, as well as to work with Arup's Ben Cooper-Woolley and his team on its product development.

"Companies in the construction industries are not known for their openness and willingness to work with early-stage startups and are often looking for much more mature and de-risked solutions," says Laing O'Rourke's Rowan Braham.

He started talking to SiteHive when it had only a very early prototype and has been able to build up a deep understanding of the product and what it can do.

"We shared some of those learnings with SiteHive so that they can in turn, improve their product. So, I feel like that's an important aspect of the whole ecosystem as well," says Braham.

He sees this as a benefit of working with an early-stage startup, rather than a large incumbent with a well-defined solution.

"If you want something that's a little different from what they offer, it's very, very challenging," says Braham. "You often have to make yourself, as an organisation, fit the solution rather than having the solution fit itself to what you want."

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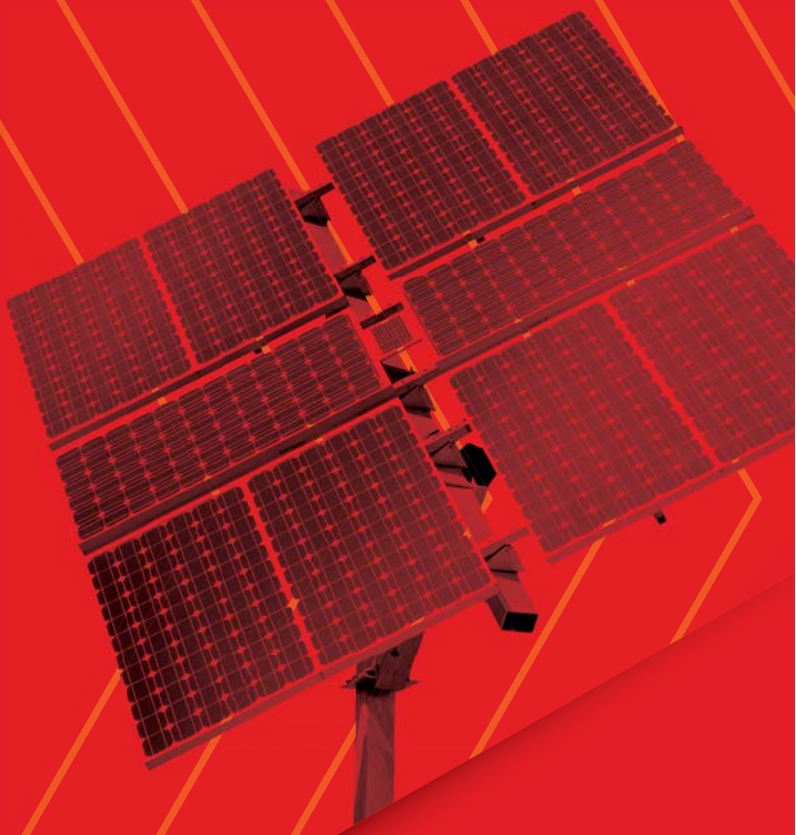

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WORDS BY **MICHELLE WHEELER**

RARE TECHNIQUE

SOUTH AUSTRALIAN RESEARCHERS ARE TRIALLING A NEW APPROACH TO EXTRACTING CRITICAL METALS FROM LOW-GRADE ORE, MINE TAILINGS AND INDUSTRIAL WASTE.

FOR MOST people, a pile of mine tailings is simply waste. But for University of South Australia minerals and resources engineer Dr Richmond Asamoah, it's an opportunity.

Asamoah is researching a new way to extract battery metals and rare earths elements from tailings, low-grade ores and mine waste.

"In Australia, most of our deposits tend to have some of these critical metals at low concentrations, alongside primary commodities," he says.

"Because they are not economical … they are not recovered, so they go to the tailing stream."

Asamoah hopes to turn trash into treasure by extracting these critical metals from tailings.

"[We want to] make them profitable, basically, and not just keep them sitting there," he says. "That's one of the key drivers."

The research uses a method originally developed ten years ago by engineering company InnovEco Australia. Asamoah says the technology is able to extract 95 to 98 per cent of the copper in a mineral deposit, compared to about 70 per cent for traditional heap leach processes.

It's also faster.

"With the traditional technologies … you need to build heaps, like manmade mountains or hills," Asamoah says.

"You sprinkle the reagent on the hills, and it extracts the metal from that.

"So, it takes quite some time – about 10 months – to be ›

BELOW: A total of $70.5 million in copper could be recovered from these deposits.

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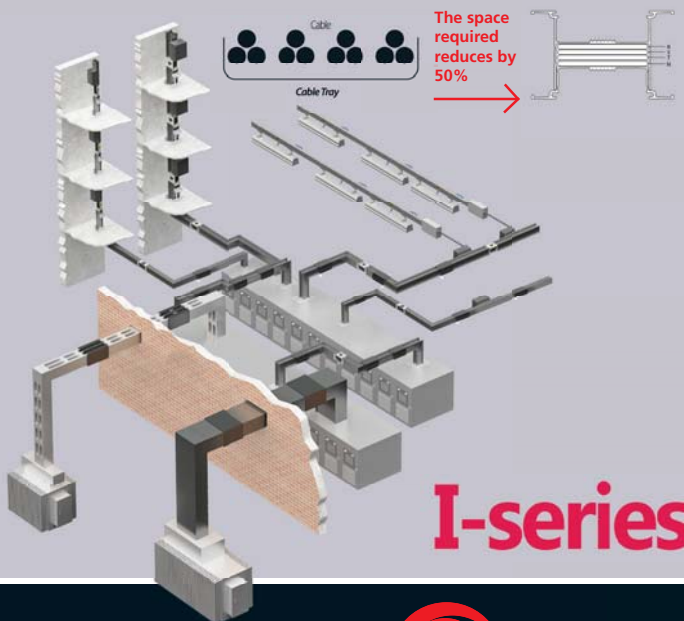

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"WE'RE WORKING ON A NEW PROTOTYPE WHICH WE BELIEVE WILL BE ABLE TO PROCESS UP TO 500 MICRONS. IT'S ANOTHER STEP TO MAKE IT MORE ECONOMICAL."

able to start getting everything out of the deposit."

Asamoah says large-scale processing modules using the new technology could extract metal from 1000 t of material a day. That would see a 10,000 t hill processed in just 10 days.

METAL RECOVERY

InnovEco Australia Director and Research and Development Manager Dr Pavel Spiridonov says the technology development started 10 years ago when a South Australian copper miner had a problem with its heap leach process.

ABOVE: Extracting materials in the lab. LEFT: Richmond Asamoah, University of South Australia.

"The recovery rate was low – like 50 to 60 per cent," he says. "[It made] the whole operation uneconomic."

Along with his colleagues, Spiridonov, a chemical engineer, tried to process material from the mine using ion-exchange resins. Initial benchtop tests suggested the resins could be used to recover 90 to 95 per cent of the copper.

The company built two "resin in pulp" mini pilot plants, trialling the technique with different materials. Spiridonov also spent seven months in Chile as part of a start-up program, developing the process further with Chilean engineering company Oryxeio.

InnovEco Australia is now developing a novel metal recovery method known as "resin in moist mix".

Spiridonov says traditional methods can only extract minerals from fine particles, usually 100 ➤

microns and below. But the resin in moist mix technique has been demonstrated on particles up to 300 microns.

"Now we're working on a new prototype which we believe will be able to process up to 500 microns," Spiridonov says.

"It's another step to make it more economical."

RESOURCES FOR TOMORROW

Asamoah says most high-grade mineral deposits have already been exhausted and inexpensive technologies will be needed to process low-grade deposits in the future.

"Currently, the heap leach technology has been one that has been deployed for those low-grade deposits," he says. "But it also has its challenges ... relating to some ore types that cannot be processed at all."

Asamoah says the resin technology is able to process difficult ore types, while also being very economical. He is currently trialling the resins to extract battery metals such as nickel and cobalt, as well as rare earth elements.

"[These are] metals that are very critical for the future economy, the green energy transition that we need, and also the high-tech equipment required for the future," Asamoah says.

At the same time, research partners in India are looking at chromium and manganese.

Asamoah says the technique could also be used to extract minerals from industrial waste, as well as to recycle spent batteries and magnets. And it could remove harmful substances from water.

"It can also be applied in sequestering heavy metals from wastewater, for instance," Asamoah says. "But we need to know how selective it will be because ... initially the technology was developed for copper."

Asamoah is looking to develop the process to clean up acid rock drainage, a major environmental problem caused by the uncontrolled oxidation of sulfidic minerals exposed to air and water. This can create an acid that dissolves copper, zinc and other heavy metals out of rock, causing them to leach into nearby water bodies.

"In some circumstances, that wastewater can also be processed, and those metals can be extracted," he says.

ECO-MINING

Asamoah says mining wastes are becoming an increasingly valuable source of metals and energy, but there's a lack of productive and economically viable extraction technologies.

"IT CAN ALSO BE APPLIED IN SEQUESTERING HEAVY METALS FROM WASTEWATER. BUT WE NEED TO KNOW HOW SELECTIVE IT WILL BE."

LEFT: Dr Pavel Spiridonov, InnovEco. RIGHT: Ion-exchange resins come in the form of small beads.

He sees the technology as a way of enabling safer extraction with less environmental impact.

"[It] also saves significantly on water and energy, so it's very suitable to the future."

For Spiridonov, the partnership is an opportunity to validate the technical and economic parameters of the technology and demonstrate its potential to recover metals other than copper.

"There's a lot of good opportunities for us," he says. ●

IMAGE: INNOVECO AUSTRALIA

Recovery session

InnovEco Australia's metal-recovery technology uses ion-exchange resins to recover valuable metals from low-grade ore, tailings and other material.

The resins come in the form of small beads — typically 0.5 mm to 1 mm in size — and can have different functional groups. This makes them selective towards specific metals.

InnovEco Australia Director Dr Pavel Spiridonov says the first ion-exchange resins tested were selective for copper, although other resins can extract nickel and cobalt, uranium, gold and more.

To remove metals from low-grade ore and tailings, raw material is mixed with ion-exchange resins in a slightly acidic solution. Leaching and sorption occur in a single step, with valuable metals dissolving into the aquatic solution and then sorbed by the resin beads. At the elution step, the metals are stripped from the beads, which can then be reused on fresh material.

In some cases, the process works best by targeting a single metal at a time. But when extracting two similar metals — such as nickel and cobalt — it can be more effective to leach the metals together, then separate them.

"In other cases, it could be sequentially," Spiridonov says. "For example, uranium or other metals can be removed first, and then some other metals like copper and nickel. So there are different options."

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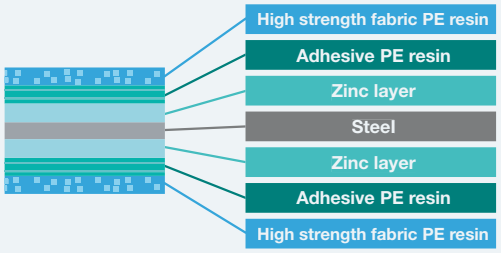

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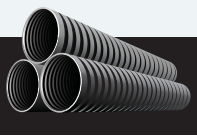

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HIGHLIGHTS FROM AUSTRALIA'S MOST UP-TO-DATE ENGINEERING RESEARCH

CAN THE HYDROGEN ECONOMY CONCEPT BE THE SOLUTION TO THE FUTURE ENERGY CRISIS?

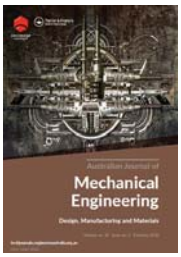
Journal: *Australian Journal of Multi-Disciplinary Engineering*
Author: M.C. Clarke

The concept of the hydrogen economy is being proposed as a means of reducing and eventually decarbonising the world's energy use. It looks to hydrogen as being a replacement for methane and a means of removing all fossil fuels from the energy supply. This paper argues that hydrogen has and will have a role in the world's energy, but that role will be limited to industry.

INFLUENCE OF USING A PEN-AND-PAPER OR COMPUTER-BASED APPROACH ON ENGINEERING STUDENTS' SELF-EFFICACY DURING IDEA GENERATION

Journal: *Australasian Journal of Engineering Education*
Author: A. Valentine, I. Belski & M. Hamilton

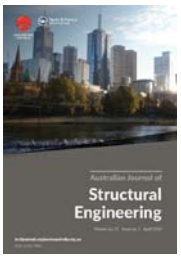
Creativity is an important skill for engineers, but many students face a lack of experience in idea generation, often compounded by low-self efficacy towards creativity. Providing students with online training modules has been suggested as one solution. This study demonstrates that using a computer can influence performance and self-efficacy in a different manner to using pen and paper.



A NOVEL DESIGN OF COMPLIANT FORCEPS WITH SERPENTINE FLEXURES

Journal: *Australian Journal of Mechanical Engineering*
Authors: L.B. George & R. Bharanidaran

This paper recommends compliant forceps with a novel serpentine flexure. Compliant mechanisms are flexible mechanisms that are jointless in nature and which transfer force and displacement from input link to output link through an elastic body deformation. The compliant mechanism provides an optimum solution for many micro applications, which is suitable for solving many problems in medical engineering.

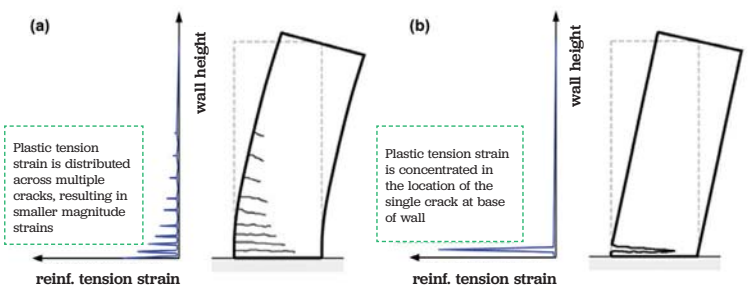


RC walls in Australia: Seismic design and detailing to AS 1170.4 and AS 3600

Journal: *Australian Journal of Structural Engineering*
Authors: S.J. Menegon, J.L. Wilson, N.T.K. Lam & P. McBean

This paper aims to clarify seismic design procedures to practising structural engineers and undergraduate students in Australia, who have had little exposure to seismic design given the lower seismic nature of Australia. With direct reference to the Australian earthquake loading code, AS 1170.4, and the Australian concrete structures standard, AS 3600, it emphasises issues with the detailing of RC wall structures, as these structures form the majority of low, mid and high-rise multistorey buildings in Australia.

RIGHT: STRAIN DISTRIBUTION OF THE EXTREME TENSILE REINFORCEMENT IN AN RC WALL FOR DIFFERENT CRACK DISTRIBUTIONS. (A) RC WALL WITH DISTRIBUTED CRACKING. (B) RC WALL WITH SINGLE CRACK.



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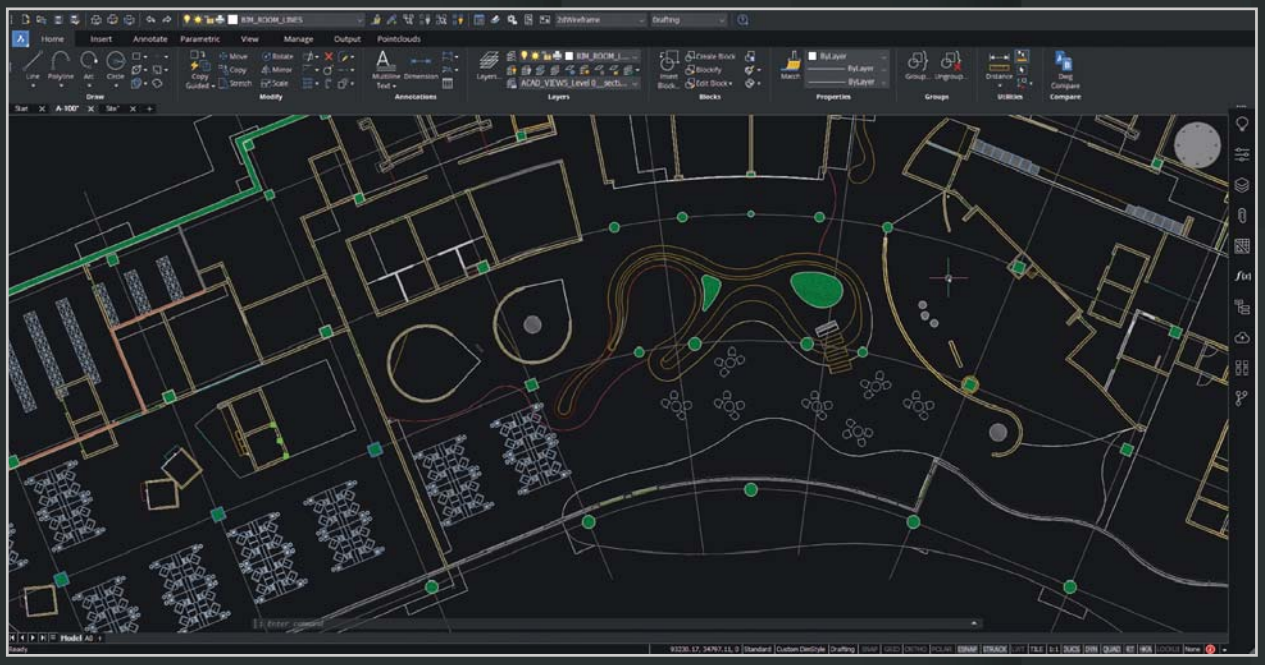

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Location: Online and in-person *Melbourne (hybrid)*
Website: *aseconference.org.au*
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Registration open

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Registration open

04-09 DEC 2022
INTERNATIONAL CONFERENCE ON COASTAL ENGINEERING (ICCE)

Location: in-person *Sydney*
Website: *icce2022.com*
ICCE promotes academic and technical exchange on coastal-related studies covering a wide range of topics, including coastal waves, nearshore currents, coastal structures, natural hazards and coastal management.
Registration open

27-01 FEB-MAR 2023
AUSTRALIAN INTERNATIONAL AEROSPACE CONGRESS (AIAC20)

Location: in-person *Melbourne and Avalon*
Website: *aiac.com.au*
AIAC is the preeminent aerospace forum in the region, incorporating three major conferences focusing on aeronautics, health and usage monitoring and space engineering, held in conjunction with the Australian International Airshow at Avalon.
Early-bird registration now open

22-23 NOVEMBER 2022

Climate Smart Engineering Conference 2022 (CSE22)

Location: Online and streamed in-person at Engineers Australia venues in *Melbourne, Sydney, Brisbane and Perth (hybrid)*
Website: *eacse.com.au*

CSE22 builds on the success of the inaugural 2021 conference. An exceptional line-up of national and international expert speakers will shine a light on projects — exclusive to view at this conference only. This solution-focused, two half-day event will highlight how the engineering profession can better manage the complex challenges of achieving net-zero emissions.

Register at *eacse.com.au*

CONFERENCE ON RAILWAY EXCELLENCE 2023 (CORE)

19-21 JUNE 2023

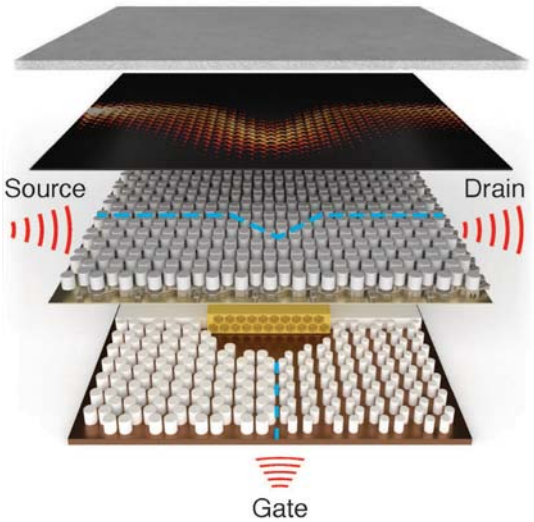
Call for abstracts

CORE, the premier technical conference in Australasia's rail industry calendar, is celebrating 25 years in motion. The Railway Technical Society of Australasia invites you to submit abstracts for the conference program.

Submit abstracts: core2023.org

THE LATEST DEVELOPMENTS FROM AROUND THE WORLD.

01



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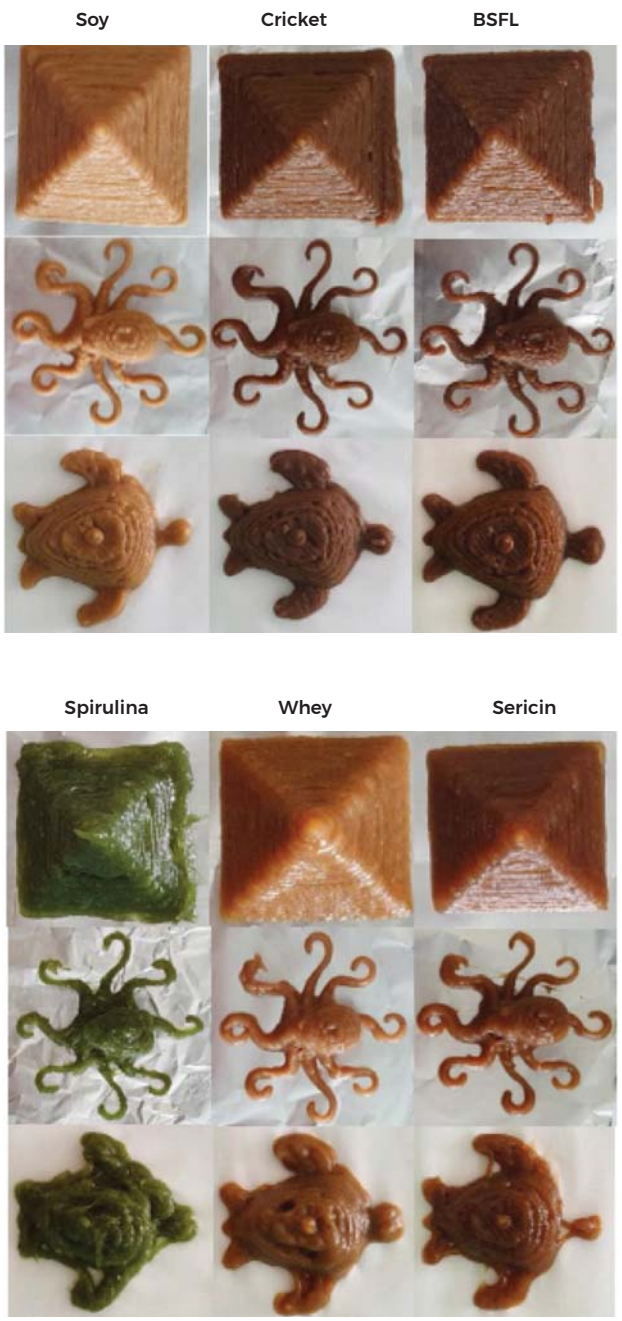

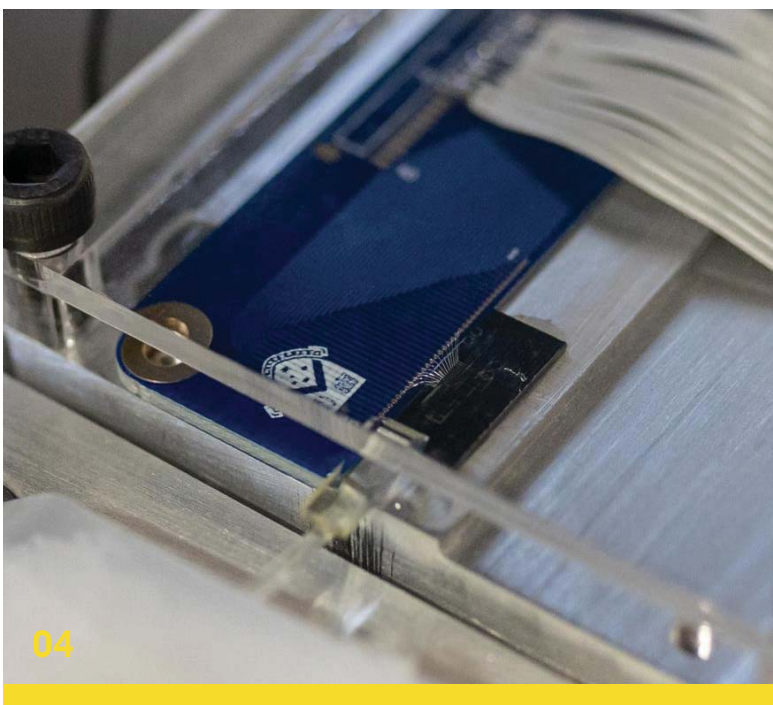

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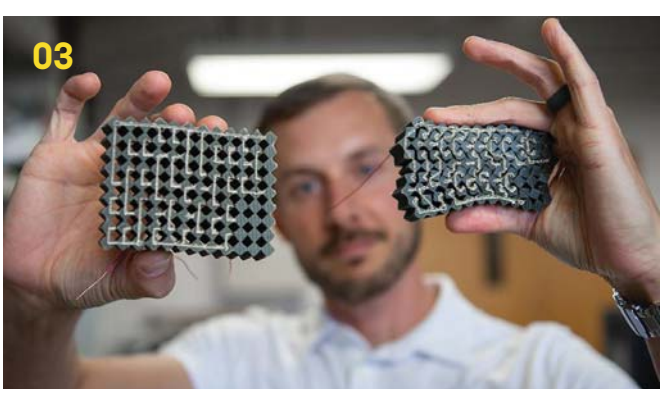
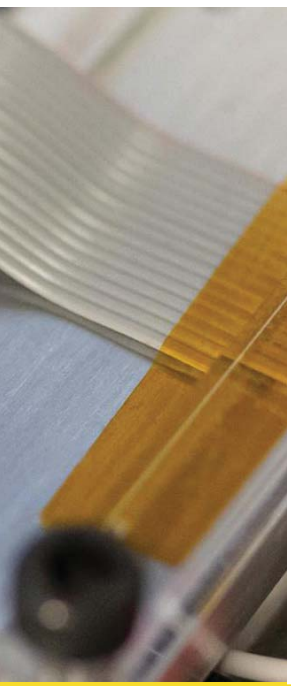


03

01 Acoustic transistor

A lattice of waveguides permits and prevents sound travelling in the system, acting as a transistor. Image: Hoffman Lab/Harvard SEAS

Harvard University has developed a topological acoustic transistor that uses sound waves instead of electrons. The technology solves the problem of how to use topological materials, which allow electrons to flow across their surface without any loss, in a way that permits a current to be turned on and off. Using sound waves means the flow can be shut down at a universal logic gate. The system takes the form of an air-tight box containing a lattice of steel pillars, which, depending on their size and arrangement, permit sound waves to travel along different channels. Applying heat to the lattice changes the waveguide, while a second device that turns ultrasound into heat permits one waveguide to change the next, like electrons flowing through transistors. "Although the materials we used won't yield an electronic topological transistor, our general design process applies to both quantum materials and photonic crystals, raising hopes that electronic and optical equivalents may not be far behind," says Professor Jenny Hoffman.



02 3D-printed protein

Food inks made from alternative proteins can be 3D-printed in different shapes. Image: Singapore University of Technology and Design

Alternative proteins such as insects, plants or algae have been proffered as a way of meeting increasing food demand around the world. To make the prospect of such comestibles more palatable, engineers from the Singapore University of Technology and Design have proposed a 3D-printed solution. "The appearance and taste of such alternative proteins can be disconcerting for many," says Professor Chua Chee Kai. "This is where the versatility of 3D food printing rises to the challenge, as it can transform the way in which food is presented and overcome the inertia of consumer inhibitions." Chua's team has developed food inks created from, for instance, combinations of carrots and crickets, that can be extruded in aesthetically pleasing forms. The team's central composite design approach optimises the ink to provide mechanical strength, taste, nutritional value and a pleasing colour, and experiments with a range of proteins, including soy, black soldier fly larvae and sericin.

03 "Thinking" material

Rather than computing via electronic input, this material responds to mechanical stress. Image: Kelby Hochreither/Penn State

Researchers at the US's Penn State University have developed advanced materials that can "think" like a brain, responding to mechanical stress instead of electronic input. Instead of using an integrated circuit to process information, the technology translates external input — squeezing, for instance — into electronic signals that can be used for computing. "We discovered how to use mathematics and kinematics — how the individual constituents of a system move — in mechanical-electrical networks," says Associate Professor Ryan Harne. "This allowed us to realise a fundamental form of intelligence in engineering materials by facilitating fully scalable information processing intrinsic to the soft material system." Made of a soft polymer with reconfigurable circuits, the material processes digital strings of information into new sequences. It could one day be used in anything from infrastructure repair to autonomous search-and-rescue systems or bio-hybrid technology that neutralises airborne pathogens.

04 Self-calibrated chip

This photonic chip helps form infrastructure needed to carry large amounts of data at high speed. Image: Monash University/RMIT

A collaboration between engineers at Monash University and RMIT has resulted in a photonic chip that can switch great streams of data between different ultra-high-speed internet applications. Where previous data-switching infrastructure had taken the form of boxes the size of cigarette packets, the new chip, which is self-calibrating, is the size of a fingernail. The chip separates light into different colours that carry different messages. As well as manipulating and routing the data, the photonic circuits are able to identify patterns. "As we integrate more and more pieces of bench-sized equipment on to fingernail-sized chips, it becomes more and more difficult to get them all working together to achieve the speed and function they did when they were bigger," says Dr Andy Boes, now at the University of Adelaide. "We overcame this challenge by creating a chip that was clever enough to calibrate itself so all the components could act at the speed they needed to in unison."

Sekaran Alagesan

CPEng, Senior Mechanical Engineer
Austin Engineering

CHARTERED STATUS HELPED SEKARAN ALAGESAN PROVE HIS ENGINEERING TALENTS AND LAND HIM NEW PROFESSIONAL OPPORTUNITIES.

WHEN MECHANICAL engineer Sekaran Alagesan moved to Australia after 14 years' experience in India and the United States, he needed a career boost. That's why he decided to pursue Chartership with Engineers Australia.

"It takes time for a new country to recognise your skills and your talents," he tells *create*. "Chartered status is something that implies that your competence is assessed, knowledge, skills and credentials are verified and you are committed towards continuous professional development."

Chartered engineers are highly esteemed by industry, Sekaran believes — so much so, that he attributes the accreditation with helping him secure a new position as Senior Mechanical Engineer at mining equipment manufacturer Austin Engineering.

"It was quite obvious for me; within a month's time [of becoming Chartered] I got a couple of offers," he says. "Since I already had prior experience as a senior engineer, the Chartered really was a ... factor which pushed me to the next level of the job market in Australia."

Sekaran has worked on projects around the world for heavy equipment manufacturer Caterpillar, where he went from simple modelling and detailing to overseeing major projects.

"One interesting project was for Cat Power Systems oil and gas platforms; it's about design components for engines and gensets. It was given as a pilot project to me," he recalls. "I started as a two-member team, and then down the line the team grew to a size of 36. I was the one who built the team for almost three-and-a-half years. And I needed to start from defining the scope, formulating design guidelines, standard work procedures, quality metrics, process and workflows to do the job."

The project was such a success he was recognised with an Outstanding Performer of the Year award by the company.

"I always believe an engineer should have the capability or trait of giving solutions — that's what engineering is all about," Sekaran says. "Building a safe and sustainable solution for any problems existing in the world."

Sekaran achieved his Chartered status by interview, and he speaks highly of the process.

"The initial interview started with regular formal questions, and then the first five minutes is always a bit tense, but then it was an informal chat," he says. "The best part ... about the interview was the interviewer was very knowledgeable in understanding the skill set of the person he's interviewing.

"Based on that, he was able to correlate with the projects which I was explaining, and he was able to ask questions on that front. It was a very smooth process." ●

05 TIPS FOR SUCCESS

1. Always look to provide solutions when presented with a new problem.
2. Step out of your comfort zone and learn the larger context of the projects on which you are working.
3. Pay attention to detail and seek continuous improvement.
4. Look to align your career goals with the goals of your organisation.
5. Keep learning, challenge yourself and upgrade your skills.

Dulux
PROTECTIVE COATINGS

The West Gate Bridge Project

Dulux® Protective Coatings is proud to have partnered with McElligotts on one of Australia's largest steel maintenance projects – the West Gate Bridge.

Built in the 1970's, this Melbourne icon was coated with Dulux Protective Coatings and now 40 years on it was time for a remediation project.

Exposed to pollution from traffic and sea water the West Gate Bridge required superior protection. For the 800m-long steel deck, Dulux Protective Coatings along with Mark Dromgool of KTA-Tator Australia specified a four-part coatings system, plus a special stripe coat for more than 120,000 bolts!

After extensive product trials by the McElligotts team, Dulux's durable system was chosen as the fastest drying solution with the best finish. Here are the steps in our specification:

BLAST: The 800m long steel deck had a total of 60,000 square meters to repaint. The underside of the steel deck was abrasive blast cleaned.

PRIME & FIRST COAT: Zincanode® 402 was applied with a Cold Cure Hardener. The two-pack epoxy zinc rich primer is ideal for use over abrasive blast cleaned steel.

SECOND COAT: The second coat of surface tolerant epoxy Durebild® STE was then applied.

THIRD COAT: Durebild® STE MIO added a layer of surface tolerant micaceous iron oxide, working as a barrier coat for protection against water ingress.

FINISH: A final topcoat of Weathermax® HBR MIO ensured a high build finish.

Become a leader in your field

Further your career with advanced qualifications and deeper technical expertise.

With a postgraduate Engineering degree from RMIT, you'll develop internationally-recognised skills in the areas that interest you most. With 14 different specialisations to choose from and accreditation by Engineers Australia, RMIT's suite of Masters degrees are globally recognised and highly regarded by industry, both locally and internationally.

From manufacturing to management, you could find yourself designing and creating products, systems, structures and services that transform our world and improve lives.

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