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CONTENTS

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CONTENTS

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Engineering innovation knows no boundaries

IN 2023, INNOVATIVE AND CREATIVE ENGINEERING WILL MATTER MORE THAN EVER WHEN IT COMES TO SOLVING THE BIG CHALLENGES FACING AUSTRALIA AND THE WORLD.

It's a new year, and 2023 will no doubt be filled with groundbreaking engineering innovations making a positive and tangible difference to some of our greatest global challenges.

Our first issue of the year showcases the breadth of the profession's reach and impact. It's packed with powerful stories detailing engineering transformations across disciplines and sectors.

These include construction, defence, bionics and electrical engineering. The latter comes from a team at the University of NSW that has created a tiny, yet powerful magnetic motor prototype the length of a pen, which, if commercialised successfully, could be used in industries from electric vehicles to ventilation.

The summer months showcase some of the best sport offerings in Australia, and our cover story on Dr James Waldie and his creation of custom-designed compression garments for elite athletes is a topical one. It's also a prime example of innovative engineering. The technology used in the outfits is drawn from Dr Waldie's vast experience developing compression garments for astronauts.

The athletic garments are made from a similar anisotropic material to his spacesuits, but include moisture-wicking, UV protection systems and the elasticity required for sporting endeavours.

An athlete's body is 3D-scanned and analysed using precision technology, then the clothing is designed to match the athlete's precise measurements and selected compression regime.

"The coming decade will see the culmination of a unique set of challenges for the Australian economy and the engineering profession."

In his words, Dr Waldie says: "We like to say we make the best compression garments on and off the planet."

As we start 2023, there has never been a more important time to be an engineer. The coming decade will see the culmination of a unique set of challenges for the Australian economy and the engineering profession.

We face rapid and constant technological change, multiple industries in transition, a record multibillion-dollar pipeline of public and private infrastructure investment and a pressing need to decarbonise our economy to achieve net-zero emissions by 2050.

To address all of this we need engineers, and we need them to continue to think critically, creatively and innovatively.

This month's magazine demonstrates engineers doing just that. It is an important read and reminder of the pivotal contribution our profession continues to demonstrate in advancing society through great engineering.

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New foundations

AN INNOVATIVE NEW PRODUCT COULD CHANGE AUSTRALIAN CONSTRUCTION — IF THE CHALLENGES IN BRINGING IT TO MARKET CAN BE ADDRESSED.

IT TOOK Jim Prior years to find it. Searching for a sustainable alternative to polystyrene waffle pods in slab foundations, Prior saw a lot of potential products.

But it wasn't until he found a black box called Biax that Prior thought he had something that fit the bill.

"A lot of those [other] solutions that have existed have typically missed the brief on either buildability, engineering compliance, Australian-standard compliance, cost, usability on site, or even environmental," he says.

"This product ticked all those boxes."

Prior, now the general manager of Biax Foundations and Chief Operating Officer of Holloway Group, is calling it the next generation of waffle slab.

"This product is a highly sustainable, structurally sound alternative to the current existing solution," he says.

Prior says Biax is stronger, stiffer and easier to install than the polystyrene used in almost 80 per cent of Australian house foundations. It's more sustainable, thanks to its construction from recycled plastic. And the stacked product takes up about one seventh of the space, reducing carbon emissions associated with transport.

Biax was invented by Italian structural engineer Fabio Parodi, initially for commercial applications. Prior brought the product to Australia, doing a couple of years of further research and development to get it ready for the local market.

What appears at first glance to be a simple black box hides a host of design considerations. For instance, the pods have tapered sides so they stack. Prior says the taper also changes the shape of the concrete ribs from rectangular to slightly triangular.

"That aids in the stiffness of the slab in terms of structural performance," he says.

Prior says typical waffle pods in Australia have ribs spaced 1200 mm apart. In Biax, the distance is 750 mm – a measurement originally designed to comply with a New Zealand standard relating to seismic activity.

Grip nodules on the top of the pods stop builders slipping in wet ▸

RIGHT: Biax installed in house foundations at a suburban site. BELOW: Jim Prior, Biax Foundations.

IMAGES: JEN DAINER

"WHEREAS FOAM PODS CAN DRIFT APART AND MOVE UNDER CONSTRUCTION, THESE GET LOCKED TOGETHER. IT'S ALL VERY DELIBERATE IN TERMS OF DESIGN."

weather or frost. A cross on top and a cone in the centre make the pods easier to work with on site.

The pods have a 50 mm rim at the base with holes at the corners so they can be joined with a connector.

"The bottom flange helps get our spacing accurate, which is part of the ability for us to be very accurate with our materials, such as concrete volume," Prior says.

"Whereas foam pods can drift apart and move under construction … these get locked together. [It's] all very deliberate in terms of design."

While the plastic pods are more expensive than their polystyrene equivalent, Prior says the cost is comparable when considering the system as a whole. That's because Biax is quicker to install, easier to transport, and provides opportunities to use less concrete and lower grades of steel reinforcement.

Prior says the extra engineering was key to making the product cost-effective.

"Because plastic is more expensive than foam, the one-for-one replacement doesn't work financially at all," he says.

"We've got plenty of competitors trying to do it and proving that it doesn't work."

In October, Biax was recognised at the 2022 *Australian Financial Review Boss* Most Innovative Companies Awards, taking out 10th spot in the property, construction and transport category.

Biax says broad adoption of the product could help the building industry eliminate 25,000 t of polystyrene from the building market each year – a lot for a lightweight material.

Despite the benefits, Prior is realistic about the challenges of replacing an incumbent product.

"A lot of builders don't want to be the pioneers," he says.

"So we keep searching for those who are prepared to go out on a limb a little bit… and then hope that others copy. And that's starting to happen."

Prior believes there will be a tipping point where builders get on board.

"There will be a point soon, I think, where people will switch over just by virtue of the number of others using it," he says. "We've seen that happen with many other building products, including the incumbent waffle pod. When that came out 20 to 30 years ago, it took ages for enough people to be using it and for the rest of the industry to go 'right, we're in'."

Intrax residential engineer Tomi Oladele says Intrax collaborated with Biax to extensively research the product before deciding to recommend it to residential building clients. For him, the use of recycled materials rather than polystyrene is a big selling point.

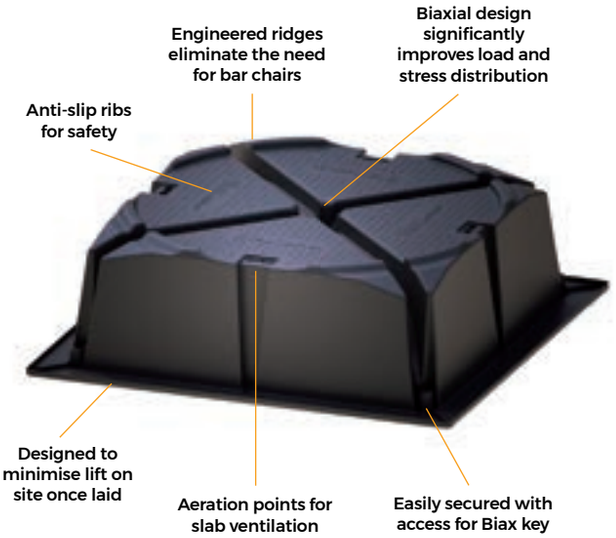
"Essentially, it can be used for everything that we typically would use a standard waffle setup for," he says.

Oladele also says it's simple to apply, particularly for highly reactive sites.

"WE KEEP SEARCHING FOR THOSE WHO ARE PREPARED TO GO OUT ON A LIMB A LITTLE BIT, AND THEN HOPE THAT OTHERS COPY. THAT'S STARTING TO HAPPEN."

ABOVE (from top): Biax pods locking together; Tomi Oladele, Intrax.

The Biax box



"The main benefit of Biax over the typical system is that it's quite customisable in terms of the reinforcement and the specifications for it," he says.

"By comparison, the conventional systems are more standardised, conservative, and max-out in highly reactive soils. Biax is quite good because it is a purpose-built slab option with design software. That also keeps things quite straightforward in terms of what can be designed and specced up."

Oladele points to engineers' role in meeting their ethical responsibilities to provide sustainable solutions and reduce carbon emissions.

"We need a collective effort from all stakeholders to make sure that we can deal with these climate issues, in terms of the manufacturing, the suppliers and also the building stakeholders," he says.

Prior hopes to get more people on board every day with an education process around the product.

"Once they're past that, as a user or as a specifier, they're pretty much on board," he says. ●

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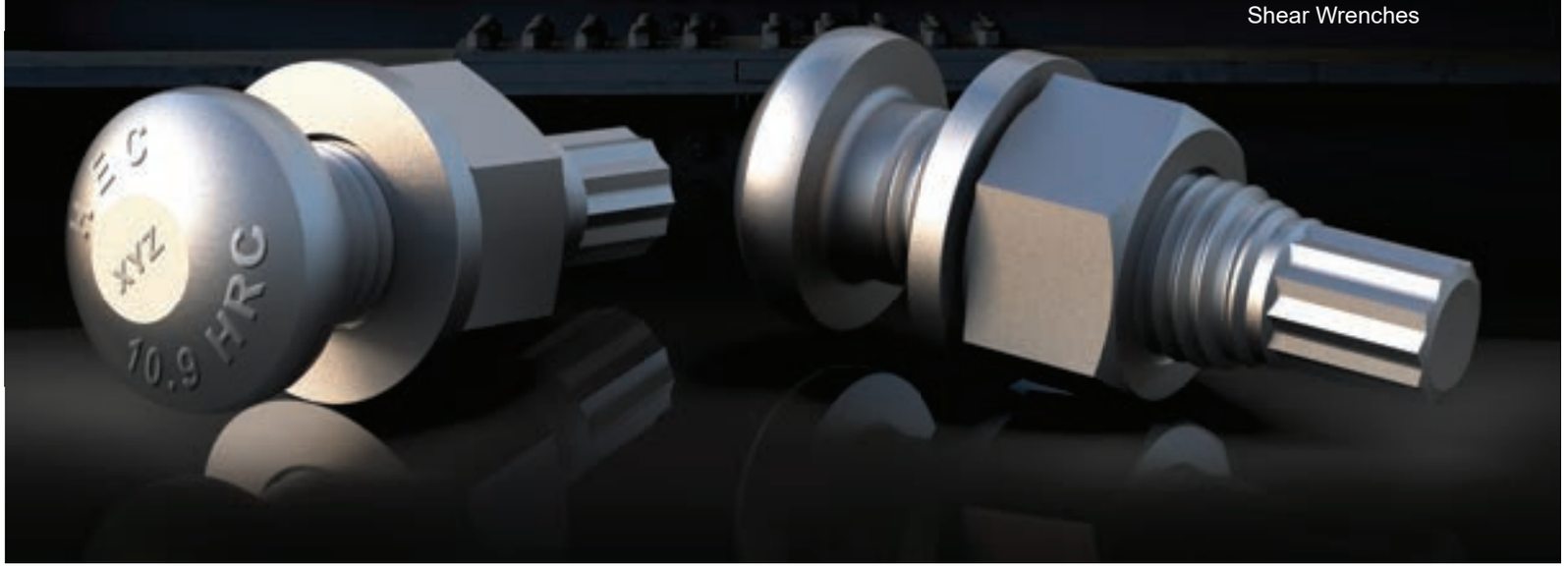

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IN SEPTEMBER 2022, Chris Deeble stepped into what he describes as his "dream job".

An RAAF veteran of almost four decades, Deeble had spent the previous three years as Chief Executive Officer at aerospace and defence company Northrop Grumman Australia. He has now returned to the Department of Defence to take up the role of Deputy Secretary for the Capability Acquisition and Sustainment Group (CASG).

"It doesn't get any better than delivering capability for the ADF," says Deeble, who served as an Air Vice-Marshal during his time in the RAAF and was awarded the Conspicuous Service Cross in 2007.

"If we are concerned about the speed of threats, we need to overmatch that with the speed to capability. And if we have standard processes where we expect to just turn a handle and get an outcome, it's time to think differently.

"We have to be able to get capability delivered much more rapidly than we've done before."

"IF WE ARE CONCERNED ABOUT THE SPEED OF THREATS, WE NEED TO OVERMATCH THAT WITH THE SPEED TO CAPABILITY."

AIR SERVICES TO INDUSTRY

CASG partners will work with industry to deliver capability to the Defence Force across a range of domains, including maritime, air and land.

It's a department Deeble knows well, having overseen more than $25 billion of complex acquisition and sustainment programs during his time with Defence, including the Joint Strike Fighter, Wedgetail Airborne Early Warning and Control, Multi Role Tanker Transport and Collins Class Submarine.

Before moving to Northrop Grumman Australia, Deeble worked for Airservices Australia as the program executive for OneSky and was responsible for delivering the Civil Military Air Traffic Management System for Australia.

He describes his subsequent shift into industry as "a bookend" to his career.

"Working in uniform to deliver capability from a defence perspective to then delivering capability within industry made sense, and I'd always found Northrop Grumman to have very strong values, which is important to me," says Deeble.

The company's technological achievements were also a drawcard for Deeble. Northrop Grumman has developed technologies such as the Multi-Role Electronically Scanned Array radar for the E-7A Wedgetail aircraft, as well as the Large Aircraft Infrared Countermeasures system, which can automatically detect a missile launch, determine if it's a threat and activate a countermeasure system to track and defeat it.

Under Deeble's leadership, Northrop Grumman Australia adopted a new operating model to bring its profit and loss accountability in-country under General Manager, Asia-Pacific, Christine Zeitz.

"Christine has a deep experience of the defence industry here in Australia, and hopefully the value that I brought to that partnership was a keen understanding of defence technology and the strategic context to help translate that into a good business model for Northrop Grumman," says Deeble.

ABOVE: Chris Deeble served as Air Vice-Marshal in the RAAF.

IMAGE: CPL DAVID SAID © DEPARTMENT OF DEFENCE

CHANGING THE PARADIGM

Over the four years to 2020, Northrop Grumman spent more than $1 billion in the Australian economy and invested $2.1 million in research, sponsorships,

WORDS BY **SUSAN MULDOWNEY**

READY FOR ANYTHING

CHRIS DEEBLE IS PREPARING AUSTRALIA'S DEFENCE CAPABILITY ACQUISITION AND SUSTAINMENT GROUP FOR A FUTURE THAT IS CHANGING RAPIDLY.

scholarships, charities and social programs across the country.

Spending of this magnitude requires a tight rein on costs, and Deeble says his experience in industry taught him to be more cost-conscious.

"This is a lesson that I'm taking into Defence," he says. "We have to understand the cost of doing business ourselves. How much energy do we put into it? How many resources do we put into it?

"In business, being cost-conscious becomes critical because, ultimately, you are answering to a shareholder in terms of the profitability of the company. In defence, we need to be equally conscious of the cost of doing business and of the cost to industry in doing business with us.

"We need to turn more of that dollar investment into capability outcomes and delivering them."

Another key theme of Deeble's leadership will be ▸

IMAGE: LAC MICHAEL GREEN © DEPARTMENT OF DEFENCE

"HAVING ACCREDITED ENGINEERS IS CRITICAL TO ENSURING THAT WE'VE GOT THE RIGHT PEOPLE WITH THE RIGHT QUALIFICATIONS TO DELIVER ON THOSE WORTHY OUTCOMES."

what he describes as "changing the paradigm" of how defence capability is delivered.

He says the traditional four-step "OODA loop" process – observe, orient, decide, act – for making effective decisions must be enhanced through multi-domain sensing, deciding and acting.

"I see multi-domain sensing feeding into a prediction-decision loop which uses artificial intelligence and machine learning to help us predict and decide earlier to enable us to act with precision and speed," says Deeble.

With weapons such as hypersonic missiles capable of travelling around 10,000 km per hour, Deeble says multi-domain, integrated systems are required to "bring all sensors to bear".

"We need to be agnostic as to the source of the sensor or effector – whether it comes from the air, land, maritime, space or cyber domain," he says. "There will always be a place for the OODA loop, but we need to accept the fact that the threat is changing rapidly. Time is of the essence from two areas: reducing the time required to make decisions and responding to a threat that might be evolving."

ENGINEERING EXCELLENCE

A Companion of Engineers Australia, Deeble has received valuable mentoring from engineers throughout his career and has always had a deep technical interest in capability.

"The professional engineers that I have worked with, both in defence and industry, have taught me the value of engineering and the engineering discipline in delivering and sustaining capabilities," he says. "When you fly in a complex piece of kit like the F-111, which I did, airworthiness is important to you, and I greatly value the engineering that supported the F-111.

"Having engineers that are accredited – and Engineers Australia being a critical part of that accreditation – is an important part of the professionalisation of the workforce that we have in Defence."

While CASG does not set engineering regulations, Deeble says it must deliver on the regulations through its products.

"Our products have to be airworthy, seaworthy, landworthy, spaceworthy and cyberworthy," he says.

"Having accredited engineers is critical to ensuring that we've got the right people with the right qualifications – and with the right authorities that go with that – to deliver on those worthy outcomes."

Deeble says there's never been a more exciting time to be an engineer in the defence industry.

"Defence have $270 billion worth of acquisition programs that are in the mix over the next decade, and they are highly complex and aim to leverage world-class capability and innovation," he says. ●

ABOVE: Deeble (standing, centre) at the 2014 launch of the F-35 Joint Strike Fighter Autonomic Logistics Information System.

Up to speed

The challenge for the Department of Defence's Capability Acquisition and Sustainment Group in supporting multi-domain operations, Deputy Secretary Chris Deeble says, will be responding to the speed of a threat with speed to capability.

He sees technology as a catalyst to defence capabilities.

"I found in delivering capabilities like the Wedgetail, it was the human being that we actually got more out of, because once they got the technology in their head, they played with it, they understood it better and delivered different and more innovative capability outcomes," says Deeble.

"That's why you need to concentrate on fostering an environment that allows for innovation, learning by doing, accepting the fact that you might fail, and that failing fast is an important part of that equation."

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WORDS BY **CHRIS SHEEDY**

BECOMING A GREEN ENERGY SOCIETY THAT MEETS ITS NET-ZERO GOALS WILL REQUIRE MINING COPPER AT A FASTER RATE THAN EVER. HOW CAN THIS PARADOX BE SOLVED?

THE COPPER CONUNDRUM

ONE SIMPLE fact sums up the vastness of the challenge facing the mining sector and its related industries as the world races towards a 2050 net-zero deadline.

The lofty net-zero goal requires massive renewable electrification. Renewable electricity generation demands a great deal of copper. And to reach the 2050 goal, the world needs to mine more copper in the next two-and-a-half decades than has been mined in the history of mankind, says Professor Michael Goodsite CPEng.

"Copper is essential for us getting to a green and modernised society," Goodsite, Professor of Civil and Environmental Engineering at the University of Adelaide and Director of the Institute for Sustainability, Energy and Resources, tells *create*. "Let's take a common, coal-fired power plant like one we have on the east coast of Australia and replace it with wind power. To get the same amount of energy the current plant produces, we'll need to build approximately 17 wind farms, each with about 100 windmills. Each windmill alone requires about eight tonnes of copper. And we haven't even begun to connect the windmills to the grid with copper wire.

"So we need eight tonnes multiplied by 100 windmills, multiplied by 17 wind farms, to replace one coal-fired power plant. With current mining techniques and methods and the grade of copper necessary, you'd have to mine about 110 t of ore to get those eight tonnes of copper. Multiply that by 100 and then by 17 and you get what could be a very large hole in the ground."

ABOVE: Professor Michael Goodsite, the University of Adelaide.

A recent report by global research and consultancy business Wood Mackenzie, *Red metal, green demand: Copper's critical role in achieving net zero*, said under the Paris Climate Agreement targets, 9.7 million tonnes of new copper supply from projects not yet sanctioned – over and above what is being mined right now – will be required over the next 10 years.

"To successfully meet zero-carbon targets, the mining industry needs to deliver new projects at a frequency and consistent level of financing never previously accomplished," says Nick Pickens, Research Director of Copper Markets at Wood Mackenzie. "It's the significant pull on the metal's existing and potential supplies, and the investment required, that needs urgent attention."

The Wood Mackenzie team estimates more than US$23 billion annually over 30 years will need to be invested to deliver the new projects.

Mission impossible? Some would say so. But many specialists in the area have confidence that new technologies, improved mining techniques and better processes will provide the solutions the world requires to meet Paris Climate Agreement goals.

"TO MEET ZERO-CARBON TARGETS, THE MINING INDUSTRY NEEDS TO DELIVER NEW PROJECTS AT A FREQUENCY NEVER PREVIOUSLY ACCOMPLISHED."

OLD DOG, NEW TRICKS

Methods of copper extraction have remained largely unchanged over many decades, says engineer ▸

Clare Sykes, Managing Director of LarkinSykes Advisory.

But those in the copper space are now urgently rethinking how they can best meet demands for a net-zero future. This will come through new projects, new processes, new operations, and from recycling.

Engineers are at the centre of each and every one of these areas.

"I've been doing work over the last few years with the International Copper Association Australia, where we've been looking at technologies that could be required to not only meet the resources demands of the energy transition but also to consider whether a copper operation could actually have a zero-emission profile in its own right," Sykes says.

Sykes and other researchers have been looking at five parts of the copper mining value chain:

- Discovery: to find and define copper in the most responsible and sustainable way
- Water: optimising water-use and energy requirements in the extraction processes
- Material movement: how materials can be fragmented, sorted and hauled in a zero-emissions environment
- Ventilation: exploring technologies to more efficiently ventilate mines or mitigate ventilation demands and optimise a safe working environment
- Mineral processing: how valuable minerals can be separated from crude ores more efficiently.

"A typical, significant innovation in the industry could take 15 to 20 years to be fully embedded in the operational setting. But we don't have that long," Sykes says.

"There are many pathways via which engineers can play a very important role to unlock and commercialise innovations, to transfer technology from research into industry, and to implement those technologies on operating sites."

NET ZERO EMISSION MINING

In a report series recently published with the Clean

RIGHT: Clare Sykes, LarkinSykes Advisory.

"A TYPICAL, SIGNIFICANT INNOVATION IN THE INDUSTRY COULD TAKE 15 TO 20 YEARS TO BE FULLY EMBEDDED IN THE OPERATIONAL SETTING. BUT WE DON'T HAVE THAT LONG."

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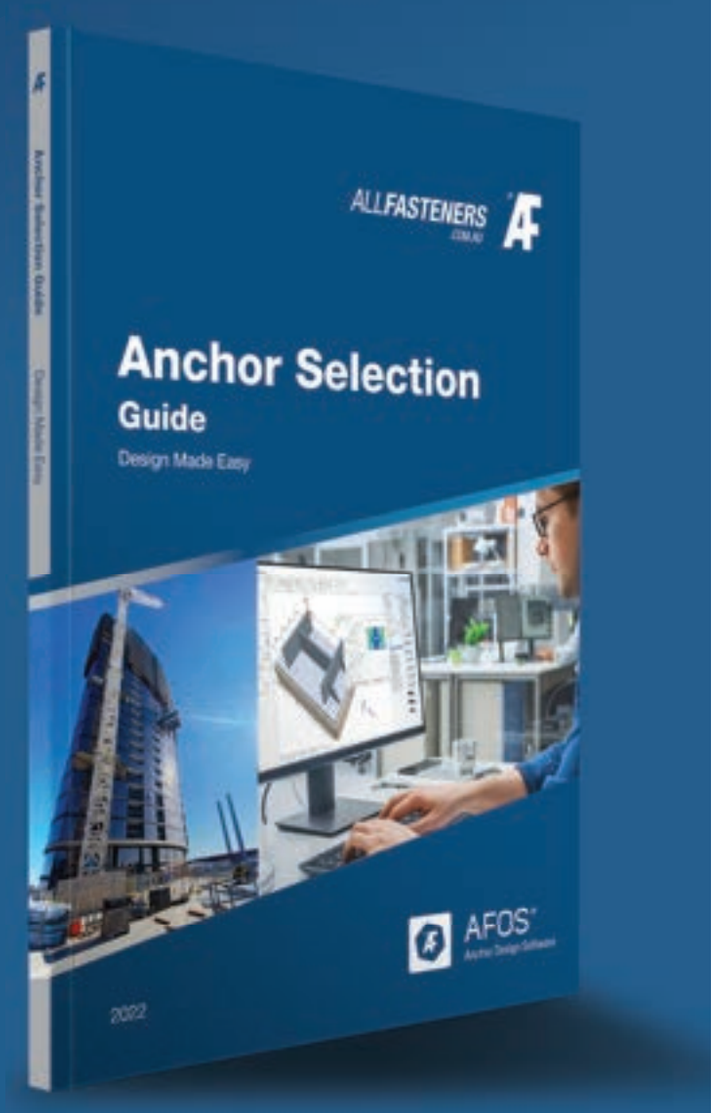

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Energy Finance Corporation, Erin Coppins, Research Portfolio Manager at the Minerals Research Institute of Western Australia, investigated emissions reduction options for a model copper mine.

She and her colleagues looked at different pathways and technology options for decarbonisation of the mine before 2050.

"It was a model brownfield operation," she says. "The purpose of the report was to demonstrate what is possible even in the most challenging contexts for decarbonising a mining operation.

"There were four different pathways that were modelled, based around three core investment phases. All demonstrated that net-zero emissions could be achieved by 2040 with different levels of cost parity. Three of the four reached cost parity with business-as-usual by 2040. The pathways took into account a range of technology choices, including electrification and options for hydrogen and ammonia."

On paper, at least, it is possible to turn an existing mine into a net-zero emissions operation in less than two decades.

"We looked at what are the key sources of energy usage and their emissions profiles," Coppins says.

"Where do they occur within an operation and what are the levers that are available to address those?

ON PAPER IT IS POSSIBLE TO TURN AN EXISTING MINE INTO A NET-ZERO EMISSIONS OPERATION IN LESS THAN TWO DECADES.

"The key is to look at the challenge from an asset level. Lots of decarbonisation targets might be set at a group, strategic level, but you really need to identify where the asset is now and where the main sources of energy use are. In line with industry commitments, the model mine in our report was able to reach net-zero by 2040 via several pathways, with electrification the most cost-effective route."

That's excellent news. But it doesn't solve the big problem: the sheer volume of copper required to meet the demands of electric vehicles and windmills, battery storage and electrical networks. That challenge is being stared down by the Copper for Tomorrow Cooperative Research Centre bid.

GREEN ENERGY SOCIETY

Currently raising $4 million per annum from stakeholders, including mining and related companies and industry organisations, and seeking an additional $40 million in matching funds from the Australian Government's CRC Program, the Copper for Tomorrow CRC bid recognises the copper paradox.

RIGHT: Erin Coppins, Minerals Research Institute of Western Australia.
BELOW: Copper wire used in an electric vehicle.

"How do we increase the production of copper needed for a green energy society? How do we achieve this while processing lower grade ores – a complicated and resource-intensive process – while also meeting environmental, social and corporate governance goals?" the CRC's website asks.

Goodsite is the Research Director of that CRC bid.

"It takes 16 years, on a global average, from the discovery of the new commodity to the first shovel going into the ground in an operational mine," he says. "So new mines discovered today won't come online until about 2038. ▸

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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.

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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.

"To reach our net-zero targets, we have to get better at mining deeper and extracting copper from more complex ores more efficiently, that is, meeting the copper – and other minerals – we need without further impact on the environment. That's what we call the copper paradox. We might have to use more energy and more water. So, it's a real challenge, and that's why we've set up a collaborative research effort."

The CRC intends to bring industry together with government, universities and external expertise from around the globe to address how to meet copper demand more sustainably.

"We will have to put a lot of knowledge together to achieve many of these goals," he says.

"We want to use a lot less energy from the grid during extraction. We might consider blasting more and grinding less. We must use chemical and biological systems and their energy, instead of grid energy, to get to the copper in the ore.

"We'll have to work with entirely new business models around the sale and export of green copper. Will people buy it at a premium? Every indication is that they will, since they do with aluminium. So what is that worth? And how do we prove it is green?"

Finally, Goodsite says, the geopolitical situation changes daily.

"How is that going to impact demand? And will people even be concerned if there are bigger security issues?" he asks

"Currently, there may not even be enough critical minerals to enable more than one out of four drivers to own an electric vehicle. So, we've got a lot of work to do, and not much time to do it, if we are to meet the net-zero goals." ●

"HOW DO WE INCREASE THE PRODUCTION OF COPPER NEEDED FOR A GREEN ENERGY SOCIETY?"

Engineers and the copper challenge

Engineers must be involved at every step of the value chain, says Professor Michael Goodsite, Research Director, Copper for Tomorrow CRC bid.

Innovative engineering will be required to figure out ways to extract copper in place, mining the mineral rather than the ore.

This challenge begins with the way copper is discovered undercover. New sensing and technologies can inform in-place recovery, meaning mining with an in-situ technique, without necessarily digging a new mine and by using other new methods.

There are essential tasks for all types of engineers, Goodsite says, as well as learnings from other sectors such as space, civil, chemical, geological, electrical and more.

"So for exploration, development, extraction, mining, processing, rehabilitation and more, all of the skill sets of engineers are going to be needed for us to efficiently meet copper demand," he says.

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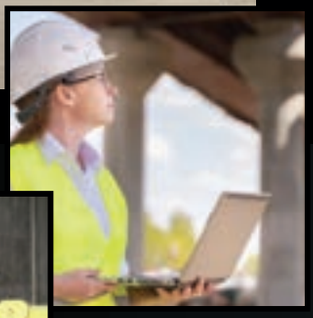

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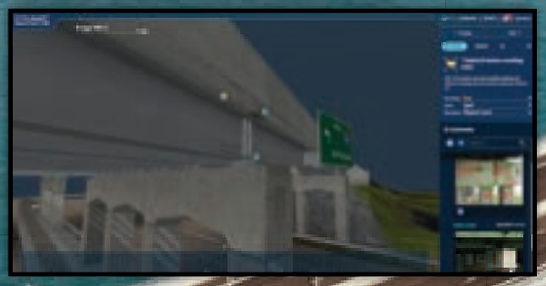

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INNOVATION TOWARDS ZERO

PERFECT FIT

PICTURED: James Waldie, CEO, Cape Bionics.

WORDS BY **SUSAN MULDOWNEY**

JAMES WALDIE'S CUSTOM-DESIGNED COMPRESSION GARMENTS WERE DEVELOPED FOR OUTER SPACE, BUT NOW THE AUSTRALIAN ENGINEER IS BRINGING THEM TO THE SPORTING FIELD.

ELITE ATHLETES have long worn compression garments to enhance performance and aid recovery but, without the benefits of a custom fit, form can outweigh function.

For Dr James Waldie, many of these off-the-shelf garments belong in the category of 'athleisure'.

"I'd describe a lot of them as tight fashion," he says. "They might look good, but there's a question mark over whether they can really improve athlete performance or recovery."

As CEO and co-founder of medical-grade compression apparel company Cape Bionics, Waldie and his team custom-design and manufacture garments for elite athletes with proprietary compression regimes optimised for performance, recovery, travel or rehabilitation.

The technology is drawn from Waldie's experience developing compression garments to support astronauts during short and long-term space exploration.

His products, including calf sleeves, leggings and arm sleeves,

are now worn by athletes in elite sporting codes across Australia and the US.

"The technology was developed with NASA, MIT and the European Space Agency, so we like to say we make the best compression garments on and off the planet," says Waldie.

OUT OF THIS WORLD

Growing up with a fascination for space and the pioneering spirit of astronauts, Waldie studied aerospace engineering and business administration at Melbourne's RMIT University, where he explored the impact of microgravity on the human body.

At this time, athletes like Ian Thorpe and Cathy Freeman were racing in their trademark bodysuits at the Sydney Olympic Games. Waldie wondered if he could engineer a similar suit for astronauts that would mimic the normal weight loading experienced on Earth.

"THE TECHNOLOGY WAS DEVELOPED WITH NASA, MIT AND THE EUROPEAN SPACE AGENCY, SO WE LIKE TO SAY WE MAKE THE BEST COMPRESSION GARMENTS ON AND OFF THE PLANET."

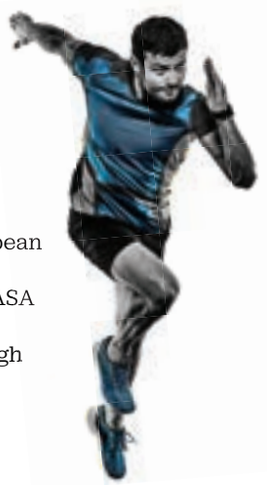
Waldie spent almost two decades developing compression spacesuits. While completing his master's at the University of California in San Diego, he made new findings into the physiological effects of different compression levels.

He then earned a PhD at RMIT and was accepted as a post-doctoral fellow at the Massachusetts Institute of Technology to develop his space skinsuit design with the European Space Agency (ESA).

He also consulted at the NASA Johnson Space Center to help reduce astronaut injury through innovative spacesuits.

So what caused Waldie to shift his focus from space to sport? It all stemmed from a golf-course conversation with his neighbour, James Turner, who is now Managing Director of communications services company Qtec Systems and CEO of specialist VoIP carrier company Coloured Lines.

Waldie had returned to Australia from MIT in 2010 and was working as an aerospace engineer at BAE Systems. Turner says he was fascinated by Waldie's spacesuit technology and, with a background in entrepreneurship and capital raising, he was curious about its commercial opportunities.



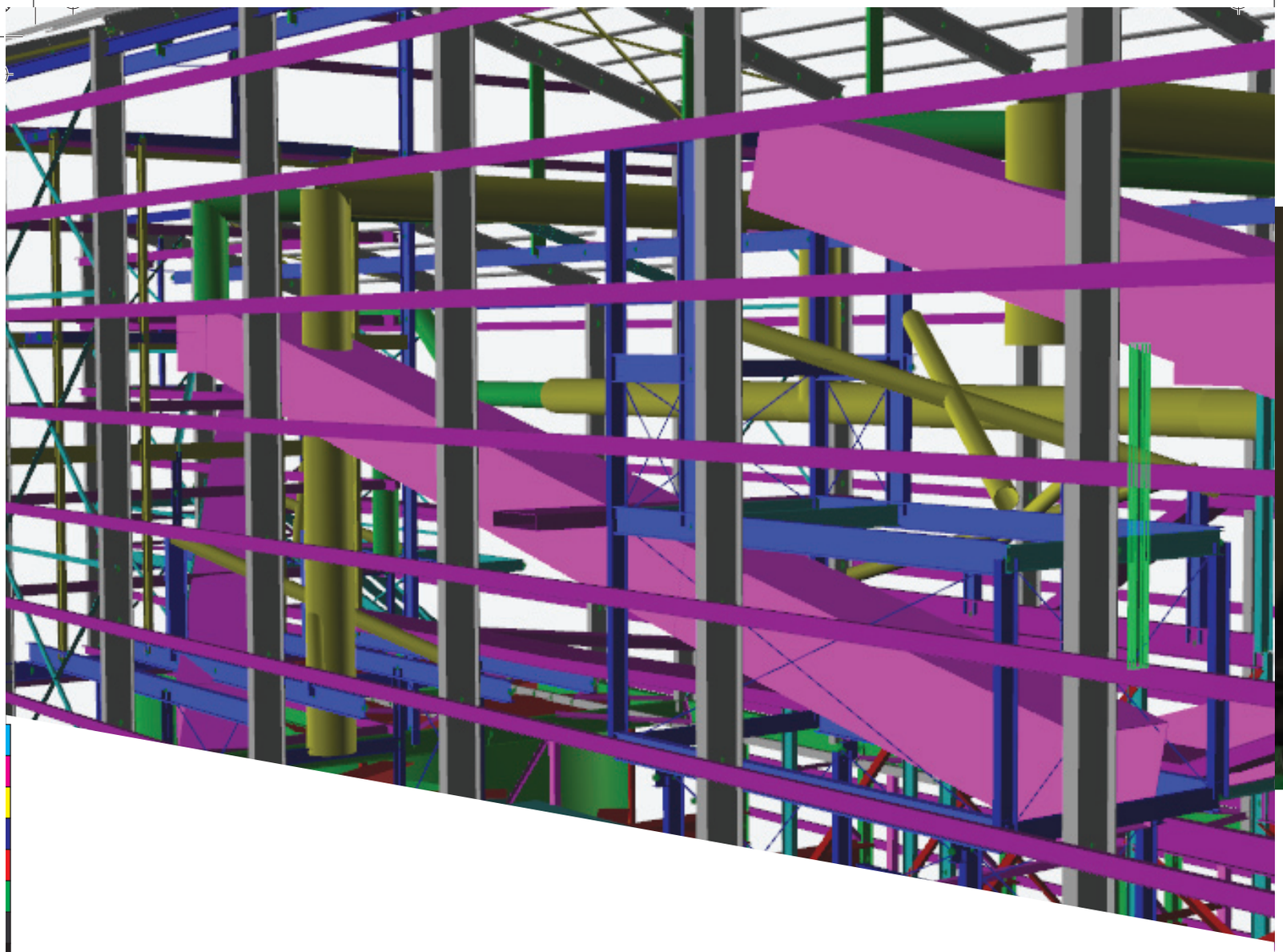
TOP: An astronaut in Waldie's Andreas Skinsuit.

"I could see that this was cutting-edge technology," says Turner. "We started talking about the occupations that command the elite precision and cutting-edge requirements analogous to that of astronauts, and we centred on medical science and professional sport."

These are industries where a one-per-cent advantage can make a real difference, he explained.

"People are always striving for an optimum outcome," says Turner. "We felt that elite sport was the industry most accessible to us as a starting point."

Waldie spend the next two years developing the technology part-time, while Turner provided some of the seed funding and commercial background. ▸



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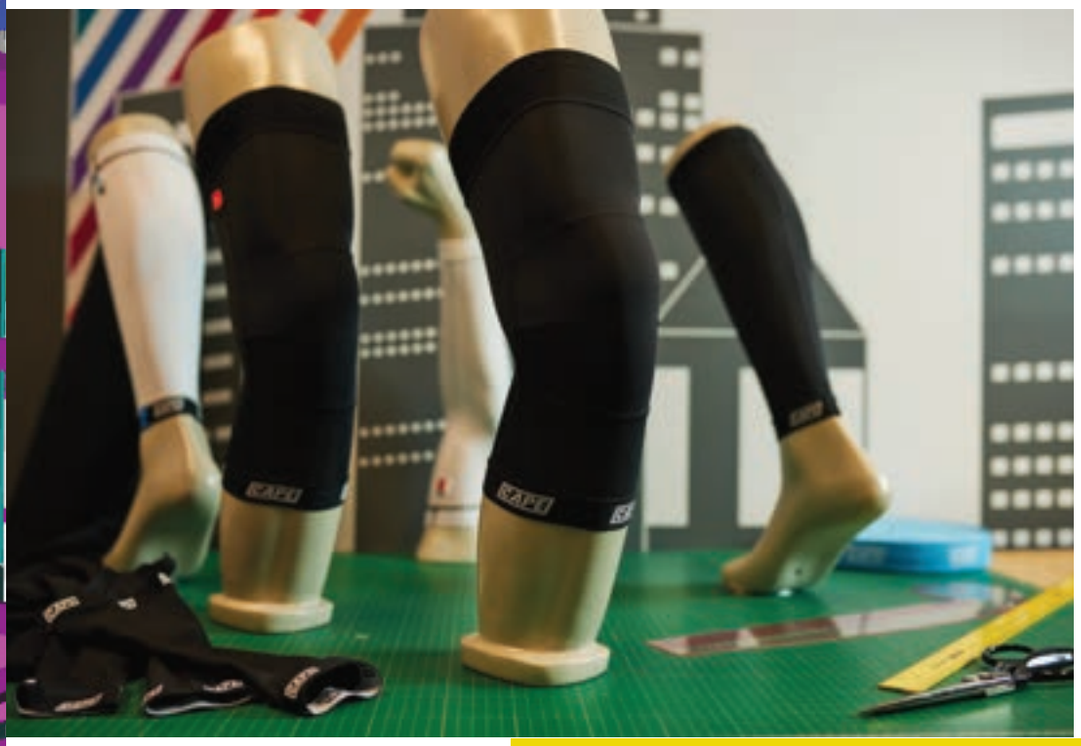
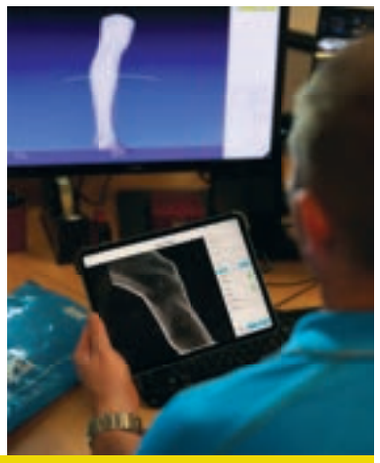




"Then James quit his job to build Cape full-time and we got our first products out," says Turner. "Our first meeting was with the Essendon Football Club, and they loved the products. From that point, we were on our way."

PRECISION TECHNOLOGY

Cape Bionics' custom compression garments are manufactured in Melbourne from a similar anisotropic material to Waldie's spacesuits.

The material is stronger in the vertical axis and is circumferentially soft on the body. Unlike the spacesuits, however, they include moisture wicking, an ultraviolet protection factor system, and the elasticity required for sporting applications.

While the traditional production of custom-fit garments includes measuring the body with a tailor's tape to create a pattern for materials to be sewn together, Cape Bionics uses a 3D scan of an athlete's body. Its patented AutoTailor system then analyses the scan and designs the garment to match an athlete's precise measurements and the selected compression regime.

"WITH A TAILOR'S TAPE, YOU MIGHT TAKE AN ANKLE MEASUREMENT AND A MAXIMUM CALF MEASUREMENT. WITH OUR SYSTEM, WE ARE DESIGNING FOR EACH POINT OF THE LIMB."

ABOVE: Cape Bionics custom-fits its garments using 3D scans.

"We have the capability to take thousands of measurements from the scan, rather than just a few with a tailor's tape," says Waldie.

"We design the garment for each one millimetre of length for the material properties and for the desired compression regime."

Waldie adds that his technology eliminates the guesswork of traditional measurement methods.

"With a tailor's tape, you might take an ankle measurement and a maximum calf measurement, for instance, but what happens in between? With our system, we are designing for each point of the limb, and that's really critical, because a lot of the compression regimes are graduated."

COMPRESSION POWER

The key benefit of compression is the augmentation of blood and lymphatic flow. Cape Bionics' research shows different compression regimes are optimal for different scenarios.

When AFL players are recovering from a game, for instance, their body is in a ▸

semi-relaxed state and their heart rate is normal.

Cape's research shows that a higher level of compression can maximise blood flow and the removal of waste by-products from recent exercise, while reducing muscle soreness, damage or swelling.

In contrast, when a player is on the field, their aerobic demand is high, and a custom compression garment designed for performance can reduce the likelihood of delayed-onset muscle soreness and increase endurance and strength.

"We're slightly manipulating the vascular system for different scenarios," says Waldie.

"We're also looking at tailored support for post-surgical procedures such as ACLs."

Jessica Stephens, a sports scientist at the ACT Academy of Sport, has a special interest in recovery modalities. While working as a PhD student at the Australian Institute of Sport, she and her colleagues compared the compression profile of off-the-shelf compression garments and how it changed with body posture.

"WE FOUND THAT THE RECOMMENDED-SIZE GARMENT DIDN'T ALWAYS HAVE THE MOST OPTIMAL PRESSURE PROFILE FOR A PARTICULAR ATHLETE."

"We looked at the compression profile of a recommended-size garment, plus a garment either below or above the recommended size," she explains.

"We found that the recommended-size garment didn't always have the most optimal pressure profile for a particular athlete, if you're looking at what a compression garment is meant

RIGHT: Waldie's technology could one day help humans survive on other planets.

SKIN TIGHT

Life in microgravity can wreak havoc on the human body, but aerospace engineer Dr James Waldie has spent much of his career developing technology that shoulders the load and makes astronauts feel more at home in space.

Along with his role at Cape Bionics, Waldie is CEO of Human Aerospace, which provides specialised space life sciences and bioastronautics services to the defence and aerospace industries.

He is currently working with a team of scientists to develop new gravity loading compression spacesuits, including an intra-vehicular activity "skinsuit".

The absence of gravitational loading in space can have an adverse impact on astronauts, leading to loss of bone density and body mass. Waldie has spent almost two decades developing compression spacesuits and his invention, the Gravity Loading Countermeasure Skinsuit, or GLCS, is a skin-tight spacesuit that gradually increases the degree of tension from the astronauts' shoulders to their toes.

This mimics the normal bodyweight loading due to gravity on Earth, but Waldie explains the suits must be personalised to each astronaut.

"That's not only because the loading is related to your body weight, but it's also down to

the shape and size of your body," Waldie explains.

"We had to have the vertical stretch of the material increasing to try and increase that vertical tension and load, but we also had to keep the suit quite tight to enable that stretch regime and to transfer the loads into the body."

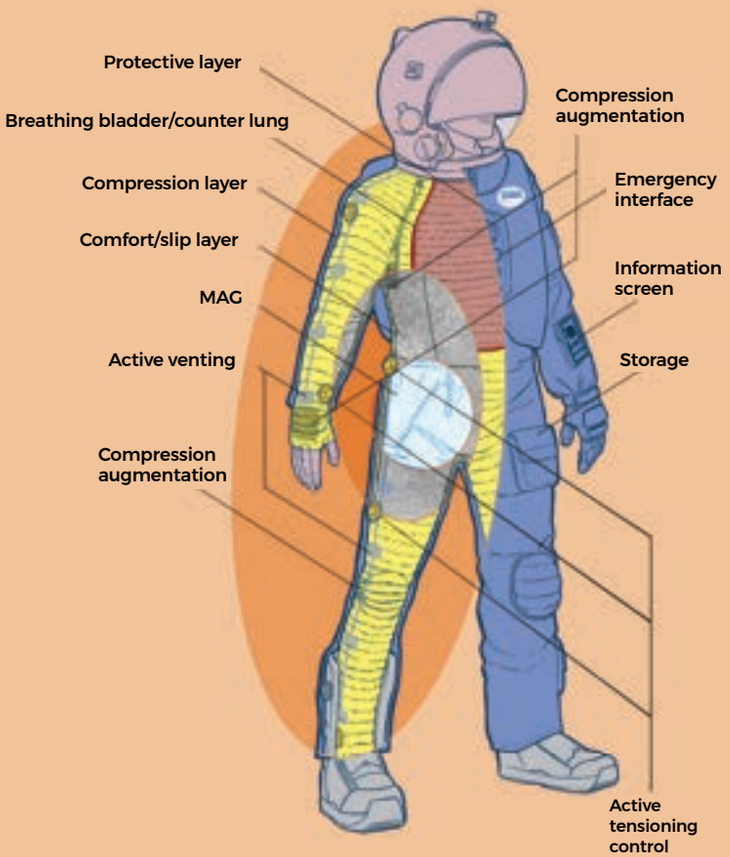
With funding from an Australian Space Agency grant, Waldie and his team at Human Aerospace are currently developing the next generation of skinsuits for astronauts to wear for the NASA Artemis lunar exploration program. He's also developing technology to support astronaut health when they return to Earth.

Up to 80 per cent of astronauts experience orthostatic intolerance after returning from a long-term space mission. The condition relates to the inability to maintain blood pressure while in an upright position.

"When astronauts who are adapted to microgravity come down on to the surface, the blood pools in the lower body and they can faint very easily," Waldie says.

That is why he sought to develop a garment that applies high compression on the lower body that would reduce that pooling and maintain blood flow to the brain.

"The technology and engineering that goes into allowing people to survive beyond our atmosphere, to float in space, to walk on the moon — and soon on other planets — has always been a passion of mine," says Waldie. "But we need to support their health when they're back on Earth, too."



to do, which is provide sequential compression based from the extremities back into the centre of the body."

PUT TO THE TEST

Cape Bionics recently launched a PhD program with the Queensland University of Technology and Queensland Academy of Sport to investigate the benefits of its garments on elite athletes.

The company has also performed ultrasound readings to examine increased blood flow generated by its garments, as well as reduced muscle oscillation for injury recovery.

"Almost all of our garments are used for recovery," says Waldie.

"Initially, we assumed that athletes would wear these garments during the games, because that's where I thought you would wish to have peak performance. But, in order to have the highest performance over a season, you need to have very strong recovery protocols."

"IN ORDER TO HAVE THE HIGHEST PERFORMANCE OVER A SEASON, YOU NEED TO HAVE VERY STRONG RECOVERY PROTOCOLS."

Ian McKeown is Director of McKeown Performance and an advisor to Cape Bionics. He completed his PhD in strength and conditioning at the Australian Institute of Sport and became aware of Cape Bionics' products while working as the Head of High Performance at Port Adelaide Football Club.

"The logic behind what Cape Bionics was doing just made so much sense to me," he says.

"While I was working with Port Adelaide, I'd have to try to work out what size compression garment each player needed for ➤

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"That's when the business can really scale, because we can start to support huge numbers of athletes," says Waldie.

"Whether they're scanned by us or self-scanned by a team member, or scanned by themselves at home using their phone, AutoTailor can ingest it and produce the pattern."

Cape Bionics currently works with sporting codes including football, baseball, basketball and soccer in Australia and the US.

It is also exploring opportunities in the medical field with compression garments to treat conditions such as lymphedema and lipedema. Its products may also be suitable for the treatment of burns, as its scanning technology eliminates

"WHETHER THEY'RE SCANNED BY US OR SELF-SCANNED BY A TEAM MEMBER, OR SCANNED BY THEMSELVES AT HOME USING THEIR PHONE, AUTOTAILOR CAN INGEST IT AND PRODUCE THE PATTERN."

PICTURED: Cape Bionics' products include (clockwise from top) calf sleeves, arm sleeves, socks and leggings.

recovery, and if I wasn't guessing, they were guessing.

"We place so much importance on recovery after a game and there is a lot of rigour behind the protocols, but it's a house of cards if you're basing it on something that doesn't fit correctly and that isn't fit for purpose. You can upgrade your recovery protocols exponentially when it's not down to chance."

McKeown adds that the custom-made nature of Cape Bionics garments can also have a powerful effect on athletes.

"There's a belief effect in recovery science," he says. "If an athlete gets a computer scan of their body to create a recovery garment that's fitted perfectly to them, that special attention can improve the efficacy of the recovery protocols."

FUTURE FIT

Cape Bionics employs a team of 12 people in Melbourne and has recently expanded its operations to the US. While its current scanning technology generally scans athletes in their training rooms, the company is developing an iPhone solution that will allow athletes to scan themselves.

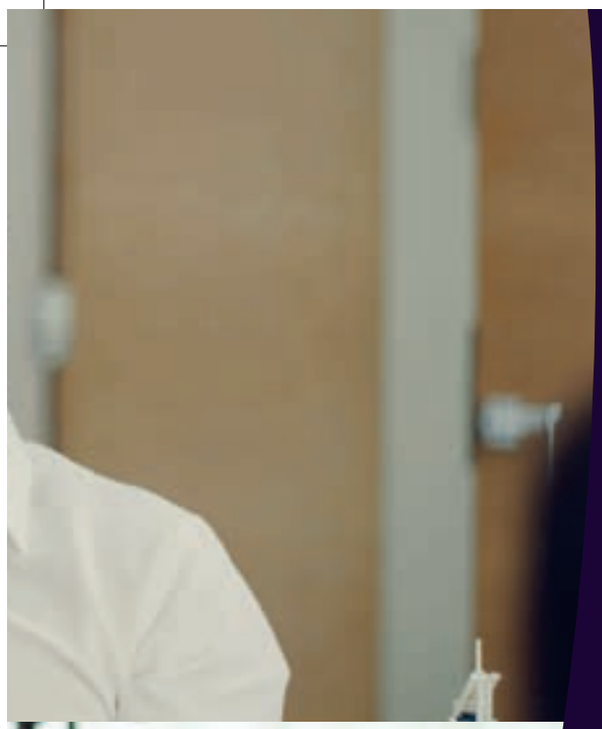
the need to touch the body in order to measure it.

"There are also pilots trialling calf sleeves from our travel compression regime, and they're finding significant benefits over traditional compression socks," says Waldie.

"There are many potential applications, but we need to be strategic in how we apply the technology, and we need to grow the business on a solid foundation." ●





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WORDS BY **NICHOLAS BRANT**

TOP SPEED

THE NEXT GENERATION OF HIGH-SPEED MOTORS IS TAKING SHAPE IN SYDNEY THANKS TO A TEAM OF ELECTRICAL ENGINEERS, A LOT OF INGENUITY AND A LITTLE INSPIRATION FROM A KOREAN RAIL BRIDGE.

MEASURING SLIGHTLY longer than the average pen and just wider than a coffee mug, the humble device sitting in the middle of this University of New South Wales (UNSW) lab proves that good things can come in small packages.

For the UNSW team of electrical engineers, this small yet extremely powerful motor – which has achieved speeds of 100,000 rpm – is the culmination of years of hard work.

If successfully commercialised, this motor technology will leave its mark across many industries – including electric vehicles (EV); heating, ventilation, and air conditioning (HVAC) systems; and computer numerical control (CNC) machining – for years to come.

The UNSW team's prototype motor represents the next major evolution of interior permanent magnet synchronous motor (IPMSM) technology, which is used in a range of applications around the world but is commonly seen in electric vehicles.

IPMSM technology contains magnets within its rotors, which are instrumental to creating stronger torque and extending speed range in electric vehicles.

However, conventional IPMSMs are not mechanically robust, because they are designed with thin iron bridges that hold the magnets within the rotating core of the motor. These bridges are known to break if they are subjected to increasing mechanical stresses, which occurs when cylindrical rotors rotate at very high speeds.

Dr Guoyu Chu of UNSW's School of Electrical Engineering and Telecommunications tells *create* his team's goal is to have its motor operate at 100,000 rpm, which would make it the fastest IPMSM built with commercial steel lamination materials.

"I determined all common rotor topologies experience mechanical stress – which ranged as high as one gigapascal – which made it impossible to design a high-speed motor using common topology," he said. "So we decided to design a novel rotor topology to meet our needs."

BRIDGING THE GAP

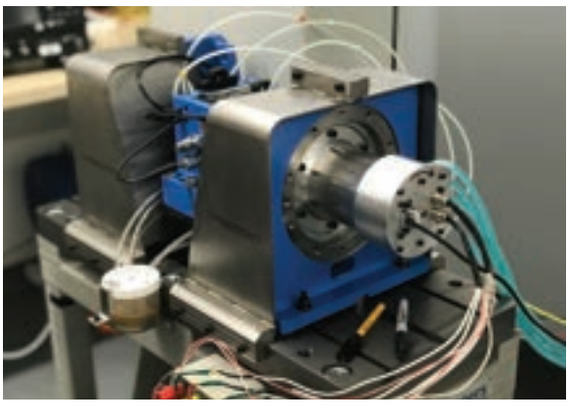
The team turned to cross-disciplinary solutions to address the challenge and build a better understanding of mechanical and civil engineering principles.

While researching successful civil engineering designs, Chu came across the Gyopo Bridge, a high-speed rail crossing in South Korea.

The team designed its motor's iron rotors based on the Gyopo Bridge's double-tied arch structure, which strengthens the overall bridge and enables it to carry very heavy loads.

The team also experimented with a compound curve – a common feature used for freeway entrances and exits – which start with a large curve radius to accommodate very high vehicle speeds.

BELOW: The UNSW IPMSM motor is about the length of a pencil.



However, the curve radius gradually reduces and, in doing so, forces the vehicles to reduce their speed accordingly.

"We took both the Gyopo Bridge double-tied arch structure design and the compound-curve-based stress distribution technique and applied them to the iron bridges in the IPMSM motor," Chu says.

"WHAT WE FOUND WAS MECHANICAL STRESS ALONG THE IRON BRIDGE WAS SUCCESSFULLY REDUCED BY HALF, FROM ONE GIGAPASCAL TO AROUND 500 MEGAPASCALS."

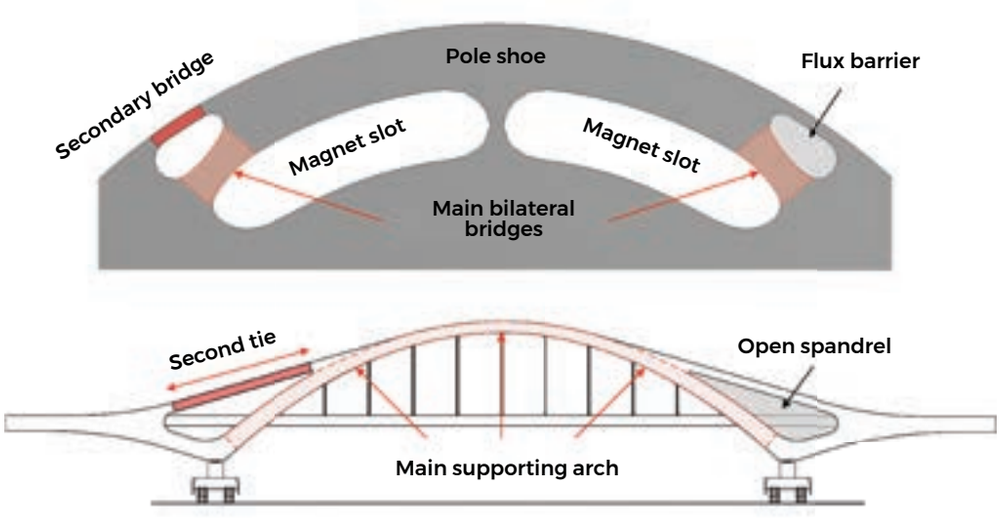
"What we found was mechanical stress along the iron bridge successfully reduced by half from one gigapascal to around 500 megapascals."

The team also adopted the bridge's open spandrels – holes in the arch's vertical sidewalls – which reduced the weight of the bridge but also allowed high-speed winds and water spray to pass through rather than impact on it.

UNSW Associate Professor Rukmi Dutta says incorporating the open spandrel design into the rotor topology created a flux barrier for the magnets.

"In IPMSM motors you need the magnetic flux in the rotors ▸

Motor vs bridge



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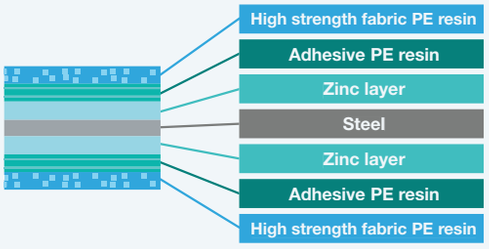

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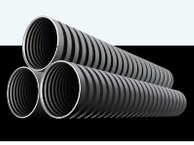

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combined with the electrical current from the stationary part of the motor, and together that gives you the torque which underpins the mechanical work you need to do with your motor," she says.

"But some of the magnetic force from the magnets will leak to the surrounding iron, so you want to minimise that leakage as much as possible.

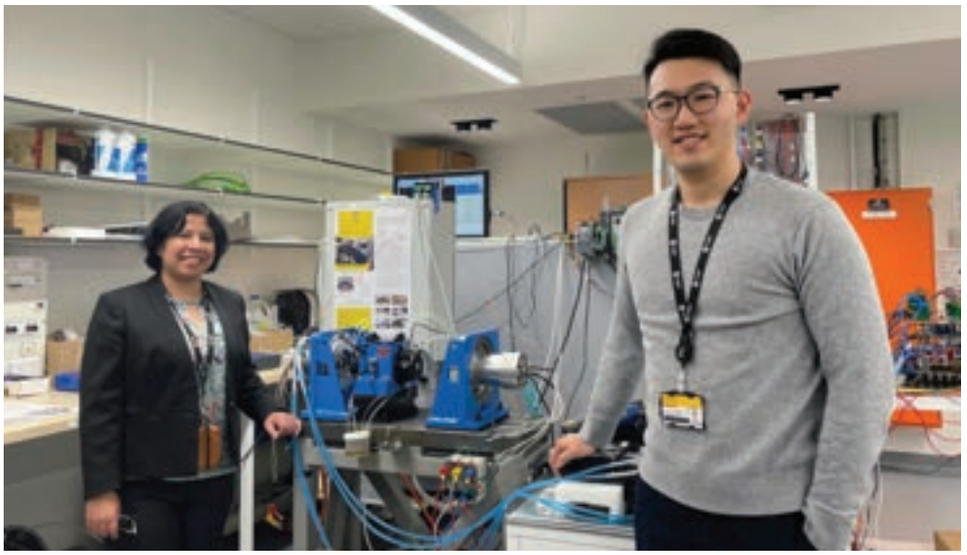
"If we have a high magnetic force leakage then we need to include more magnets to create a field that is strong enough to produce the torque and power.

"So the flux barrier limits the magnetic leakage, meaning we can utilise 90 to 95 per cent of the magnet. But if there is high leakage, we can probably only use around 60 per cent of the magnet and we need to utilise more magnets, which adds to the weight of the motor."

This more efficient rotor design produces the same amount of torque while reducing the amount of high-density energy magnets, which are reliant on the rare earth elements (REE) neodymium and dysprosium.

The team says that substantially reducing reliance on REE-rich magnets – by about 70 per cent of REEs compared to conventional IPMSM motors – is more environmentally friendly and reduces Australia's reliance on importing processed REEs for vital components.

While rotor design represents a major advancement, the team also sought to optimise the motor's overall design to achieve premium electromagnetic performance, power density and also consider vibration performance, speed and thermal performance.



The team used an artificial intelligence-assisted optimisation algorithm and input in multiple objectives and parameters to determine the best motor design.

The algorithm presented the engineers with 100 different designs, which they evaluated to find the best 50 motor designs. These were then fed back into the algorithm to create a second generation of designs. The current prototype represents the 120th generation of motor design created via this process.

"OUR MOTOR OFFERS A MUCH MORE MECHANICALLY ROBUST AND RELIABLE ALTERNATIVE, AND IT DOES NOT REQUIRE A CARBON FIBRE SLEEVE, SO IT IS SUBSTANTIALLY CHEAPER."

EVs AND TURBOCHARGERS

The resulting prototype has achieved speeds as high as 100,000 rpm while being lighter and far more compact than conventional IPMSMs.

This makes the UNSW motor suitable to a wide variety of applications, such as in aircraft, as well as HVAC systems that require high-speed compressors.

ABOVE: UNSW engineers Rukmi Dutta (left) and Guoyu Chu. ABOVE LEFT: The team's high-speed motor with a 4 kW low-speed IPMSM.

Dutta tells *create* the motor has great potential to be used in the EV industry but will most likely be scaled to provide 300 kW at about 20,000 rpm.

"IPMSMs are already used in the EV industry with most major electric vehicle manufacturers' motors achieving maximum speeds of 15,000 to 18,000 rpm," she says.

"For instance, Tesla's IPMSM can reach speeds as high as 20,000 rpm but that motor has to use a carbon fibre sleeve for the stress in the rotors.

"Our motor offers a much more mechanically robust and reliable alternative, and it does not require a carbon fibre sleeve, so it is substantially cheaper."

Dutta says the team is fielding enquiries from the automotive industry to integrate their invention with turbochargers that would require the motor to provide 100,000 rpm.

The team believes the motor could be deployed commercially in Australia within five years.

"We have a wealth of ideas and designs, but in Australia right now there is severe lack of quality manufacturing capabilities on a broad scale," Dutta says.

"In years down the track we hope to be able to have our motor design integrated with commercial products and made right here in Australia." ●

ORGANIC POWER

WORDS BY **MICHELLE WHEELER**

LEFT:
Finn Biogas's composting facility is small enough to be used by a shopping centre or apartment complex.

A QUEENSLAND TEAM HOPES SCALED-DOWN INDUSTRIAL BIOGAS PLANTS CAN PROCESS ORGANIC WASTE AT SHOPPING CENTRES, OFFICE BUILDINGS, UNIVERSITIES AND MORE.

MECHANICAL ENGINEER Jason Hawley is used to a lot of rubbish. As Managing Director of Finn Biogas, he typically oversees projects that process 50,000 to 100,000 t of trash a year, turning organic waste into compost and biogas.

It's a far cry from the average home compost heap. But a new project has seen his team design a composting facility that could offer a middle ground between industrial-scale processing and a decomposing pile of kitchen scraps in the garden.

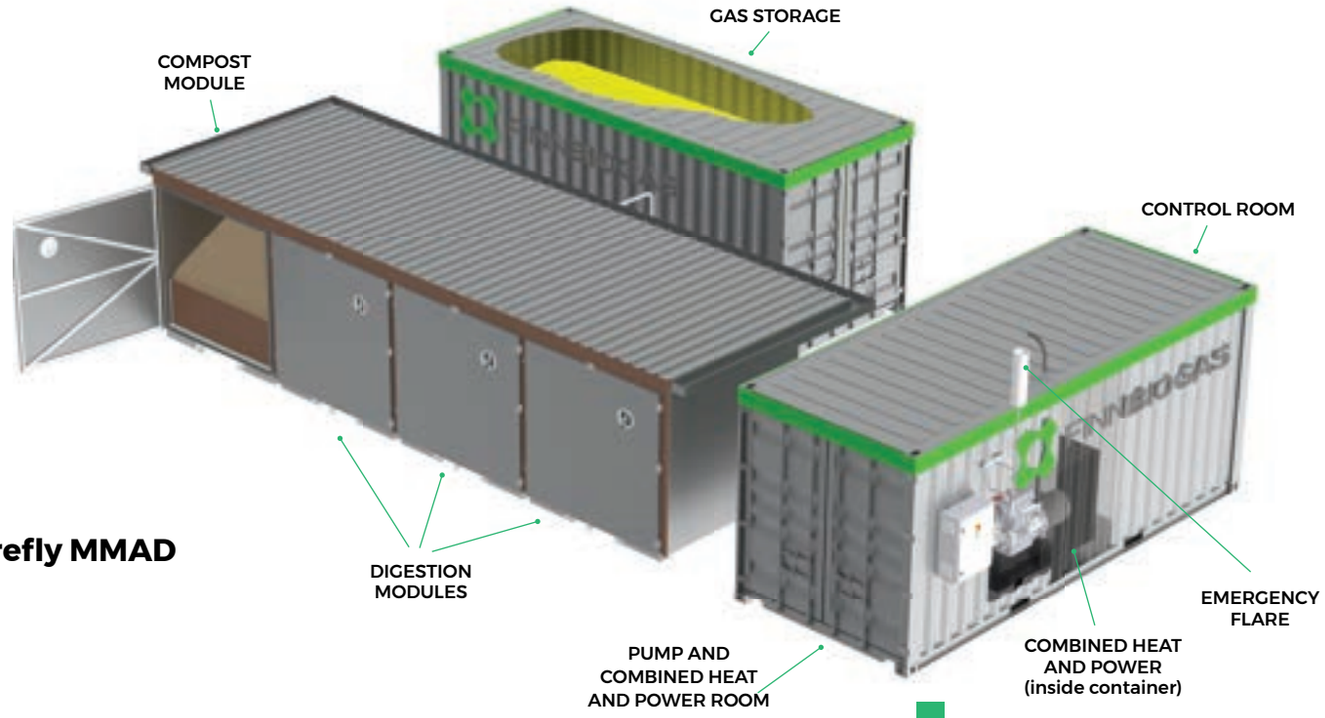
Known as the Firefly MMAD, for "micro modular anaerobic digester", the system is designed to collect "dispersed organic waste" and process it on site.

"It's the organic waste that's in coffee shops, restaurants, office buildings," Hawley says. "Leftover scraps from people's lunch and things like that."

"PROBABLY 50 PER CENT OF THE PROJECTS, WE DON'T TURN THE BIOGAS TO ELECTRICITY. IT JUST GOES STRAIGHT TO INDUSTRIAL HEAT FOR BOILERS."

Hawley says the system is designed to be small enough for an apartment complex, a large shopping centre or a university.

It is far smaller than an industrial-scale plant, and instead processes 200 to 500 t of organic waste a year. ▶



Firefly MMAD

"THIS SYSTEM SERVES A BIT MORE OF THE COMMUNITY SIDE. THE ABILITY TO SCALE IT UP OR DOWN MEANS THAT YOU'RE COVERING MORE THAN A ONE-SIZE-FITS-ALL APPROACH."

"The idea is to reduce the transport of this waste and, obviously, divert it from landfill," Hawley says.

FRESH AIR

The Firefly MMAD is a modular product. Each set-up has a plant room with pumps, small tanks, valving and a control system, along with between two and ten 2 m by 2 m waste-processing modules.

The system can operate in two modes: aerobic and anaerobic.

In aerobic mode, it simply converts organic waste to compost. In anaerobic mode, the modules also produce biogas that can be turned into electricity.

There are ways to export this energy back to the grid – similar to rooftop solar systems.

But Hawley says the electricity is usually tied in "behind the meter" for use in the same facility that the waste came from.

"We find that most of the projects we do – even at the industrial scale – if the facility is large enough to produce the volumes of waste to look at a digestion system, then they're generally large enough to consume all of the energy that it would produce," he says.

Some large-scale projects skip the conversion and use the heat directly, Hawley says.

"Probably 50 per cent of the projects, we don't really turn the biogas to electricity; it just goes straight to industrial heat for boilers," he says.

Hawley says there have been a lot of challenges in scaling down from large industrial plants to a small, modular plug-and-play solution.

"Primarily they're – from an engineering point-of-view – focused around getting the right equipment at that scale," he says.

"Obviously, equipment is produced by vendors at a certain range or a certain flow rate, so [that meant] getting equipment we're happy with, that was smaller, but also still met the needs of the project in terms of costs."

Hawley says projects of this kind don't necessarily scale linearly.

"You get much larger gains at a larger scale, because you still have to pay for the same amount of engineering and compliance and documentation," he says.

"What we found was that by making a modular [system], we could bring a lot of that engineering time forward into one development, and then it's kind of a repeatable product. So that helps drive down the cost."

BELOW: Finn Biogas Managing Director Jason Hawley.

BALANCE OF POWER

The smaller scale also meant the engineers had to work ▸

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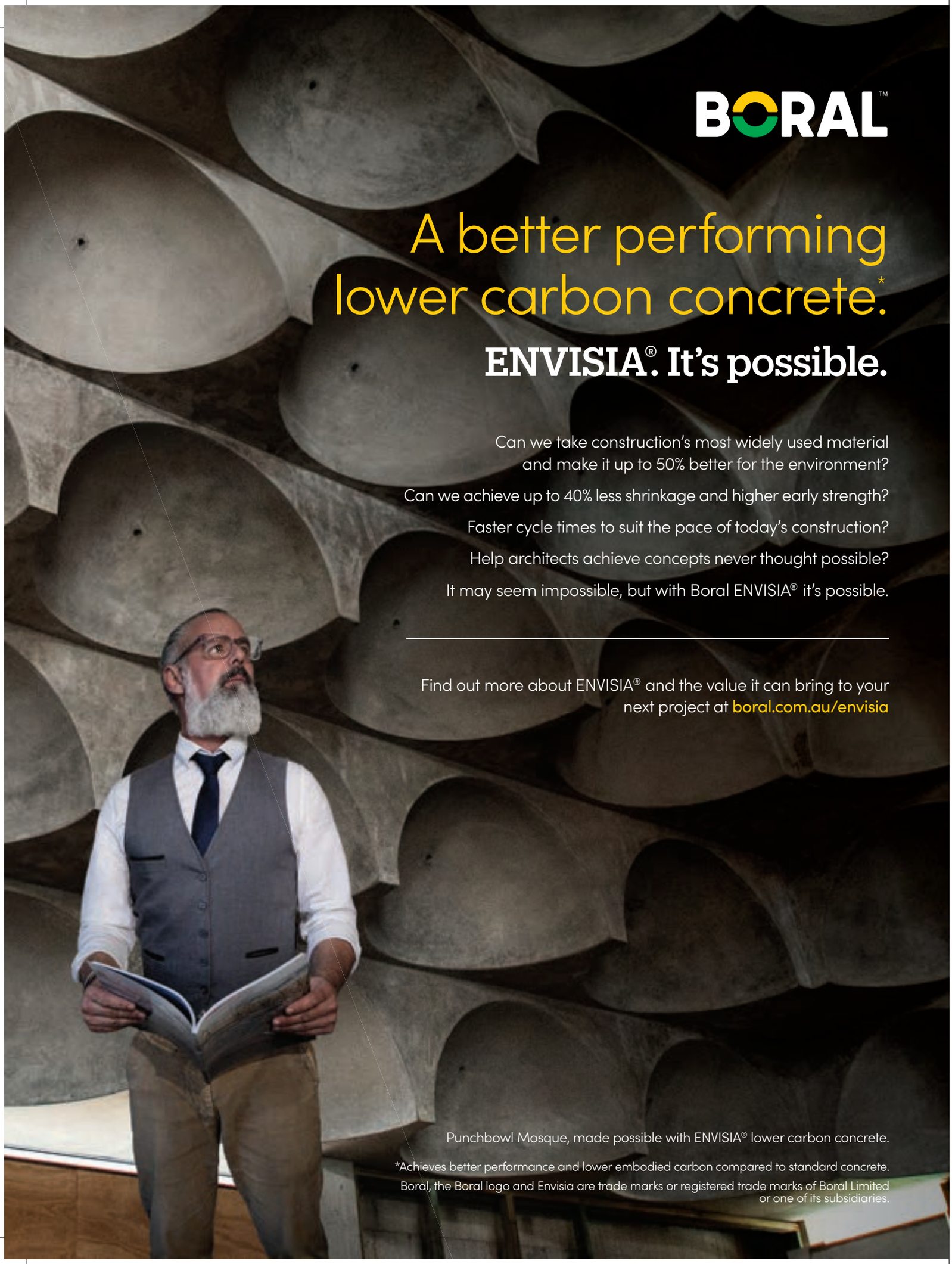

harder to achieve a net energy gain. That's because it still needs to run the pumps, motors and other equipment associated with a larger system.

But it's critical that there's a net energy benefit, Hawley says.

"The amount of energy you produce … unfortunately, is a function of the waste that goes in," he says. "If you're processing something with a lower energy content, your net energy benefit is going to be less, just as a result of something you can't change."

Greenhouse gas emissions are another part of the puzzle.

"We found that by doing decentralised treatment of waste we got some really good gains from a CO_2 point-of-view," Hawley says. "The environmental piece is really important for us."

"WE'VE GONE FROM DRAWING ON A WHITEBOARD IN AN AFTERNOON BRAINSTORM MEETING TO HAVING IT BUILT DOWNSTAIRS."

While the Finn Biogas team initially envisaged the Firefly MMAD for apartment buildings, shopping centres and universities, feedback from the market has led it to consider more directions.

"There's a lot of opportunity for us in remote mining camps, remote communities, offshore," Hawley says. "Small Pacific islands – places like this would have … centralised fruit and vegetable markets. You can obviously also go into agriculture, with agricultural waste."

Hawley argues decentralised waste treatment can reduce carbon emissions not only by diverting waste from landfill but also by taking transport out of the equation.

Finn Biogas Process Engineer Michelle Keane sees the technology as a way to make biogas accessible to more people.

ABOVE: Process Engineer Michelle Keane.

She says most biogas projects are large industrial plants or conducted in a lab or university.

"A lot of people know at least a little bit about composting – maybe sometimes they know a little bit about digestion – but struggle to get involved with it," Keane says.

"I think this system serves a bit more of the community side. I also think the ability to scale it up or down means that, again, you're covering more than just a one-size-fits-all approach."

Keane says a lot of the challenges on the Firefly MMAD are being faced for the first time.

"We've gone from drawing on a whiteboard in an afternoon brainstorm meeting to having it built downstairs," she says. "To me, that's pretty exciting." ●

Happy bacteria

In anaerobic mode, waste is inoculated with anaerobic bacteria and the system is closed up. Bacteria consume the organic waste and produce biogas.

"It's a natural process that occurs in landfill, in marsh and swamps, in the stomach of [cattle and sheep]," Finn Biogas Managing Director Jason Hawley says. "We're basically engineering an existing biological process. We're trying to work with nature as best as possible to optimise the conditions, to let that bacteria really just live its best life."

The biogas produced is captured and stored, before being burned in a small heat and power generator. The electricity is exported and the heat is reused in the process. The process also produces a nutrient-rich digestate that can be used as a fertiliser.

In aerobic mode, the system works in a similar way to large industrial composting facilities. The waste is placed in an aerated tunnel where it breaks down, producing compost. Again, the conditions are closely controlled, with temperature, humidity and aeration optimised for the best results.

"One of the really cool things about it is that we can configure the modules to be able to do just one of the processes, or both of the processes in parallel or in series," Hawley says.

ON THE FAST TRACK

WORDS BY **CHRIS SHEEDY**

MORE THAN 200 ENGINEERS AT DOWNER'S RAIL AND TRANSIT SYSTEMS ARE PART OF A CREDENTIALING PUSH TO ENSURE THEY CAN PROVIDE THE HIGHEST LEVEL OF ENGINEERING SOLUTIONS, STAFF AND CUSTOMER SAFETY, AND CLIENT CONFIDENCE.

ABOVE: Downer RTS's high-capacity metro trains project is the first new Victorian train design in nearly 20 years.

BEFORE SHE earned Chartered status with Engineers Australia, Sagarika Das CEngT wasn't quite sure of its value. After all, she had worked in India, the US and Australia in senior positions on major engineering projects in automotive and rail for 16 years.

But after completing the credentialing process, Das wondered why she didn't seek Chartership sooner.

"Now that I have my credentials, I can see the importance the industry is placing on them. It makes me feel very happy and proud that I have earned Chartered status, and I wonder why I didn't do it earlier," says Das, who until recently was Senior Systems Integration Engineer at Downer's Rail and Transit Systems (RTS)

"It really does demonstrate your growth in knowledge through the work you have done, and it's a real value addition for the individual, for their client and for their employer."

After three years in the automotive industry, Das made the leap to locomotives when she accepted an appointment at GE Transportation. She has been

BELOW:
The HCMT project comprises an order of 70 trains.

deeply involved with all types of rolling stock ever since.

"As part of my GE career I worked with Rio Tinto in Karratha and in their Melbourne office," she says. "Then I moved to Downer's HCMT project four years ago."

FOCUS ON THE FUTURE

The HCMT – high-capacity metro trains – project is the first new train design in Victoria in nearly 20 years. The Victorian Government initially ordered 65 trains as part of the largest single order of trains in the state's history.

The investment of more than $2.3 billion, which has now expanded to add five more trains to the order, includes a new maintenance facility in Pakenham East and a light service facility in Calder Park. The fleet is being built using at least 60 per cent local content and has produced more than 1100 jobs in Victoria.

Das has been working on the requirements and integration of the various systems of the HCMT project. Her current focus is the integration of the high-capacity signalling system on the HCMT.

The HCMT is one of the first operational trains on the network to be fitted with high-capacity signalling for use in the Metro Tunnel, enabling more trains to run more often and travelling at intervals of just two to three minutes.

"This is the first time we're integrating high-capacity signalling trains in Australia, and it has been a huge learning curve," Das says.

"IT'S VERY EXCITING TO BE SUPPORTING THE SIGNALLING SIDE, WORKING WITH FUTURE TECHNOLOGY TO CREATE THE TUNNEL OF THE FUTURE."

"It's very exciting to be supporting the signalling side: working with future technology to create the tunnel of the future."

What exactly is the tunnel of the future?

It's one with bigger platforms that can accommodate more people and longer, 10-car trains.

It has platform screens with doors that the trains' doors will line up with perfectly, keeping passengers on and off the trains safe at all times. And its technology allows trains to operate safely with more frequency.

The trains are loaded with technology. This includes condition monitoring technology, which allows the tracking of the train's condition in real time. Train movement on all sections of the track will be optimised, meaning trains will communicate with each other to ensure optimal speeds and fewer delays on all parts of the network, and platform information will be relayed to train operators.

"It is very exciting work, and it is very engaging work," Das says. "Does it ever get boring? Never!"

GETTING CREDENTIALED

The partnership between Downer RTS and Engineers ›

Australia was created to support the credentialing of engineers and engineering technologists, and Das says the process of becoming Chartered has been significantly streamlined.

"You still have to present lots of CPD [continuing professional development] logs, which is very important," she says.

"But the process is very focused. There is a lot of importance placed on the work you've done and the growth you've achieved through experience and CPD."

While the past three years are in sharpest focus, the process helps an engineer to appreciate the knowledge they have built over their entire career.

But the accreditation is not just about the individual. It also lifts levels of safety during construction, and for customers once the project is complete by ensuring those who recognise best practice are leading the project.

"I have a career span of 16 years across three continents," Das says.

"Even though the CPD logging was for only three years, you also have to write bullet points around case studies and experience.

"For this, I had to look back over my entire career, just to appreciate how I developed this knowledge … The fact that the company was backing me helped a lot. It gave me great confidence that the right people would appreciate the right experience and knowledge."

"THERE IS A LOT OF IMPORTANCE PLACED ON THE WORK YOU'VE DONE AND THE GROWTH YOU'VE ACHIEVED THROUGH EXPERIENCE AND CPD."

ABOVE: The HCMT fleet is being built using 60 per cent local content.

CONFIDENCE TO SUCCEED

At the other end of the process, Lead Configuration Engineer Maria Mochales is about to begin her credentialing.

The fact that her organisation is providing support, and that Engineers Australia has partnered with Downer to assist, gives her great confidence.

"I currently only work three days per week," she says, describing the levels of flexibility and diversity Downer RTS has managed to achieve.

"I have a one-year-old child, so I don't have a lot of extra time in my life. But being Chartered is an important recognition of engineering knowledge and experience, so it's okay that it's not something that happens overnight … the fact that my employer is giving me this opportunity, and also doing it with Engineers Australia, means the process is very clear and you always understand exactly what you need to do next.

"It will be a lot more straightforward than doing it on my own, including the fact ▸

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"NO MATTER WHAT ENGINEERING ROLE I'M CARRYING OUT, CHARTERSHIP WILL HELP ME IN NUMEROUS WAYS."

that I'll be able to do some of it at work."

Mochales, like Das, comes from an automotive background. She spent several years in California with Tesla as a Senior Quality Engineer, and has worked with towing, trailer and cargo management business Horizon Global and Nissan Motor Australia.

At Downer RTS, Mochales works in the state-of-the-art and purpose-built Pakenham East Depot, where the testing and commissioning of the HCMTs are carried out.

Her role is to control configuration changes during the testing and commissioning phase of the HCMTs, including analysing any potential ripple effects of various engineering changes, and ensuring those changes are rolled out to all trains at all stages of production.

"No matter what engineering role I'm carrying out, Chartership will help me in numerous ways," Mochales says.

"Downer works on projects across all of Australia and there are some states that require Chartership to practise as an engineer at a certain level ... It means I'll be able to consider those opportunities. Chartership is a very good thing." ●

BELOW: Engineers Australia Chief Engineer Jane MacMaster FIEAust CPEng (left) with Downer RTS Lead Configuration Engineer Mark Baxter.

Ensuring safety

Mark Baxter, Head of Engineering and Technology at Downer, discusses the importance of the credentialing process.

Q. Why did you enter into this partnership with Engineers Australia?

A. Engineers Australia is the largest professional engineering body in Australia with recognised MIEAust and CPEng credentialing, as well as control of the National Engineering Register. When Downer and Engineers Australia discussed undertaking a partnership to help streamline the process of ensuring our 200-plus engineers were credentialed, it was a no-brainer.

Q. Why is credentialing important?

A. Credentialing is really important for us. At Downer, Zero Harm is one of our pillars and ensuring we work in a safe way is key. Ensuring our engineers are at the height of industry standards is just one way we're able to ensure safety for staff and customers.

Our Rail and Transit Systems business operates down the entire eastern seaboard. The states have — or are in the process of legislating — registration of engineers and the credentialing process will assist in ensuring we satisfy this legislation. We're happy to undertake this opportunity as there are many benefits for us, our staff, and our customers.

Q. How has your team responded to the program?

A. They've all said how they have appreciated the quick and streamlined process towards Chartership, as well as Downer paying for it. Some have been regretful they put it off for so long. I think the credentialing process that Engineers Australia has mapped out is of real value to the engineers working for Downer.

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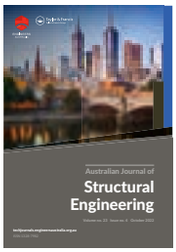


MODELING AND STRUCTURAL CONTROL OF A BUILDING WITH HOLONOMIC CONSTRAINTS

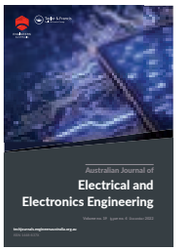
Journal: *Australian Journal of Structural Engineering*
Author: C. F. Rengifo & D. A. Bravo

This study evaluates structural control systems in terms of mechanical impedance and the peak of energy stored by the structure. Hypothesising that the higher the mechanical impedance, the lower the peak of energy reached by a structure, the researchers performed numerical simulations on a three-storey planar building comprising 12 revolute and four prismatic joints.

PERFORMANCE PREDICTION FOR MODIFIED DESIGN OF DEW POINT EVAPORATIVE COOLER FOR AIR COOLING

Journal: *Australian Journal of Mechanical Engineering*
Authors: P. Patunkar & S. Dingare

Because traditional air conditioning systems use a lot of energy, dew point evaporative air-cooling systems could be a good alternative. Cooler performance of an air conditioner is influenced by the heat exchanger. This study proposes the use of geometrically modified trapezoidal corrugated plates for counter-flow heat exchangers, which consist of alternate air and water flow passageways.



COMPARATIVE ANALYSIS OF TORQUE RIPPLE FOR DIRECT TORQUE CONTROL-BASED INDUCTION MOTOR DRIVE WITH DIFFERENT STRATEGIES

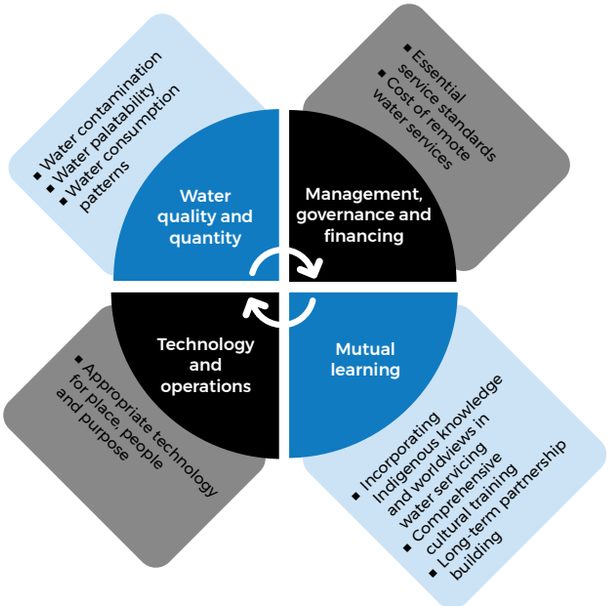
Journal: *Australian Journal of Electrical and Electronics Engineering*
Author: P. D. Patel & S. N. Pandya

This paper discusses torque ripple analysis of fuzzy logic controller-based direct torque control (DTC) of a three-phase induction motor drive. The DTC method is one of the most proficient control techniques of an induction motor. The space vector pulse width modulation-based DTC technique, which operates with regular switching frequency, helps solve fundamental issues of torque pulsation.

Safe water and sanitation in remote Indigenous communities in Australia: conditions towards sustainable outcomes

Journal: *Australasian Journal of Water Resources*
Authors: N. Lansbury Hall, K. Abeysuriya, M. Jackson, C. Agnew, C. D. Beal, S. K. Barnes, S. Soeters, P. Mukheibir, S. Brown & B. Moggridge

This research sought to identify the optimal conditions to enable consistent delivery of safe water and sanitation in remote Indigenous communities of Australia. Using a combination of literature reviews, interviews with key stakeholder groups and applied research findings, key conditions for improved water and sanitation outcomes were identified. These included technology for water and sanitation that is fit for purpose, people and place; capacity-building, training and ongoing support for local Indigenous service operators; and that all personnel involved in delivery require a level of cultural competency to the local and Indigenous context.



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Location: in-person *Sunshine Coast*
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Abstracts close 20 February 2023

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Location: in-person *Melbourne*
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Abstracts close 12 April 2023

International Women's Day

07-09 MARCH 2023

Location: in-person *Sydney, Melbourne, Perth* and *Brisbane*
Website: *eaiwd.com.au*

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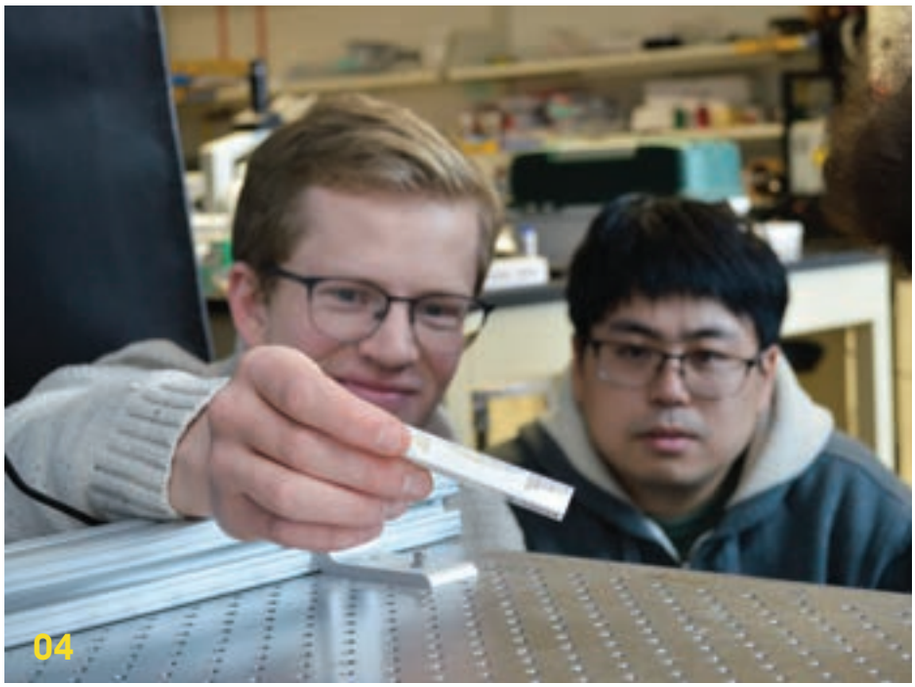
WORLD ENGINEERING DAY

03 March 2023

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

This year's theme is "Engineering innovation for a more resilient world". Engineers Australia will celebrate World Engineering Day with an online webinar on Friday 3 March. Check the website for more information.

THE LATEST DEVELOPMENTS FROM AROUND THE WORLD.

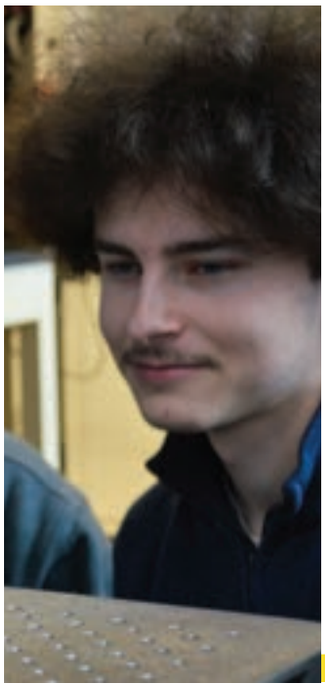


01

Sodium battery

This sodium battery is a safer and cheaper alternative to lithium batteries. Image: Deakin University

Sodium batteries are a cheaper alternative to lithium batteries and, thanks to a collaboration between engineers at Deakin University and the University of Queensland, they can also be a safer option. The team has developed a non-flammable electrolyte material — a fluorine polymer — for use in the batteries, replacing the flammable liquid solvents currently used. "Most industries that develop sodium batteries generally use carbon-based electrode and liquid electrolyte, which has low capacity and also can fuel a fire if the battery overheats," says Dr Xiaoen Wang of Deakin's Institute for Frontier Materials. "We are taking a different approach, using reactive sodium metal as an anode to increase battery capacity and in the process are developing safer electrolytes to ensure the safety of sodium batteries." The technology lasts for a comparable time to lithium batteries, overcoming the lower energy density that is usually a property of sodium batteries. Future development of the batteries could see them used for stationary energy storage.



02

Hydrogel bioink

This 3D-printed bioink retains shape and porosity and can integrate with cells in the body. Image: Amir Sheikhi

A nanoengineered granular hydrogel bioink developed at Penn State University in the US could one day be used to print three-dimensional organ shapes that can be integrated into the human body, alleviating transplant shortages. The bioink uses hydrogel microparticles and self-assembling nanoparticles, an advance over previous bioinks, most of which consist of polymer networks with nanoscale pores that only allow for limited interaction between cells. "Our work is based on the premise that nanoparticles can adsorb on to polymeric microgel surfaces and reversibly adhere the microgels to each other, while not filling the pores among the microgels," says Assistant Professor Amir Sheikhi. "The reversible adhesion mechanism is based on heterogeneously charged nanoparticles that can impart dynamic bonding to loosely packed microgels. Such dynamic bonds may form or break upon release or exertion of shear force, enabling the 3D bioprintability of microgel suspensions without densely packing them."

03

Self-healing robot

When one of this robot's limbs is damaged, it can recognise the harm and begin healing. Image: Cornell University

A team from Cornell University has created a soft robot that detects damage to itself and uses that information to heal the puncture. By combining optical sensors with a composite material made of a polyurethane urea elastomer, the robot deploys reliable dynamic sensing and can self-heal at room temperature. "Our lab is always trying to make robots more enduring and agile, so they operate longer with more capabilities," says Associate Professor Rob Shepherd. "If you make robots operate for a long time, they're going to accumulate damage. And so how can we allow them to repair or deal with that damage?" Hydrogen bonds in the composite material help the four-legged robot heal quicker and, while it is repairing itself, the robot can adjust its gait to compensate for the weakened limb. The team plans to next integrate machine learning algorithms into the technology so that it can better recognise tactile events.

04

Contact-free movement

University of Minnesota students examine an object with a metamaterial surface. Image: University of Minnesota/Olivia Hultgren

A technique for contact-free object manipulation has been developed by researchers at the University of Minnesota. Making use of ultrasound waves, the approach uses materials that have been developed deliberately to interact with waves to move objects without touching them. "We have known for a while that waves and light and sound can manipulate objects. What sets our research apart is that we can manipulate and trap much bigger objects if we make their surface a metamaterial surface, or a 'metasurface,'" says Assistant Professor Ognjen Ilic, a mechanical engineer. "When we place these tiny patterns on the surface of the objects, we can basically reflect the sound in any direction we want. And in doing that, we can control the acoustic force that is exerted on an object." The waves can not only push an object away, but pull it forward, offering potential uses in manufacturing and robotics.

Stephen Slobodian

CPEng, Head of Operations and Engineering Design
Distribution Power Design

FOR STEPHEN SLOBODIAN, BECOMING CHARTERED MEANT HE COULD BRING HIS INNOVATIVE THINKING FURTHER INTO THE ENERGY SECTOR.

WITH MORE than 20 years' experience in the Australian energy sector, Stephen Slobodian has developed networks across the country, working in partnership with other states and other companies.

He has developed expertise across technologies, developing skills in everything from gas to electricity distribution networks and beyond.

And he has seen shifts in the types of energy that are being used to run the country, from oil and gas to an increasing interest in greener sources.

"Renewable energy's become a big thing, and the world is conscious about carbon and wants to reduce emissions," he tells *create*.

"I worked on hydrogen pilot projects during my time in the gas industry, but I've noticed that a lot of gas companies are transitioning into renewables: solar, wind and biomass."

He is now Head of Operations and Engineering Design at South Australia's Distribution Power Design (DPD), and he says that's where real innovation in energy is taking place.

"The advancement in all this renewable energy is really in the electricity sector," Slobodian says. "DPD is a specialist electrical infrastructure design company. They undertake a wide range of consultancy services involved in design of electrical reticulation distribution and street lighting systems."

The company also designs new powerline systems for mining, oil and gas companies as well as electrical utilities, including working on solar network systems.

"I'm really responsible for overseeing the company's technical and business operations, which includes introducing innovation, which is really at the heart of what we do at DPD," he says.

"The business allows me to be involved in all areas of its operations, not just engineering work."

Slobodian credits his Chartered status with Engineers Australia for helping him advance his career, including to his current position.

"Chartered, for me, was probably one of the most important and valuable milestones in my career," he says.

"Becoming Chartered allowed me to reflect on my competencies and being Chartered enabled me to maintain the highest level of competency and professional integrity.

"So Chartered status enhanced my professional experience and allows me to approve designs nationally. It also allows me to stand out in the job market." ●

05 TIPS FOR SUCCESS

1 At every opportunity, map out your career and have some goals in mind.

2 Explore what systems and training your employer offers to support you.

3 Find a mentor through programs such as Engineers Australia's Mentor Match.

4 Stay current with industry trends and innovations.

5 Get into the habit of recording your professional development to keep track of your achievements.

Looking for insights to keep your business ahead of the curve?

The Construction Industry Pulse contains valuable sector insights on business confidence, technology investments, cyber security and mental well-being. Some key insights include:

- **78%** of growth-oriented companies see technology as key to their business strategy
- **84%** of construction businesses say that technology has improved productivity
- **82%** of construction businesses are confident about business conditions for the year ahead

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