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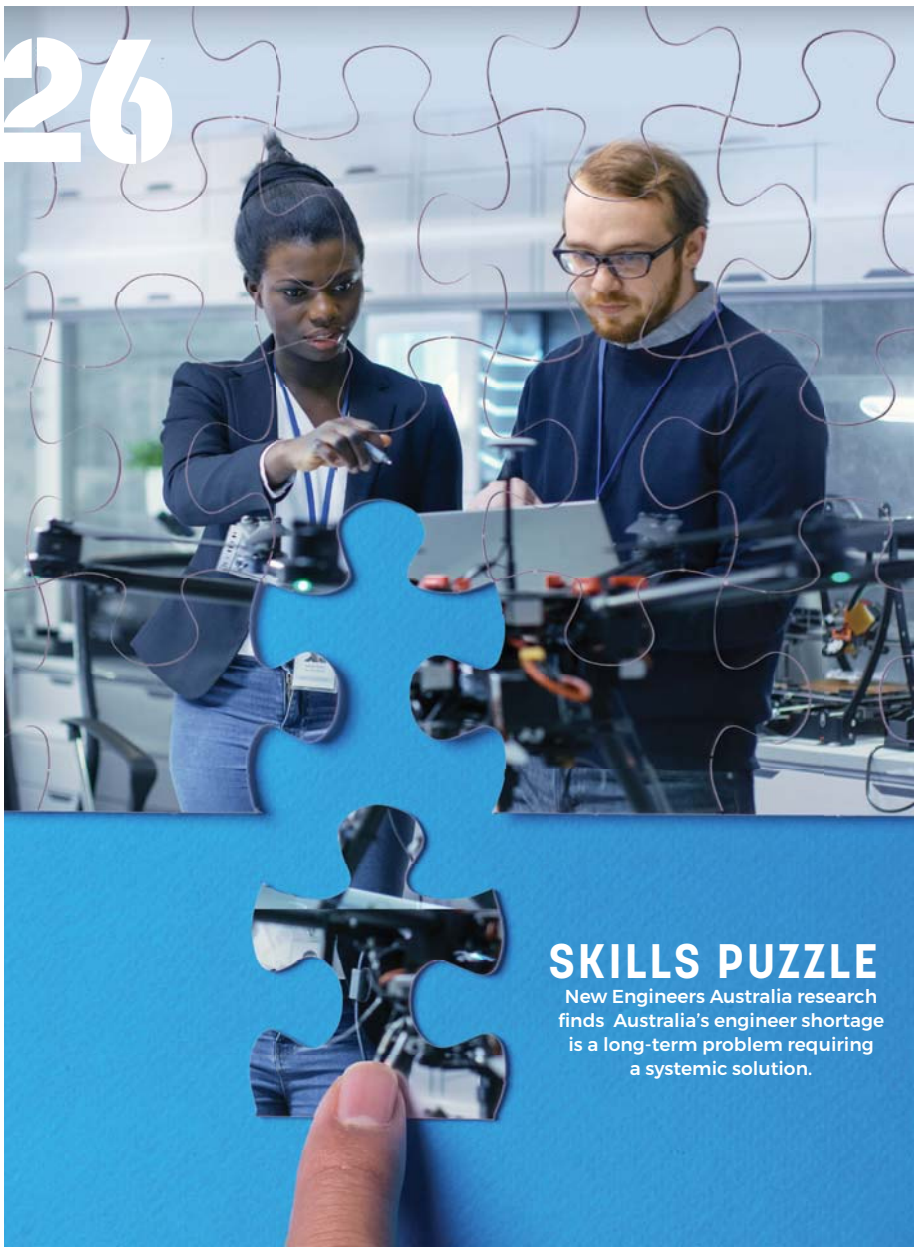

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SKILLS PUZZLE

New Engineers Australia research finds Australia's engineer shortage is a long-term problem requiring a systemic solution.

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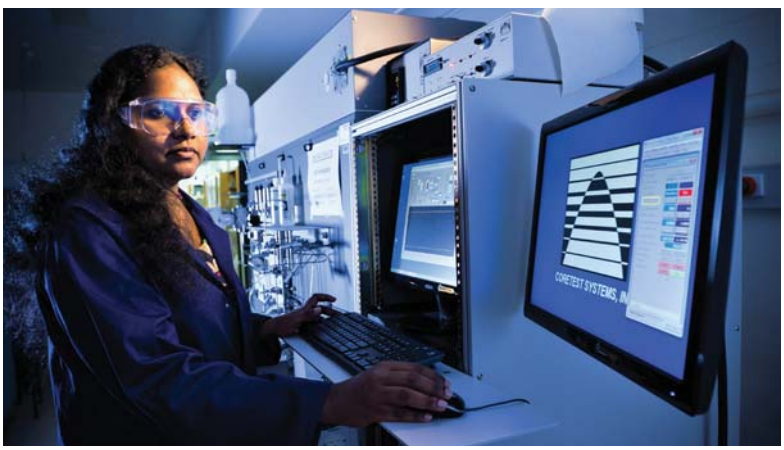

EVERY ISSUE

NEWS

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

Skilling up

A SKILLS SHORTAGE LOOMS IN AUSTRALIA'S FUTURE, AND TALENTED ENGINEERS ARE FORECAST TO BE IN EVEN HIGHER DEMAND THAN THEY ARE TODAY.

Welcome to the September issue of *create*. The season has turned and the complexion of leadership around the nation has also changed.

We see the new federal government acting on climate change legislation with its introduction of the Climate Change Bill 2022, and the month has opened with the Jobs and Skills Summit.

Employers, peak bodies and other skills sector experts have come together at Parliament House, Canberra, to discuss the labour market, skills shortages, equal opportunities, productivity and wages.

You can read about our research in this issue, which outlines a forecast increase in STEM-related occupations in the next five years, and chronic shortages in almost all fields of engineering.

Engineering graduates are prized across all industries for their advanced skills in design and problem-solving; in fact, less than two-thirds of engineering graduates work in engineering roles.

Our numbers of domestically trained engineers are declining and more than half of qualified engineers in Australia are born overseas in an era when other nations are also competing for their skills.

A Brisbane engineer has come up with a solution to the piecemeal approach with a framework to protect shoreline assets. Further, research by a University of Melbourne professor has determined that, over the past four decades, wave heights in the south-east have changed size and direction, which can shift sand and sediment off beaches and deposit it further along the coast.

It is these insights into the behaviour of waves, tides and currents that will help future-proof coastal infrastructure design.

This edition also explores the Western Australia Metronet Railcar project, a $1.6 billion initiative to revamp the state's rollingstock and bring railcar manufacturing back to the west, with a future goal of using 70 per cent locally sourced materials. We hope you enjoy reading it.

"More than half of qualified engineers in Australia are born overseas in an era when other nations are also competing for their skills."

Engineers Australia has long advocated for a deep dive to address the skills shortage in engineering, and we are pleased to present our findings with the release of our report, *Strengthening the Engineering Workforce: Solutions to address the skills shortage in the short, medium, and long term*. We have been active in our communication with policymakers in connection with the summit and productive discussions will continue.

The skills summit is timely and we are happy to be contributing to the conversation.

Also in this issue is a look at management systems to combat coastal erosion. Eighty-five per cent of Australia's population lives within 50 km of the nation's vast coastline, yet our plans to manage the impact of rising sea levels on built-up areas are relatively ad hoc.

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A TOOL DEVELOPED BY A UNIVERSITY OF SYDNEY ENGINEER WILL HELP SURGEONS PLAN THE COMPLICATED TASK OF JAWBONE RECONSTRUCTION.

ONE TYPE of jaw surgery involves placing a 3D-printed scaffold where a portion of the jaw has been removed, then allowing the patient's own tissue to regrow to its original state.

Used in treatment for oral cancer or when someone has suffered significant physical trauma, the surgery can be complex and involve long recovery times.

Ben Ferguson, a PhD student in the University of Sydney's School of Aerospace, Mechanical and Mechatronic Engineering, is making it easier for surgeons to approach this difficult task.

His analysis helps determine the ideal position to place the titanium fixation plate used in the surgery, identifying the best placement by height and angle for each individual patient.

"Surgeons can face a decision dilemma when they are planning a surgery such as this, because there are many different considerations they must weigh up," Ferguson says.

"On the one hand, they must ensure that the structure is going to be strong enough to allow the patient to bite down without it breaking. But if the patient is biting down, then the structure also needs to be stiff enough that it won't deform significantly."

The tool uses tissue engineering and 3D printing, taking a CT scan of the patient, and then, using 3D computer modelling, designing and fabricating a 3D-printed tissue scaffold.

"This surgical planning methodology is patient-specific and driven by CT imagery, finite element analysis engineering software and multi-objective optimisation algorithms," Ferguson says. "Firstly, we build a digital twin of the patient's mandible using CT image processing. The computer-aided design models of the tissue scaffold and the 19 different fixation plates are designed to be conformal to the organic shape of this patient's mandible.

"The 19 models are then transferred to Abaqus software for finite element analysis to simulate biting."

ABOVE: University of Sydney student Ben Ferguson (right) with supervisor Professor Qing Li.

By helping surgeons better identify where and how to conduct operations such as these, Ferguson's tool will help patients recover faster and reduce the need for repeat surgeries.

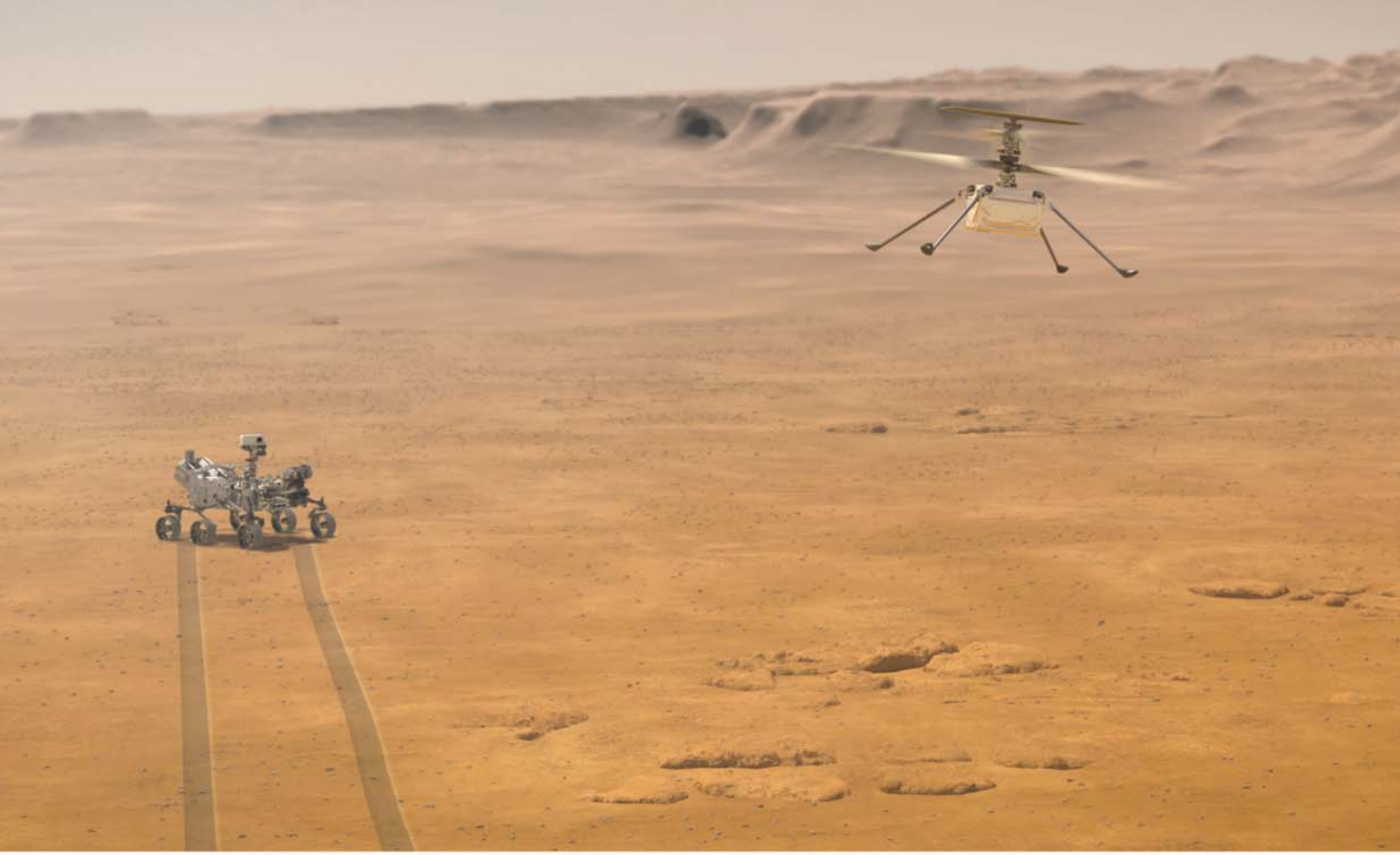
"Nowadays, it would be unthinkable to construct a building without running an engineering simulation on it beforehand," Ferguson says.

"This is the industry standard in civil engineering. The same expectation should be applied to surgery on a human being." ●

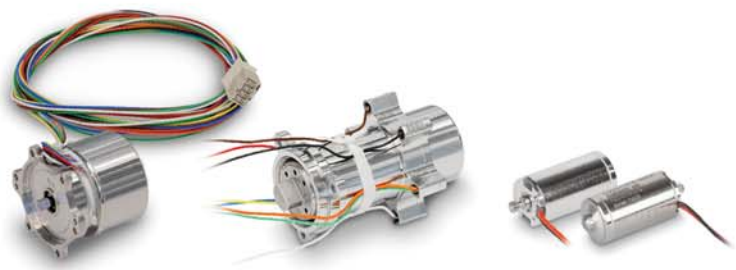
JONATHAN BRADLEY

"SURGEONS CAN FACE A DECISION DILEMMA WHEN THEY ARE PLANNING A SURGERY SUCH AS THIS, BECAUSE THERE ARE MANY DIFFERENT CONSIDERATIONS THEY MUST WEIGH UP."

IMAGE: UNIVERSITY OF SYDNEY



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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WORDS BY **SUSAN MULDOWNEY**

TURNING THE TIDE

KEEPING COASTAL ENVIRONMENTS SAFE FROM EROSION IS A CHALLENGING TASK THAT CAN REQUIRE MORE REFINED APPROACHES THAN SIMPLE SEAWALLS.

LEFT: The beach at Gold Coast's Burleigh Heads.

AS CLIMATE change heats the world's oceans, some of Australia's iconic beaches are at risk of disappearing.

Sea levels around the country are rising at a rate of about 35 mm per decade and, with more than 85 per cent of Australians living within 50 km of the coast, this presents a threat to both the natural and built environments.

The urgency is causing many local governments to reconsider how they manage and develop their beaches, and an innovation by coastal engineer Matthew Barnes is delivering a new approach.

A principal coastal engineer at BMT in Brisbane, Barnes has pioneered a trigger-based approach to development approvals for structures such as seawalls, which can protect assets in urban areas from changes in shoreline position.

Rather than constructing a seawall while the risk to assets is low, Barnes's framework defines the preferred seawall footprint, sets triggers for when detailed design should be completed, and includes further triggers for when construction works can commence.

The framework is also supported by soft engineering works, including dune management and beach nourishment, before the seawall triggers are reached.

"The development approvals framework tends to be quite static and you generally get the approval and have to build within two years," says Barnes, who was ▸

"UNFORTUNATELY, WE DON'T HAVE A CRYSTAL BALL TO DETERMINE THE OPTIMAL TIME FOR WHEN PLANS FOR THINGS LIKE SEAWALLS NEED TO BE IMPLEMENTED."

recognised in *create*'s 2018 Most Innovative Engineers listing for his trigger-based approach.

"Unfortunately, we don't have a crystal ball to determine the optimal time for when plans for things like seawalls need to be implemented.

"By having a framework that the regulators are aware of and that can be supported through the monitoring of a coastal zone to understand how erosion is changing after storm events or sea-level rise, we can determine when an erosion trigger is met and when to move to the next stage of environmental management.

"A CHANGE IN WAVE DIRECTION CAN CAUSE EROSION AS WELL AS INCREASES IN SEDIMENT IN OTHER PLACES, BECAUSE THE SEDIMENT IS TAKEN FROM A BEACH, CARRIED ALONG THE COAST, AND DEPOSITED ELSEWHERE."

"This may eventually include hard engineering options like seawalls as a last defence."

ADAPTING TO CHANGE

Barnes grew up near Torquay at the eastern end of Victoria's Great Ocean Road and describes himself as "a coastal and marine science nerd".

"I knew as a kid that my career would have something to do with the beach," he says.

Barnes moved north in 2005 to complete his PhD in civil engineering at the University of Queensland and has lived in Brisbane ever since.

"For better or worse, there's lots of work for coastal engineers in Queensland," he says.

"I think some of that has to do with decisions that were made several decades ago around where to develop, and we're dealing with some of those decisions and the challenges they present now."

Barnes says the increased focus on climate change is generating more interest in his trigger-based approach, which has been adopted by local councils such as the City of Gold Coast and Moreton Bay Regional Council.

"They are investing in understanding when triggers for seawall upgrades, for example, might be reached and how that varies throughout their local government area, because every beach is unique and responds differently to what Mother Nature throws at it," he says.

"Our customers want to invest in making the best decisions possible."

TOP: An eroded Queensland beach. LEFT: Coastal feature along Holloways Beach, Cairns. BELOW: Matthew Barnes, BMT.

FIT FOR THE FUTURE

Changing conditions in wave height and direction might also affect how beaches and coastal infrastructure are managed in the future.

Alexander Babanin FIEAust is Professor of Ocean Engineering at the University of Melbourne. His research projects include investigations of the wave climate of the Bass Strait and south-east Australia over the period from 1981 to 2020.

Analyses of model outputs across the 40-year period show that wave height has increased by approximately five per cent and there has been a slight counter-clockwise rotation of peak wave direction.

Babanin notes that changes in wave direction could have a greater impact on shoreline position than a change in wave height.

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Senior Civil Designer (MWH)

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"A change in wave direction can cause erosion as well as increases [in sediment] in other places, because the sediment is taken from a beach, carried along the coast, and deposited elsewhere," he says. "Governments need to be able to look at the large-scale effects like this."

A SHIFT IN FOCUS

Barnes describes his role as a blend of engineering and planning.

"One of my colleagues has coined the term 'plan-gineer', because she feels like we're often doing a bit of both," he says.

"But the engineering behind this trigger-based approach is very much in the understanding and the modelling of coastal processes – the waves, currents, tides and all of those things

"PLANNERS AND ENGINEERS WORKING HAND-IN-HAND THROUGH THAT WHOLE PROCESS IS HOW THESE PROJECTS RUN SMOOTHLY."

LEFT: A sea wall along Queensland's Fraser Coast.

will feed into the design of the coastal infrastructure.

"Planners and engineers working hand-in-hand through that whole process is how these projects run smoothly."

This past July, Barnes's focus shifted from engineering to full-time caregiving when he started six months of parental leave.

When he returns to work in January next year, he expects to continue his work with local government clients. His trigger-based approach is helping to address challenges that arise where freehold land intersects with public spaces.

"You can end up with a situation where some private residents have already built seawalls, but the neighbours potentially have not," says Barnes. "That creates its own issues where an ad hoc approach doesn't really deliver the best outcome for the beach if a sea wall is to be implemented.

"We've seen councils wanting to get a preliminary approval for a reference design that private residents will take up and implement when they're ready to build their seawall. The idea is that along a stretch of coast, you would end up with a consistent seawall design, but it is being funded by the private landowners."

Barnes also expects his work to extend beyond local councils to local industry, such as ports.

"A lot of our port customers are wanting to understand their exposure to sea level rise and how their infrastructure is going to function under certain scenarios," he says. "What upgrades will they need to be planning for and how much will they cost?"

Ports play an important role in the national economy, Barnes says, so he expects a lot of investment in how they manage for climate change.

"I think it's a sector that I'll be focusing on when I'm back on deck next year." ●

Not-so-great walls

Seawalls are a common local government response and have been integral to coastal defence systems for centuries. However, BMT coastal engineer Matthew Barnes explains that they also present risks for beach environments.

"The energy from the waves breaking on to the seawall tends to get reflected back out to sea and that takes a lot of sand with it, which lowers the beach," he explains.

"In some cases, that can impact the social and recreational value of a beach."

Another challenge is building structures that are suitable for future environmental conditions.

"A seawall that satisfies a sea-level rise projection for 2100 would be a much larger structure than what would be needed for today and may impact the way people use the space," says Barnes.

"A challenge is that you want to maintain social and recreational values for as long as possible, while making sure that a structure is fit for purpose for present-day conditions and can also be adapted for future conditions."

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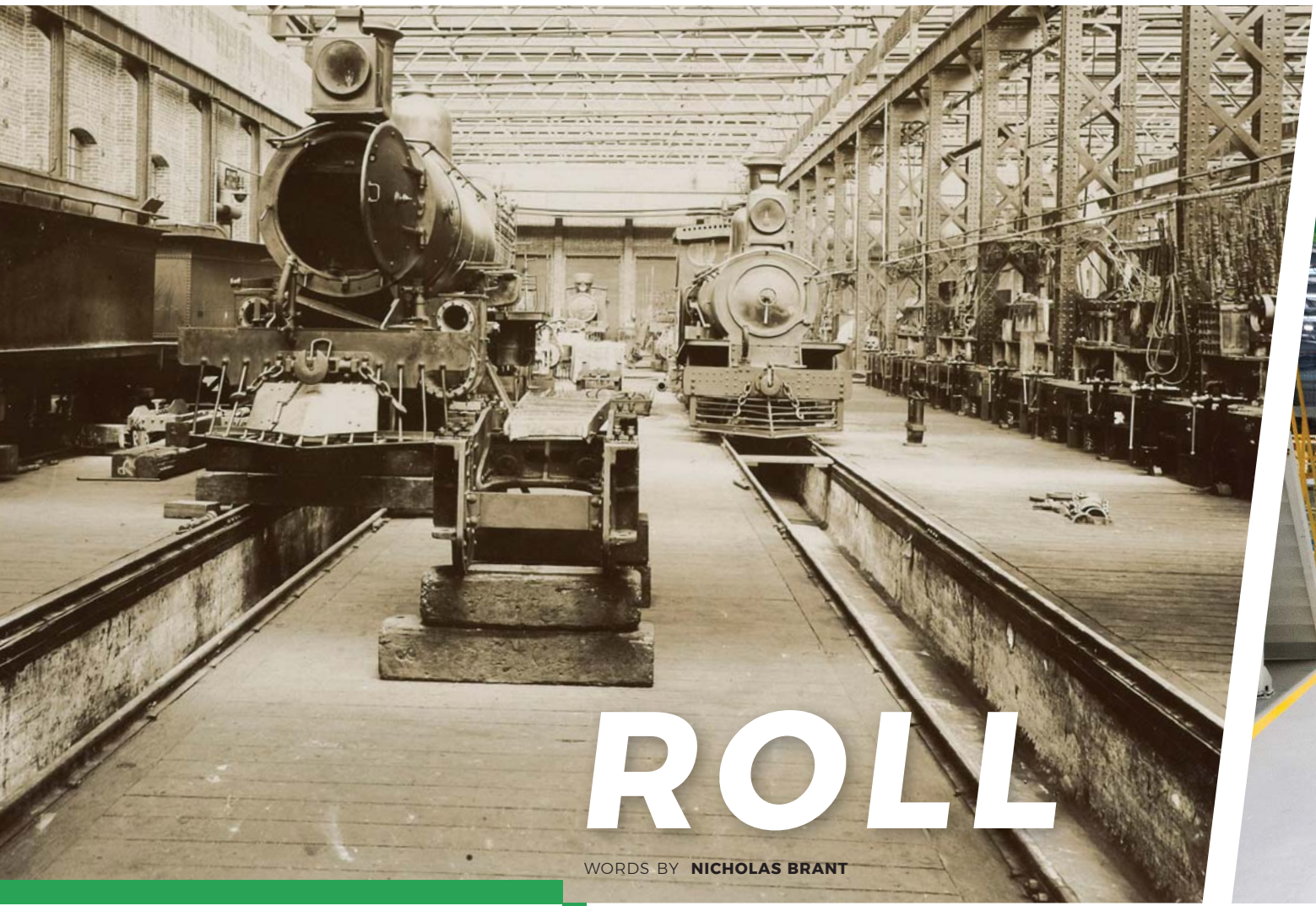

ROLL

WORDS BY **NICHOLAS BRANT**

THE DAILY RAIL COMMUTE FOR RESIDENTS ACROSS PERTH IS GETTING A REVAMP THANKS TO SKILLED ENGINEERS WHO ARE DELIVERING THE NEXT GENERATION OF TRAINS IN WESTERN AUSTRALIA.

ON THE outskirts of Perth, a sprawling industrial complex is playing host to the biggest shake-up of train manufacturing capabilities in Western Australia in nearly 30 years.

This takes the form of the WA Government's Metronet Railcar project, which will see the construction of 246 new C-series railcars for the Perth metropolitan rail network.

ABOVE: Historical image of the iconic Midland Railway Workshops.

The project – which sees the return of railcar manufacturing to the state – also includes building six diesel railcars to replace the Australind service, which runs south of Perth.

The $1.6 billion project is being led by international rail specialist Alstom and supported by more than a dozen WA subcontractors, which are delivering 50 per cent of the project's total value with local expertise, facilities and materials.

While components are made at each subcontractor's existing facilities, all the work converges at the bespoke railcar manufacturing complex in the Perth suburb of Bellevue.

The facility is split into three separate workshops. One is for the assembly of bogies, which mainly consist of the frame, wheelsets and suspension system. Another is for high voltage (25 kV) testing.

Much of the actual train assembly work takes place in the main workshop, with every railcar passing through six distinct stations – assisted by overhead gantry cranes – to undergo specific works.

STATION TO STATION

The site team receives the fabricated railcar shell into the workshop and begins at station one by enclosing each railcar with floor, ceiling, doors and windows.

At station two, Alstom's crews make and test all the relevant

OUT

looms and fit them along with pneumatic piping to cable trays which run the length of the railcar.

Once fully assembled, the cable trays roll under station two and are affixed to the underside of the railcar shell, thereby making the process ergonomically comfortable for the crews.

Station three features multi-level scaffolding, which allows for roof access to install air-conditioning systems and underframe access so workers can install traction and auxiliary converters as well as other underframe equipment.

Once the cabling of the railcar has been extensively tested, it is sent to station four and attached with the pre-assembled bogie frames. Exterior signage and final inspections are carried out at station five where the railcars are coupled together to make each set of six cars.

ABOVE: The site team receives the fabricated railcar shell.

"THE SITE IS STILL IN THE RAMP-UP PHASE. THERE WILL BE 150 TO 170 EMPLOYEES WORKING IN BELLEVUE BY THE END OF 2022."

Outside the main workshop, the completed railcar goes through a watertightness test and additional testing in the high voltage workshop. At the time of *create*'s visit, the Bellevue facility was home to 110 fulltime Alstom employees with most staff hired locally.

"The site is still in the ramp-up phase. There will be 150 to 170 employees working in Bellevue by the end of 2022," Alstom Project Director and mechanical engineer Fabrice Ponti says.

"Much of the team consists of fitters and electricians, as well as manufacturing engineers, quality control engineers, buyers, supply chain specialists, and an extensive project team.

"Our engineers work closely with the mechanical and electrical fitters and electricians in the workshop to ensure the many systems in the train are assembled ›

"THESE PROCESSES GIVE AUTONOMY TO THE PRODUCTION TEAM TO ENSURE THE RIGHT LEVEL OF QUALITY AND EFFICIENCY."

properly and are working as per the expectations."

Once Alstom has fully ramped up, it has set a time of six days per car per station. Every six days a railcar is moved between stations for the next stage of works. Alstom expects to take three-and-a-half months from the first car shell entering and the completed six-car train leaving the facility.

Alstom has implemented the latest tools and efficient processes, with workers given iPads to manage their activity in the workshop and, for example, log quality issues and missing parts found in a particular fitting station.

"These processes give autonomy to the production team to ensure the right level of quality and efficiency," Ponti says.

He says their processes are helping with the complex logistics associated with a project of this size. He stops and points to a rack holding small bins filled with components.

"For instance, our smart bins are all on scales and are connected to an app that sends data to our supplier. So when our staff remove components, the scales register that weight change, and our supplier is informed that the corresponding bin needs to be replenished."

While work in Perth gets underway, Alstom has also set its sights on a portion of the Queensland Government's Train Manufacturing Program, which is slated to build 65 new six-car passenger trains.

The work includes constructing a $239 million bespoke manufacturing facility in the Maryborough region near Hervey Bay, a rail facility on the Gold Coast and additional stabling and train wash infrastructure to support the new fleet of trains.

Alstom, CAF and Downer Rail are preparing detailed proposals with a successful vendor expected to be named by the end of the year.

TAKING SHAPE

Meanwhile, in neighbouring Bassendean, engineering specialist Hofmann Engineering is gearing up to build the vital bogie frames that will connect the trains to the rail network. Operations engineer Karl Hofmann tells *create* that the company's Perth team is set to build 450 bogie frames for the Alstom project.

ABOVE: Every six days a railcar is moved between stations for the next stage of works.

The international Perth-based firm is no stranger to rail manufacturing, with its Bendigo team having manufactured more than 1000 bogie frames for the Victorian Government's own metro train and Yarra Tram projects while its Newcastle facility manufactured UGL's freight locomotive bogies.

"We have a good pedigree of delivering quality rail components, but we didn't have a specific bogie frame production line in Perth so upgrading the facility to allow us to manufacture these frames ▸

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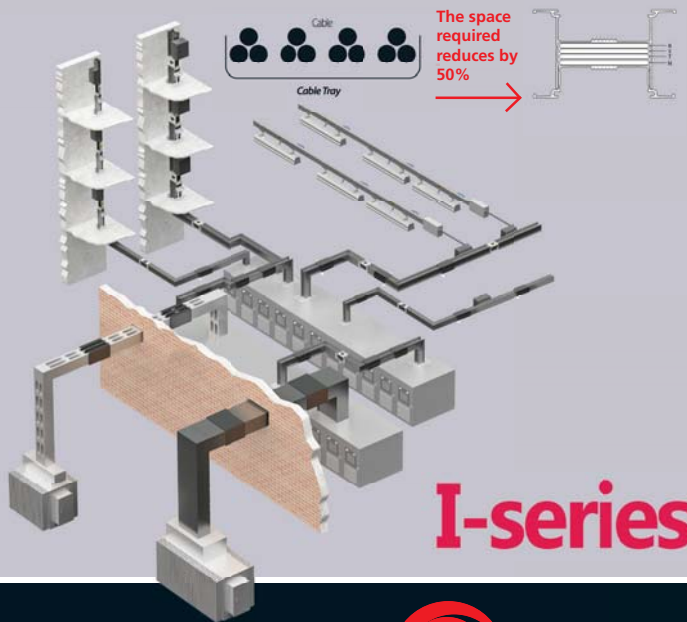

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"THIS DRIVES THE NEED FOR AN EXPANDED RAIL ENGINEERING WORKFORCE IN THE STATE."

efficiently was the first challenge for us," Hofmann says.

The company invested $30 million in its local factory, installing a robotic welder, a plate-cutting machine, plate-bending machines and fabrication equipment for holding together the bogie frame components.

At the other end of the production line, the company has built a fully automated blasting and cleaning facility and a painting facility to properly coat the fully machined components.

"We are also in the process of installing a new gantry milling machine which will be crucial for making bogie frames and other equipment," Hofmann says.

Hofmann – whose grandfather and great uncle founded the company in 1969 – says while the investment in facilities is significant, the company is confident it places it in a better position to serve other clients in the mining and renewable energy sectors.

"Moving forward we will build the frames utilising about 70 per cent of Western Australian materials, with the remaining 30 per cent coming from overseas in the form of raw castings and plate material," he says.

The manufacturing process will be in the hands of Hofmann's team, which includes 40 mechanical engineers and electrical engineers who work with a team of boilermakers, machinists and metallurgists.

ABOVE: Fabrice Ponti, Project Director, Alstom.

"There are always new and novel ways of manufacturing, and working with experienced train specialists like Alstom on this project has been a great learning opportunity for us," he says.

"Likewise, there are procedures that our team in the jobbing shop environment have introduced to the manufacturing process to bring the efficiency up so there is a good exchange of knowledge and information all around."

The railcar project is one of many Metronet projects revolutionising the Perth rail network, with the NEWest Alliance, consisting of Downer and CPB Contractors, building the Yanchep Rail Extension and Thornlie-Cockburn Link.

Downer Engineering Manager Graham Holden FIEAust says, "Whether rollingstock or infrastructure, the testing, commissioning and introduction of a new asset into service is ▸

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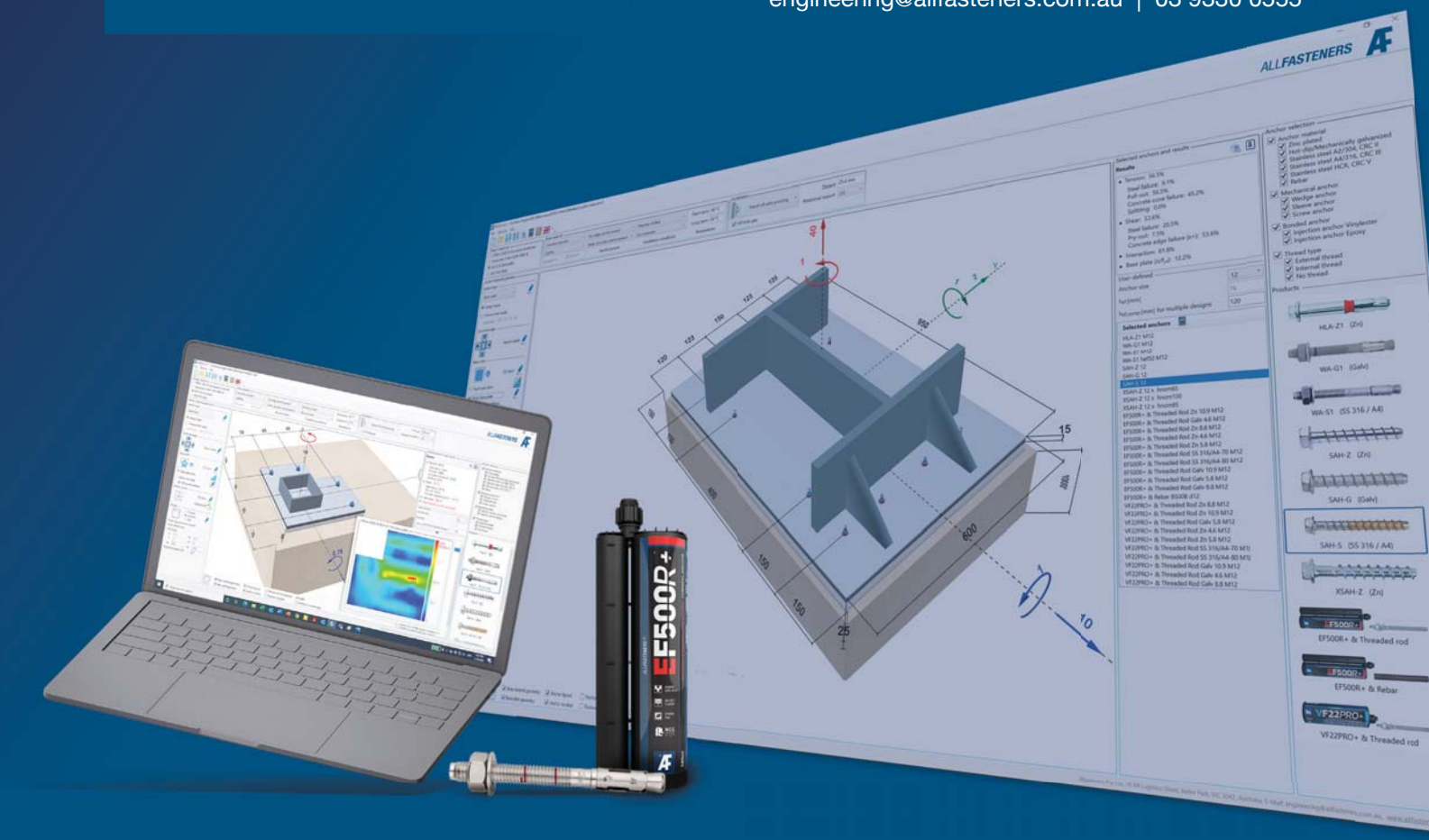

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Holden also says Metronet is unprecedented in WA history in its scale and value. "This drives the need for an expanded rail engineering workforce in the state," he says.

Not only does the industry need more specialists, it also needs leaders and engineers who can address the complicated and complex interfaces both within and between the Metronet projects. "There are enormous opportunities for engineers with the skills and motivation to enable effective integration," Holden says.

NETWORK INTEGRATION

Meanwhile, Western Australia's Public Transport Authority (PTA) is overseeing the entire project and has a dedicated team ensuring the next generation of trains will operate effectively on an existing rail network.

PTA Project Engineer Stephanus Oosthuizen has been involved with the project from the tendering stage. When asked about engineering challenges the team is currently working through, Oosthuizen points to the addition of a third door on each side of the railcars – to help passengers egress faster and reduce station dwell times – as presenting the team with a complex task.

"Our network has some platforms located on curved sections of track, so it means that the middle door will potentially have a bigger gap between the platform edge and the rollingstock compared to the doors at each end of the individual railcars," he says.

"The PTA are currently evaluating several options to resolve the matter."

The PTA will carry out testing to ensure the trains are suitable for use by the public. Oosthuizen says all the testing will happen at a railcar level and a train level in Perth on the PTA's existing passenger network.

"This is already quite unique for us, as our existing A-series and B-series trains were tested in Queensland where they were manufactured," he says.

The Alstom team will carry out all factory-level testing and static testing at the Bellevue facility.

Starting in the last quarter of 2022, the PTA teams will then oversee tests conducted by Alstom on the trains on isolated sections of the passenger network.

The first trains will commence passenger service in late 2023. ●

ABOVE: Historical image of the Midland Railway Workshops, which was involved with construction and maintenance of rollingstock and engines.

"OUR NETWORK HAS SOME PLATFORMS LOCATED ON CURVED SECTIONS OF TRACK SO IT MEANS THAT THE MIDDLE DOOR WILL POTENTIALLY HAVE A BIGGER GAP BETWEEN THE PLATFORM EDGE AND THE ROLLINGSTOCK."

Comeback in the west

Western Australia's Metronet project has seen the return of train manufacturing not just to Western Australia but also to the local area, where former generations of workers had toiled away at the Midland Railway Workshops.

The historically significant workshops first opened in 1904 to support WA's growing need for rail transport and were in operation for 90 years until the facilities were de-commissioned in 1994.

It has been reported that over the course of history, the workshops were used to manufacture, repair and maintain the state's trains as well as trams and trolley buses which were heavily used in the Perth area.

The site was recorded as having employed up to 3000 people, including up to 500 apprentices at its peak in the 1950s.

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WORDS BY **JONATHAN BRADLEY**

AS AUSTRALIA'S ECONOMY BOUNCES BACK FROM THE COVID-19 PANDEMIC AND INDUSTRY ADAPTS TO A CARBON-NEUTRAL FUTURE, ENGINEERING SKILLS WILL BE IN DEMAND. THE SHORTAGE OF STEM TALENT, HOWEVER, IS NOT NEW.

WHILE UPS and downs in the economy can affect immediate demand for skilled workers, Australia has an enduring shortage of engineers that requires a systemic solution.

Skills shortages in a range of industries came under scrutiny at the Jobs and Skills Summit convened by the Australian Government at the beginning of this month, and a new Engineers Australia report shows that addressing future and current challenges in the supply of engineers will be vital to the nation's economic success.

"The immediate cause of the shortages is an increase in demand for engineering skills at a time when international border closures have hindered skilled migrants arriving in Australia," says the report, which is titled *Strengthening the Engineering Workforce in Australia*.

"However, research indicates the issue is much larger than the immediate cause of the reported shortages."

ABOVE: Engineers Australia CEO Romilly Madew.

Engineers Australia CEO Romilly Madew AO tells *create* the report is the culmination of groundbreaking research commissioned by Engineers Australia with a critical analysis of Australia's engineering supply and demand dynamics.

"Our economy and society are more reliant on the engineering profession than ever before," Madew says. "We need to ensure we have the engineers necessary to deliver on current government priorities and conceptualise the solutions needed to solve our society's most complex problems."

Engineers Australia Chief Engineer Jane MacMaster FIEAust CPEng tells *create* the report was inspired by industry concerns.

"Around last year, I began noticing a pattern in the conversations I was having with senior engineering executives," she says. "It was all about skills. They were saying, 'What's keeping me awake is I can't find the people to do the work that we need to do.'"

Over the following 12 months, Engineers Australia investigated Australia's skills landscape, as well as the supply and demand challenges facing the nation.

"It shouldn't be surprising really to any of us that we're facing a skills shortage across the broader economy," MacMaster says. "We've got older Australians – the baby boomers, a large part of our population – entering into retirement age, and it's particularly exacerbated for engineering and technology because the pace of change of technological advancement is increasing and it's becoming more pervasive.

"There's almost no aspect of our daily lives where technology isn't prevalent, and the material and sophistication of that technology is increasing. The reliance on the engineering profession is increasing in step with that."

MacMaster also points to a growing number of national priorities as another source of the problem, from sovereign manufacturing capabilities to nascent areas such as nuclear-powered submarines and the civil space sector.

"All these national priorities absolutely rely on the engineering profession, so the demand is increasing at a time when supply is decreasing," she says.

"The whole economy is crying out for resources. We've got all sectors of engineering experiencing a skills shortage except for biomedical engineering – that's the only discipline or area of practice that we're hearing about that's in oversupply. All other sectors and fields of engineering we are hearing about are experiencing quite a severe shortage."

NO NEW PROBLEM

Madew says the problem has deep roots.

"Our research shows that for decades, this issue keeps cropping up: there is a systemic shortage of engineers in Australia," she says.

While temporary economic conditions, such as the 2000s mining boom or current demand stoked by climate change adaptation, COVID-19 pandemic-related stimulus spending and sovereign risk-derived onshoring, affect the market for engineers, longer-term and enduring solutions are also necessary.

Don Moloney, Defence Project Director at management consultancy Coras says the defence industry is one sector affected by these engineering skills shortages.

"As a nation we have a strategic need to build a stronger pipeline of STEM skills, STEM teaching, provide attractive careers in the defence sector, and increase these resources nationwide," he tells *create*. "A career as a defence engineer contributes to the safety, security and prosperity of our region and we should be ▸

"THERE'S ALMOST NO ASPECT OF OUR DAILY LIVES WHERE TECHNOLOGY ISN'T PREVALENT. THE RELIANCE ON THE ENGINEERING PROFESSION IS INCREASING IN STEP WITH THAT."

inspiring potential engineers to that mission."

That inspiration, for Moloney's sector and others, will involve encouraging more Australians to enter engineering fields, ensuring Australians trained in those fields continue to work in engineering after training, and ensuring the nation can make the best use of skilled migrants.

According to a prediction by the National Skills Commission, the number of people working in STEM occupations will increase by 12.9 per cent over the next five years.

"We are seeing commencements and graduations in engineering continue to decline – they've been declining since 2014," says Madew.

"We need to make sure that we've got an adequate supply of engineers coming through our pipeline – domestically trained – who are getting the experience that then puts them into the demand categories when these cycles come along."

And while the nation's skills shortages have been exacerbated by border closures during the pandemic, opening back up to overseas engineers will not solve the problem by itself.

"Migrants will always play a very important role in the Australian economy and in engineering," Madew says.

"The challenge with relying on migration in the longer term – or even in the shorter term – is that we're not the only country experiencing this shortage.

"The US, the UK, as two very similar countries to us, are both experiencing a shortage of engineers as well. Our reliance on migrant engineers is not going to change in the short to medium term, but we need to look at it as bolstering our domestic supply as well to shore us up in the future."

It is also important, Madew says, to ensure that the migrant engineers who are here are able to actually work as engineers.

"There is a cohort of migrant engineers in Australia that are qualified, experienced engineers who are underemployed or unemployed. They cannot get a position that really aligns to the qualifications and experience that they've had back home," she says.

Moloney says migrant engineers are rejoining the workforce as lockdowns end, but this solution does not affect all sectors equally.

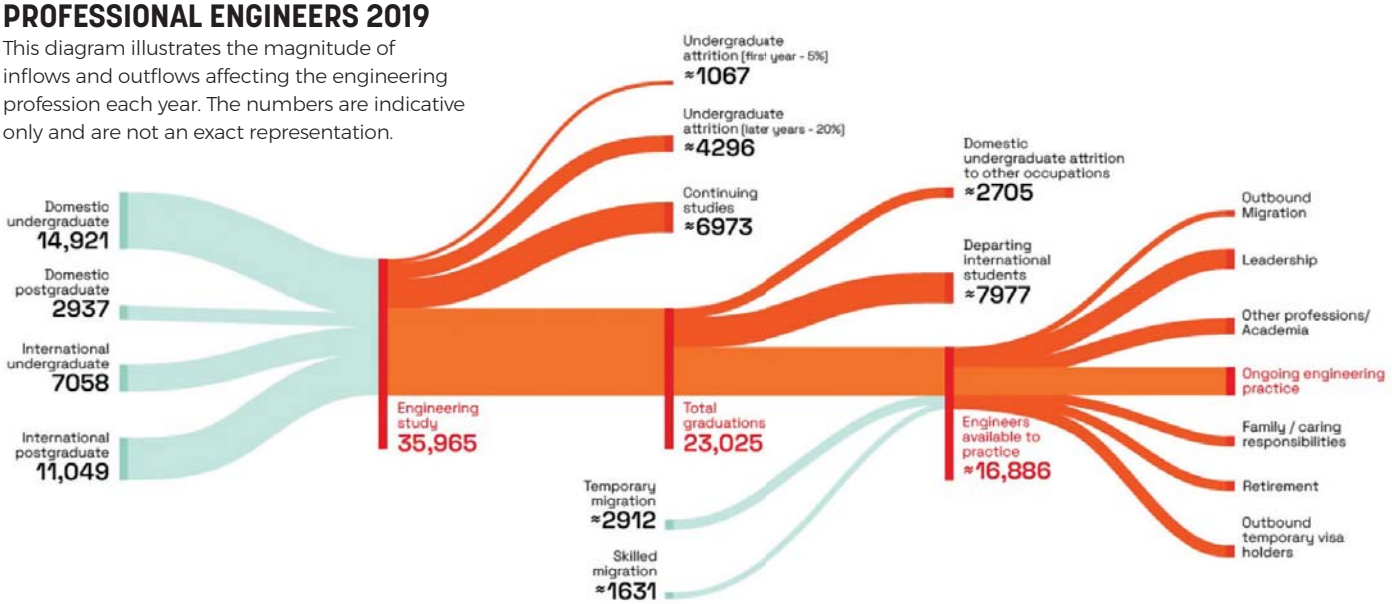
"This relief to the local jobs market may not be seen in the defence sector due to the difficulty for non-citizens to achieve an Australian Government security clearance," he says.

"The strain on the engineering workforce is being felt across all domains of defence and the defence industry. Key roles sit vacant for months, delaying work ›

"WE NEED TO MAKE SURE THAT WE'VE GOT ADEQUATE SUPPLY COMING THROUGH WHO ARE GETTING THE EXPERIENCE THAT THEN PUTS THEM INTO THE DEMAND CATEGORIES WHEN THESE CYCLES COME ALONG."

INFLOWS AND OUTFLOWS OF PROFESSIONAL ENGINEERS 2019

This diagram illustrates the magnitude of inflows and outflows affecting the engineering profession each year. The numbers are indicative only and are not an exact representation.



Australian Engineering Higher Education Statistics 2009-2019, Australian Council of Engineering Deans, December 2020 & King, R, Working Paper: Pipelines into Professional Engineering Occupations, Australian Council of Engineering Deans, December 2021

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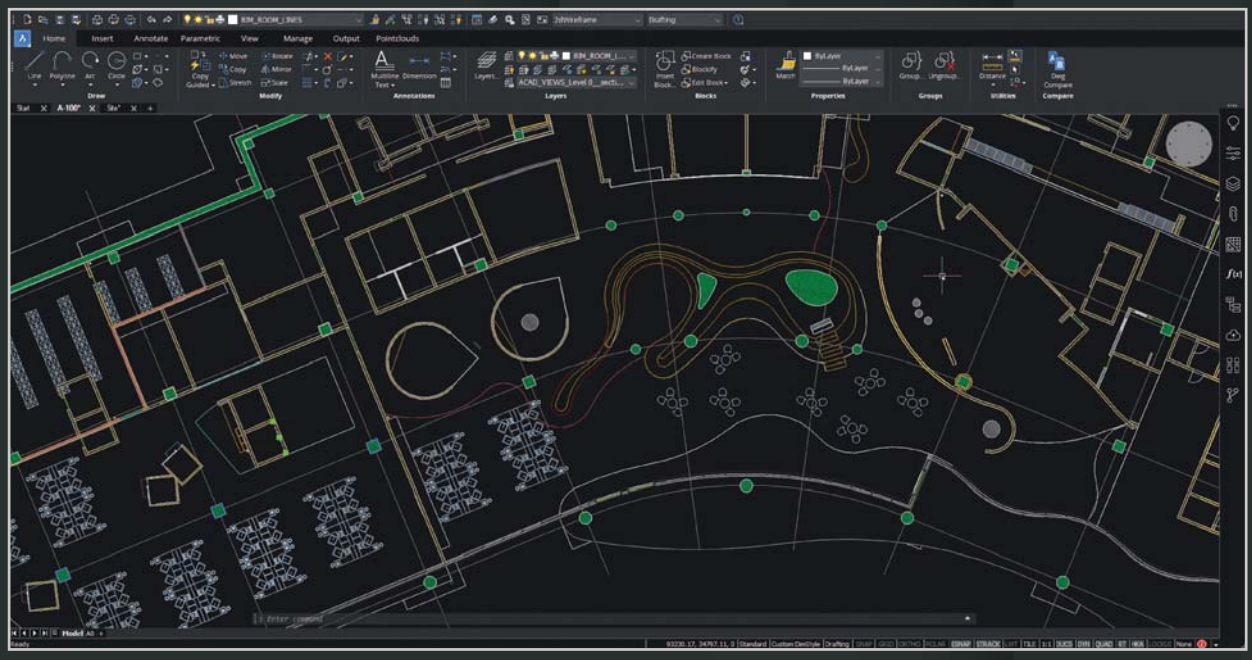

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and increasing risk to capability, as well as putting additional, unsustainable pressure on the remaining workforce."

LOCAL EFFORTS

The mismatch between skills and employment also exists for locally trained engineers.

"We know that a lot of engineers – somewhere around 35 per cent of engineers – don't enter the engineering profession," Madew says. "They graduate with an engineering qualification, but then they move on to another area.

"So how can we better support those engineers? How do we support parents and carers returning to work and those returning to the engineering profession after they've taken leave?"

Madew advises a broad-based response to the problem.

"The longer-term solution to resolving these challenges involves investment in young people and schools, industry-led development of early career graduates, a greater recognition of the value of migrant engineers and community-wide awareness of the engineering profession," she says.

Women similarly hold much potential for giving certainty to the future supply of engineers. The report notes that while engineering is the biggest employer of the STEM professions, it has the smallest female representation.

Previous Engineers Australia research has identified this problem and explored ways to boost the number of women and girls who study engineering and then go on to make it a career.

"Of all the women we surveyed who didn't choose to study engineering, 90 per cent of them said that they didn't even consider engineering or barely considered engineering," says MacMaster.

"That's a really high proportion, which is somewhat alarming. But it's also an opportunity, because the single most commonly cited reason for not considering engineering was a lack of awareness of what engineering is and what engineers do."

MacMaster says it is vital to increase awareness of engineering as a career among students, as well as among the parents and teachers who influence them.

"That will be the focus as we transition from the first phase of our work, which is understanding the problem and the factors that influence our engineering workforce," she says. "And now we're transitioning into the second phase, which is prioritising those factors and developing initiatives to address them and alleviate the skill shortage."

ABOVE: Chief Engineer Jane MacMaster.

"THE SINGLE MOST COMMONLY CITED REASON FOR NOT CONSIDERING ENGINEERING WAS A LACK OF AWARENESS OF WHAT ENGINEERING IS AND WHAT ENGINEERS DO."

Madew believes Engineers Australia can respond to these problems through greater advocacy of engineering as a desirable profession among the broader community.

She says there are roles for government and industry as well, particularly in ensuring long-term demand matches supply.

"We don't want to see an issue where we overcome the skills shortage, but then there are engineering graduates coming out each year who can't get work because the work isn't available" she says. "We need to look at how government, Engineers Australia, industry and others can work together to better demand-forecast."

MacMaster believes it is important to act immediately.

"I do feel that the problem's going to get worse before it gets better, and the sooner we act, the sooner we'll start alleviating the skills challenge," she says.

"Engineers Australia will continue to be conveners of the key stakeholders including government, the tertiary sector, industry and professional associations required to solve this complex problem," Madew says. ●

The big five

Engineers Australia's *Strengthening the Engineering Workforce in Australia* report identifies five key factors in addressing short, medium and long-term skills shortages:

01
Primary and secondary education: The number of young Australians choosing to study engineering after they finish school.

02
Vocational and higher education study: Factors influencing engineering graduation rates.

03
Retention in the engineering workforce: Factors influencing how many qualified engineers work in an engineering role.

04
Skilled migrant workforce participation: Factors that influence how many skilled migrant engineers work in an engineering role.

05
Demand forecasting: How data on current and future demand for engineering skills can enable better workforce planning.

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WORDS BY **MICHELLE WHEELER**

DATA DRILLING

SRAVANI MUKKISA IS OPTIMISING A TECHNOLOGY THAT CAN GIVE MINERS AND GEOLOGISTS THE DATA THEY NEED TO MAKE DECISIONS WHILE DRILLING.

WHEN MECHANICAL engineer Sravani Mukkisa first started working on an innovative new drilling tool, she knew the technology had huge potential for the mining industry.

The prototype equipment, known as DrillMax, could give miners crucial geophysics data in real time, helping them make smart decisions in the field while drilling. But there was a challenge. The tool was unreliable, consistently breaking down two to three days into drilling.

Mukkisa, an engineering manager at Rig Technologies International, went back to the drawing board. She and her team systematically analysed every failure, bringing the product from proof-of-concept to a commercial reality in a matter of months.

REAL-TIME DATA

DrillMax is a downhole "geophysics while drilling" tool. It contains instruments that measure natural gamma and take a complete hole survey as drilling is taking place.

The tool also provides information about drilling dynamics, which provide insights into rock strength and density, as well as the nature of discontinuities such as fractures and voids.

Without this live data, Mukkisa says, miners are drilling blind.

"Having that visibility on where you are drilling, what sort of formations you are drilling into, is extremely valuable as we are moving towards sustainable digital transformation in mining. You need data to get to that phase," she says.

Mukkisa, a finalist in the Chamber of Minerals and Energy Western Australia's 2022 Women in Resources Awards (WIRA) – Technology Innovation Awards Category, says logging while drilling is already prominent in the oil and gas industry. She says 30 years of development has led to advanced surface and downhole tools.

LEFT: Sravani Mukkisa won the People's Choice Award at WIRA 2022.

As well as a two-decade head start, Mukkisa says that's because oil and gas primarily uses rotary drilling systems that don't see the same level of shocks and severe space constraints as mining percussion drilling.

"The [oil and gas] industry sees a high amount of efficiencies, drilling optimisations, exploration, planning – they benefit quite a bit," Mukkisa says.

"On the other hand, mining is not there yet."

In mining, Mukkisa says there is growing interest in understanding the ore body during drilling. That's led to the use of wireline logging – measuring the properties of a formation by lowering instruments into the borehole.

In some cases, samples are collected and sent to labs for further analysis. That means geologists don't have the information until later.

"They analyse the information after the fact of drilling, not during the drilling," Mukkisa says.

"It's not right then and there."

When Mukkisa joined the team, the feasibility and proof-of-concept work for DrillMax had already been done. It had an innovative ▸

PICTURED: DrillMax employs reverse circulation drilling.

"HAVING THAT VISIBILITY ON WHERE YOU ARE DRILLING, WHAT SORT OF FORMATIONS YOU ARE DRILLING INTO, IS EXTREMELY VALUABLE AS WE MOVE TOWARDS SUSTAINABLE DIGITAL TRANSFORMATION IN MINING."

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new technology, but it only worked some of the time.

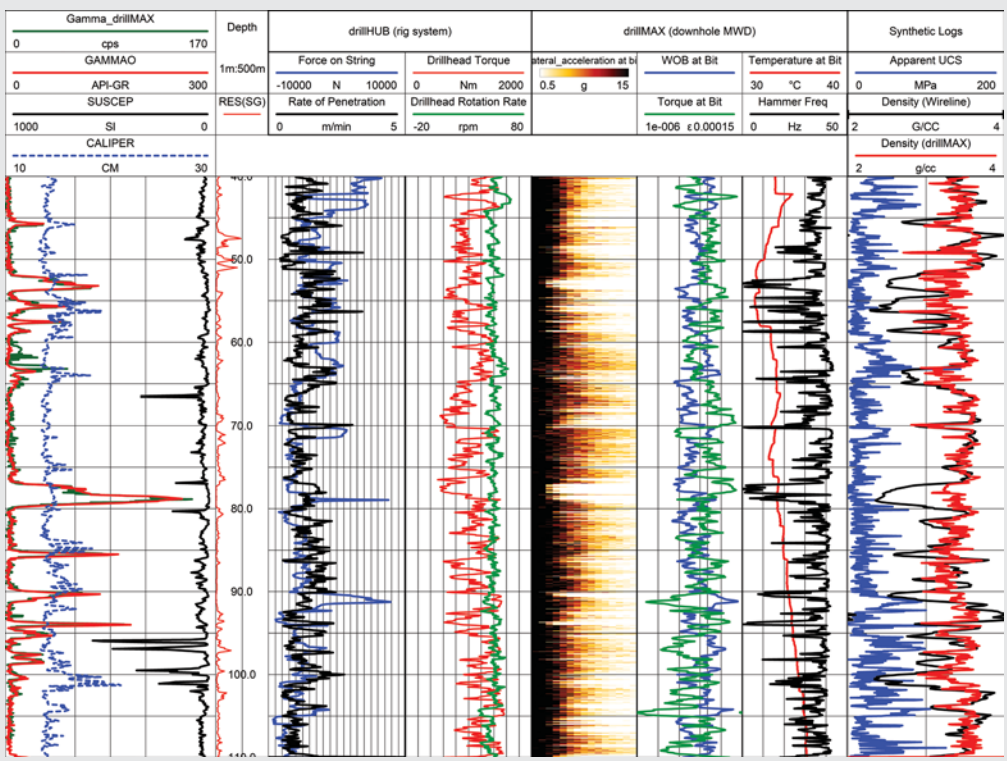
Mukkisa says the tool had to be swapped out every two to three days – it lasted about 400 m.

"We had multiple points of failure, so it was unreliable," she says. "Any technology … if it's not reliable, it's not sustainable, it's non-economical, it's not commercial, then you cannot see the benefits of the technology."

The engineering team started to look at failure points, collecting data and performing root cause failure analysis. They systematically reviewed every aspect of the tool, making changes to DrillMax's design, assembly and operating procedures.

"THE IMPROVEMENT IN DRILLMAX RELIABILITY UNDER HER GUIDANCE HAS EXTENDED THE SERVICE FROM GROUNDBREAKINGLY INNOVATIVE TO COMMERCIALLY COMPELLING."

ABOVE: Mukkisa engineered a "quantum leap" in DrillMax's reliability. BELOW: Log output of DrillMax.



Mukkisa says DrillMax's design, assembly and operating procedures.

"We gathered the data, performed analysis, came up with the plan, iterated and iterated quite significantly fast," Mukkisa says.

Orica Orebody Intelligence principal research fellow Roger Griffiths says Mukkisa was instrumental in engineering a "quantum leap" in the durability of DrillMax.

"The improvement in DrillMax reliability by more than an order of magnitude under her guidance has extended the service from groundbreakingly innovative to commercially compelling, with significant associated business impact and customer operational efficiency improvements," he says.

SHOCK VALUE

Percussion drilling can come with shocks of 2000 G and up. But Mukkisa says the sensitive instrumentation on board wasn't designed to reliably withstand such a hostile environment.

First, the team had to engineer a damping system that reduced the highest level of shock generated by the hammer. Then, the sub-component systems were designed to further reduce the shocks experienced by sensitive electronics housed inside.

"During the initial phase, the sub-component damping system was not done right," Mukkisa says. "It was failing inconsistently.

"So we started experimenting with different dampers itself – the materials that can absorb shocks. And also, the system around it, how we are mounting them, and what is the room of flexibility that we can provide."

Once the damping system was fixed, the team faced their next big challenge: wear. This moved the tool from having inconsistent reliability issues to being limited by the wear rate of the inner tubes.

Mukkisa says DrillMax works with reverse circulation drilling. It's a method that uses dual-wall drill rods: an outer drill rod and an inner tube. ▸

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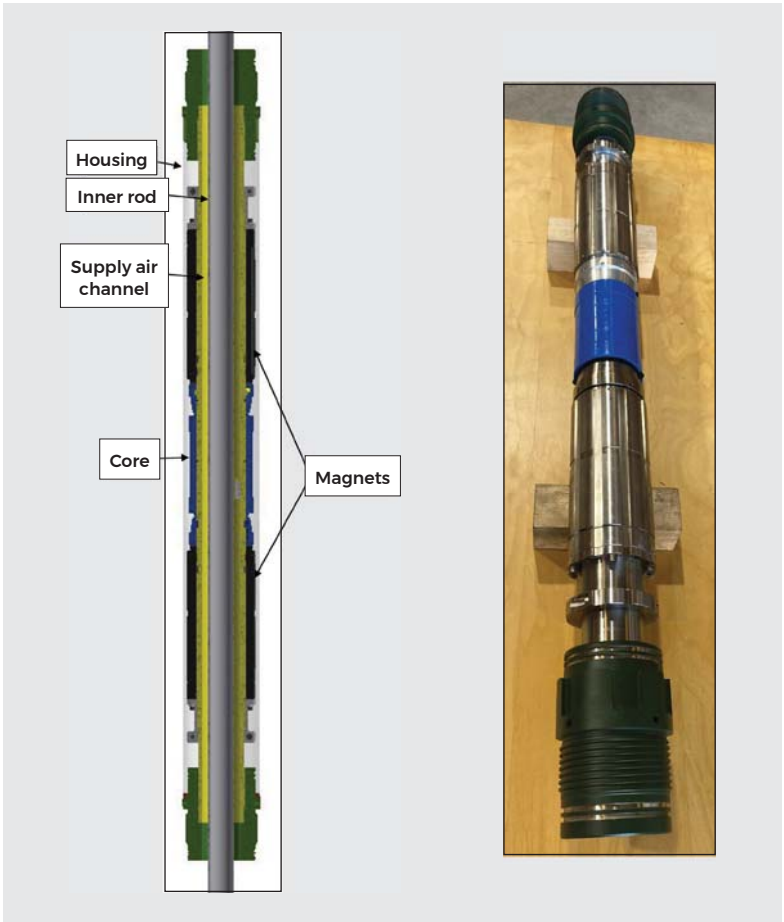

FAR LEFT: Cross-section of antenna assembly. LEFT: Prototype of the geo probe.

Maximum effect

Today, DrillMax is the only tool of its kind, capable of running on the percussion drill string and providing geophysics data while drilling, Sravani Mukkisa says. It can survive up to 2000 G of shock for days at a time.

In fewer than 10 months, DrillMax has gone from being a prototype, unreliable beyond 400 m of drilling, to a commercially viable product.

"The record is about 4400 metres," Mukkisa says. "So you don't have to touch the tool once you put it in there for 15 to 30 days.

Mukkisa believes the technology will make mining more efficient.

"When you optimise anything, it takes less time to do the same thing," she says.

Drillers can optimise rock fragmentation based on the type of formation and drilling parameters, which further improves loading, hauling and downstream process planning, Mukkisa says. This significantly reduces the huge energy requirements of mine to mill operations.

"SOME WOULD WEAR FASTER, SOME WOULD WEAR SLOWER. IF YOU'RE DRILLING INTO GRANITE, IT'S DIFFERENT VERSUS DRILLING INTO CLAYS."

"You have a cylinder in a cylinder," Mukkisa says.

Air is pumped through the gap between the two cylinders, and the hollow inner tube allows the drill cuttings to be transported back to the surface. But when the rock samples come through the inner tube, it wears out.

DrillMax is also designed with a dual wall, so miners can still get the drill cuttings, and there are pockets within the tool to accommodate the sensors.

The diameter of the inner tubes matches that of the hammer inner tube, so customers don't lose the sample rock sizes they're used to.

Mukkisa says that meant working with really thin sections inside the tube. In early iterations of the tool, the inner tube wore so fast that it would buckle or collapse under pressure within three to four days of use.

"I literally sectioned the inner tube to see the wear pattern and the rate," Mukkisa says.

Adding to the challenge was that the wear was different depending on the type of formation being drilled.

"Some would wear faster, some would wear slower," Mukkisa says. "If you're drilling into granite, it's different versus drilling into clays."

Mukkisa then went back to the manufacturing and design process, modifying the design and adding high-strength materials to the part of the inner tube that copped the most wear – right behind the hammer.

REFINED PRODUCT

In the future, Mukkisa hopes to be able to include even more sensors on DrillMax. That includes spectroscopy tools that would allow miners to work out the mineral composition as they drill.

Key to this is the development of live communications, a downhole power generator and reliable inter-tool communications.

"The application is open for all the things that we would do on wireline," Mukkisa says.

Mukkisa says you can have great technology, but no one will reap the benefits if its performance isn't economically viable.

"Even a phone – if it's not reliable enough, you're not going to buy it," she says. ●

WORDS BY **HARRY WELLER**

THE MAJOR AUTOMOTIVE MANUFACTURERS HAVE LEFT THE COUNTRY, BUT THIS NEW UTE STILL SPEAKS WITH A DISTINCTLY AUSTRALIAN ACCENT, THANKS TO THE AUSTRALIAN DESIGNERS AND ENGINEERS WHO LEAD THE COMPANY'S GLOBAL T6 PLATFORM DEVELOPMENT.

DESIGNED LOCALLY

WHEN FORD engineer Pritika Maharaj and her colleagues whisked the covers off the 2022 Next-Generation Ford Ranger ahead of the first media drives this past July, it was the culmination of a five-year journey for the design and development team.

But it was also merely the end of the beginning. The Australian launch of the Ranger, one of Ford's most important global models, precedes a roll out to more than 180 markets worldwide, to be closely followed by the related Raptor pick-up and Everest SUV.

Maharaj has lived, breathed and sweated the details of Ford's Australian-developed third-generation T6 body-on-frame global architecture, the platform upon which the Ranger, Raptor and Everest are based.

She tells *create* that she started with Ford Australia as a graduate engineer.

During her extensive career at the company, Maharaj has worked in practically every area of vehicle development, including test engineering, engine design, powertrain warranty, vehicle interior, cost engineering, and product development quality engineering with the Ranger and Raptor manufacturing plant in Thailand.

She returned to Australia in 2021 to take up her current role as T6 program manager, which entails being across every aspect of the Ranger, Raptor and Everest development.

"As program manager, I span the entire T6 platform. My job

PICTURED: Ford's Next-Generation Ranger.

is to make sure we deliver the program on time, with quality, to the budget, and it's really all the different elements that come into that," says Maharaj. "As we go through the program, it involves different things at different stages. Right now, it's all about making sure that we meet all the deliverables for the launch. But before that there's a lot of changes we need to make along the way, plus of course the base engineering at the start of a program.

"When you get to the back end of the program, like we're at now, there are still changes needed, but it's critical to work out which ones we must do and which ones we don't, because stability is the key at launch."

ABOVE: T6 Program Manager Pritika Maharaj.

Maharaj says a lot of her time is spent working with teams looking at the changes they want to make, acting on things they've learned about the process and supporting manufacturing plants.

"The rest is around making sure all the elements are delivered, which can be anything from an owner's manual to spare parts," she says.

"All these elements come under my remit, and my responsibility is to make sure we close them off robustly and that we're ready to go when it hits the road."

One of the many challenges for Maharaj and her colleagues has been the sheer breadth of the Ranger model portfolio, with the Australian model range comprising three engines, two transmissions and three body styles in two and four-wheel drive variants.

Ford says its aim is to have a Ranger for practically every use case, resulting in a 22-model range that starts with the construction-site-ready two-wheel-drive single cab XL and culminates with the top-of-the-range Ranger Wildtrak dual cab 4x4.

LOCAL TO GLOBAL

Among many changes Maharaj has experienced during her time at Ford Australia, one of the most significant has been the transition from a largely domestically focused operation to a design and engineering centre of excellence for global products.

This has necessitated a change in the engineering disciplines required.

"AS PROGRAM MANAGER I SPAN THE ENTIRE T6 PLATFORM. MY JOB IS TO MAKE SURE WE DELIVER THE PROGRAM ON TIME, WITH QUALITY, TO THE BUDGET."

"We have such a diverse range of skills in Ford Australia today," she says. "When I first started, mechanical engineers were the main part of our engineering team from a product development perspective, with a few electrical engineers thrown in for good measure. The manufacturing guys had their robotics and their manufacturing engineering, but there was only a small group that really covered the wiring, the electronics, all of that.

"Now, that side of the business is huge, so it's a much more diverse range of engineering skills

that we have, and that you need to have for the vehicles that we build today."

These include mechanical, mechatronics, electrical and electronics engineers.

"A chassis engineer used to just be able to do the greasy bits. Now, a chassis engineer also must be able to talk to the modules that then talk to the rest of the car," Maharaj says. "And that's true for any of the systems, powertrain, chassis. All the traditional 'greasy' parts of the vehicle have now become important to be able to talk and work together."

One of the other big ongoing changes is the industry's attempts to lower or eliminate tailpipe carbon emissions. For this reason, the T6 platform has been "protected" or future-proofed for electrification.

"We've future-proofed the Ranger for new technologies, and I think we've even gone so far as saying that we've protected the Ranger for electrification. That's really all about the platform. The platform is our basis for what we can and can't do," Maharaj says.

ABOVE: Design of the Ranger's cab. LEFT: Wiring systems in contemporary vehicles require a team with a diverse range of skills.

"When we talk about future-proofing, we're saying that the platform has been designed and developed in a way that we can migrate when, and if, we need to other technologies and electrification."

Maharaj says the engineering team has developed in tandem with the technology and the size of the department handling electrical and electrification has expanded significantly.

"I think it's just evolutionary," she says. "As the technology and as the vehicles moved into more of that space, with all the different modules, connectivity and so forth, our team has had to develop as well."

GLOBAL COLLABORATION

Maharaj believes Australia's multicultural society is something of a superpower that places it well to work on global collaborative projects such as T6.

"There's more than just technical skill involved in being a good engineer. There are certain other elements, like communications, that are also important. When I first started at Ford, we worked pretty well independently in Australia and were able to do our own thing. Now, we're a much more connected company globally.

"A CHASSIS ENGINEER USED TO JUST BE ABLE TO DO THE GREASY BITS. NOW, A CHASSIS ENGINEER ALSO MUST BE ABLE TO TALK TO THE MODULES THAT THEN TALK TO THE REST OF THE CAR."

Engineering challenges on offer at Territory Generation

"At Territory Generation, we pride ourselves on excellence. A highly capable and innovative engineering workforce is critical to support our delivery of service as the Territory's trusted and respected energy services provider,"

– Gerhard Laubscher, Chief Executive Officer

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Territory Generation has recently partnered with Engineers Australia to accelerate our engineers' attainment of Chartered status. We have a variety of exciting civil, electrical and mechanical engineering challenges on offer, including:

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- **Yulara Energy Transition Initiative:** delivering cleaner, lower-cost power to the Yulara resort and community
- **Microgrid feasibility studies:** investigating sustainable and resilient electricity supply options in the remote tourist hubs of Yulara, Kings Canyon and Tennant Creek
- **Alice Springs Future Grid:** collaborating as a project partner to identify and overcome barriers to further renewable energy penetration in the Alice Springs electricity system
- **Central Australia power supply project:** constructing 10.7 km of dedicated transmission line and a new 66/11kV substation
- **Fuel assessment and testing:** determining the capability of our generation fleet to utilise different fuels sources for maximum efficiency
- **Renewables:** integrating renewable generation into the Territory's power systems

TERRITORY GENERATION

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Our supply base is very diverse and we're working with a huge diversity of cultures, languages, geographical locations," she says.

"I think that fits well for Australia because we're used to the multicultural aspects, and that gives us an advantage when we're working with different markets like India, Thailand, the Philippines, and Malaysia, as well as European countries like Germany.

"You've got to have good, strong communication skills. You've got to have a bit of empathy and understanding for different cultures to be able to work successfully with them."

"MANY OF OUR ENGINEERS HAVE COME FROM PRACTICAL BACKGROUNDS INCLUDING AUTO-MECHANICS, RACING AND FARMING. THESE MAKE FOR A RESOURCEFUL AND ADAPTABLE ENGINEERING TEAM."

DIVERSE SKILLSETS

The Ranger is sold in more than 180 markets worldwide and manufactured at plants in Thailand, Vietnam, South Africa, North and South America.

As a result, Maharaj and her colleagues have become adept at working with engineering and product teams around the world.

Another particular strength of the Ford Australia engineering team, Maharaj says, is the fact they have such diverse and often practical backgrounds.

"Many of our engineers have come from practical backgrounds including auto-mechanics, racing and farming. These experiences and interests make for a very resourceful and adaptable engineering team."

Maharaj declines to discuss Ford's long-term engineering future in Australia but does confirm small groups are working on mid-term engineering programs.

"The things I can say are that we are continuing to invest in our engineering facilities. The design studio recently had a massive upgrade, so that's really expanded both in terms of technology and footprint. And from an engineering perspective, we're continuing to develop our facilities at the proving ground, which is our main technical development hub now," she says.

"We're also continuing to invest in our graduate program. We've got grads coming through all the time, including as part of my team, where I have a balance of very experienced engineers, but also some of our newer engineers that have only been with the company a couple of years.

"While we are continuing to see all this activity, that gives us confidence in general. So, there's no promises, there's no assuredness, but certainly, I'm not sitting here feeling nervous about what the future holds." ●

ABOVE: The Ranger's T6 platform is engineered in Australia.

Surviving and thriving

Despite in 2016 being the first of the "big three" auto manufacturers to close its local car-making operations, Ford Australia has retained the country's largest engineering and design footprint.

Today, Ford is Australia's largest automotive employer, with a team of more than 2500 engineers, designers, technical, automotive and other specialists employed at four locations across Victoria.

The parent company has also continued to invest significantly in local operations as the T6 program ramped up, with Ford Motor Company investing more than $2.9 billion in Australian research and development between 2016 and 2020. Almost $538 million was spent on local research and development in 2020 alone, with an additional $30 million spent that year on new and upgraded facilities and equipment at the company's Design Studio, Campbellfield Innovation Hub, You Yangs Proving Ground, and its Research and Development Centre in Geelong.

Australia is now a key product development hub for Ford globally. A spokesperson says such investment directly supports the Australian engineering team's central role in the development of the T6-based Ranger and Raptor pick-ups, as well as the Everest SUV.

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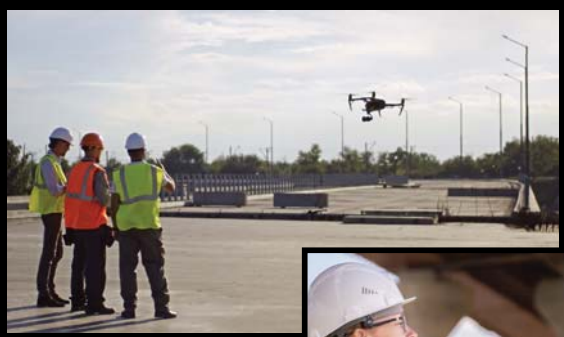

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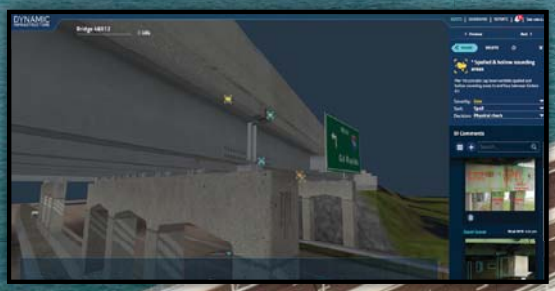

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INNOVATION TOWARDS ZERO

WORDS BY **MICHELLE WHEELER**

DOWN TO EARTH

GEOTECHNICAL ENGINEERS ARE AT THE FOREFRONT OF EFFORTS TO MEET AUSTRALIA'S COP26 COMMITMENTS AND ADAPT TO A CHANGING CLIMATE. BUT THE PATH TO GREEN ISN'T ALWAYS BLACK AND WHITE.

WORKING ON road and rail infrastructure in Queensland, Dr Chris Bridges FIEAust feels he is trying to serve two contradictory masters.

On one hand, the technical director of ground and underground engineering at Aurecon is seeing a push to design for greater resilience in embankments. That's aimed at protecting transport infrastructure from the effects of a changing climate, particularly flooding.

On the other hand, that resilience demands bigger, heavier structures. That means more materials, more cost and more carbon.

"With my sustainability hat, I want to be using less material, less carbon," Bridges says. "And then with my resilience hat, I'm trying to protect the infrastructure

for the next 100 years. So, at the moment in the industry, we have this contradiction."

This requires making things heavier, Bridges says.

"A lot more concrete, a lot more protection work, just to get the resilience," he says.

"But that counteracts our sustainability requirements."

It's led him to consider radical solutions to reduce the material needed. While he's yet to prove it will work or examine the cost benefits, Bridges is exploring ideas such as hollow embankments.

"To reduce the amount of fill, we could make them hollow by putting pipes longitudinally through the embankment rather than crossing it," he says. "More sacrificial material on the slope face will protect the core.

"But it's really a struggle now to make sure that we really understand the weather and can predict how that will change the inner workings of an embankment."

PAST IS NOT PROLOGUE

Bridges is concerned that government infrastructure specifications, standards and codes are based on the weather patterns of the past 50 years.

BELOW: Dr Chris Bridges, Aurecon.

"WITH MY SUSTAINABILITY HAT, I WANT TO BE USING LESS MATERIAL, LESS CARBON. AND THEN WITH MY RESILIENCE HAT, I'M TRYING TO PROTECT THE INFRASTRUCTURE FOR THE NEXT 100 YEARS."

"The next 50 to 100 years might not be so forgiving," he says.

"All our specifications are based on the past, not really on what we anticipate is going to happen in the future. So there is a bit of thinking we need to do as an industry."

While a lot of resilience work looks at extreme flood levels, Bridges fears we're missing other issues. He points to changing rainfall patterns as something that could damage infrastructure in a way we've not thought through.

Bridges says Queensland has historically had about six months of wet season followed by six months of dry.

"But look at the weather now in Queensland – it's our dry season and it hasn't stopped raining," he says.

Embankments, for example, should get wet and then dry out before it rains again, Bridges says.

"If we're going to have longer wetter periods, then the water will reach further in and damage our core," he says. "And that will mean that what our design was based on may no longer be relevant."

Bridges is currently researching the impact of climate changes on ▸

Protecting the core

Groundwater is typically well below subgrade and generally not an issue.

Rainfall and flooding are two sources of water than can impact the subgrade and need to be managed.

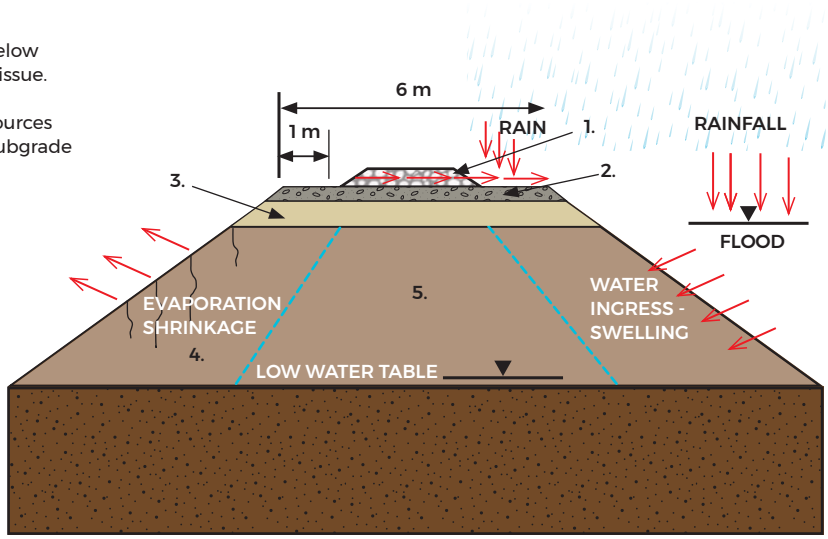

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Illustration adapted from SMEC

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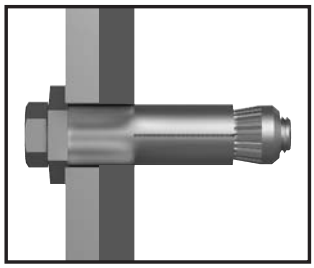

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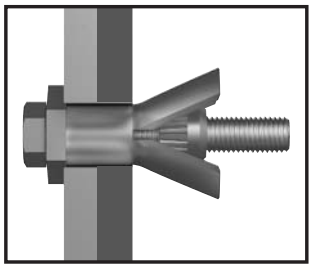

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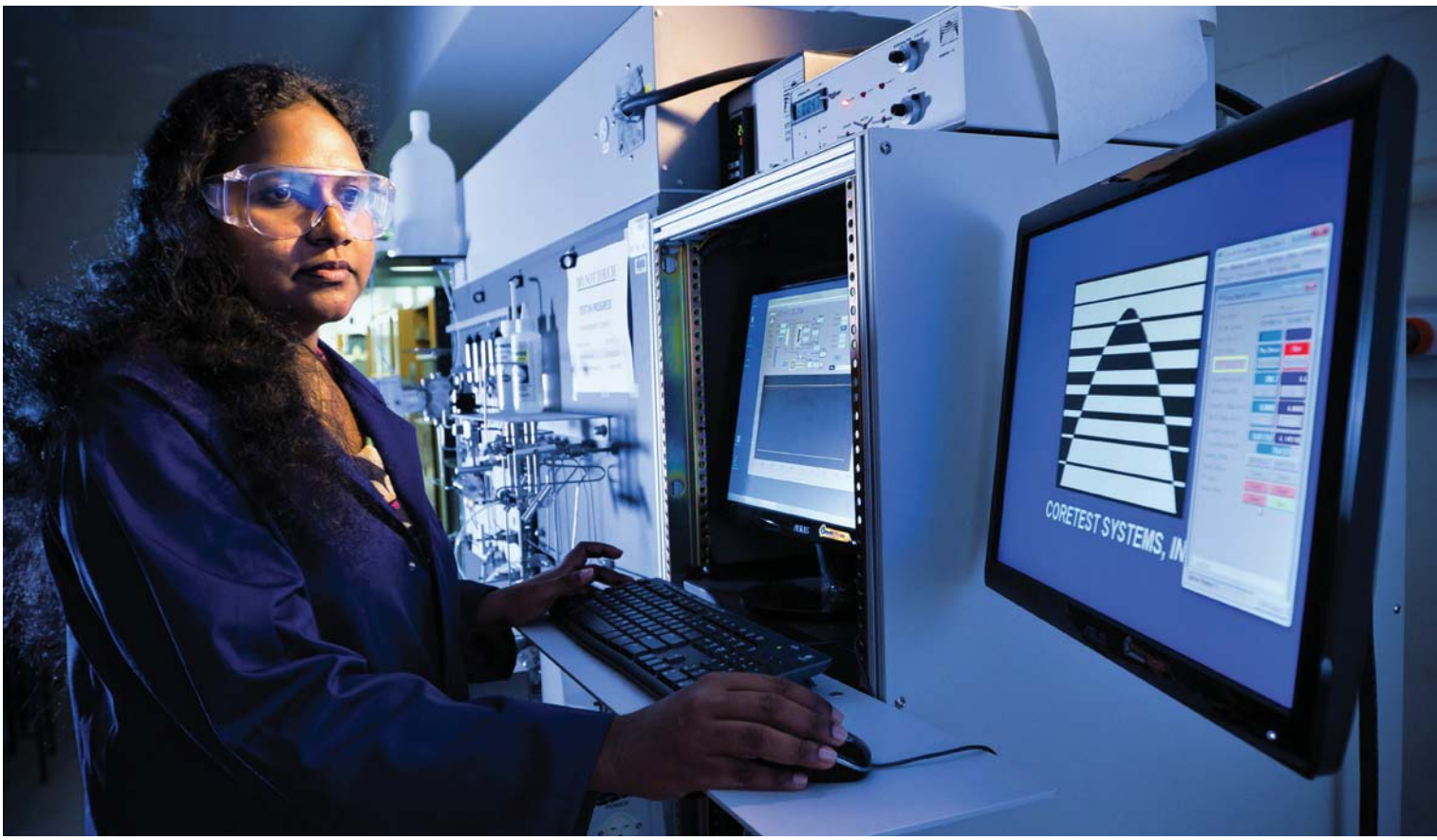


"IT HAS A LIQUID-LIKE DENSITY, GAS-LIKE VISCOSITY. THE SWELLING IS MUCH, MUCH GREATER COMPARED TO THE GAS OR LIQUID CARBON DIOXIDE."

soils. He believes we first need to define the problems we're facing.

"Only then can we understand what we need to design for," Bridges says. "We need to step back, I think, and look a bit broader at what the impacts are. A lot of the work is really around flood level, either river or sea. But this is extreme wet-drying and is going to probably have bigger impact."

BELOW GROUND

Dr Samintha Perera, a lecturer in geotechnical engineering at the University of Melbourne, has spent more than a decade researching complications that can arise from trying to store carbon dioxide underground.

It's a hot topic among geotechnical and reservoir engineers, particularly since Australia committed at last year's COP26 summit to achieve net-zero emissions by 2050.

Carbon sequestration involves capturing greenhouse gas emissions from fossil fuel power stations, energy-intensive industries and gas fields, and injecting them back into the ground. That could be in depleted oil and gas reservoirs, saline aquifers or – in the case of Perera's research – deep coal seams.

Perera says deep coal seam gas reservoirs can absorb more than 80 per cent of the carbon dioxide injected into them.

"Carbon dioxide exists in there as a very stable material," she says. "We can store carbon dioxide for hundreds to thousands of years – a very long time period – safely."

ABOVE: Dr Samintha Perera, University of Melbourne.

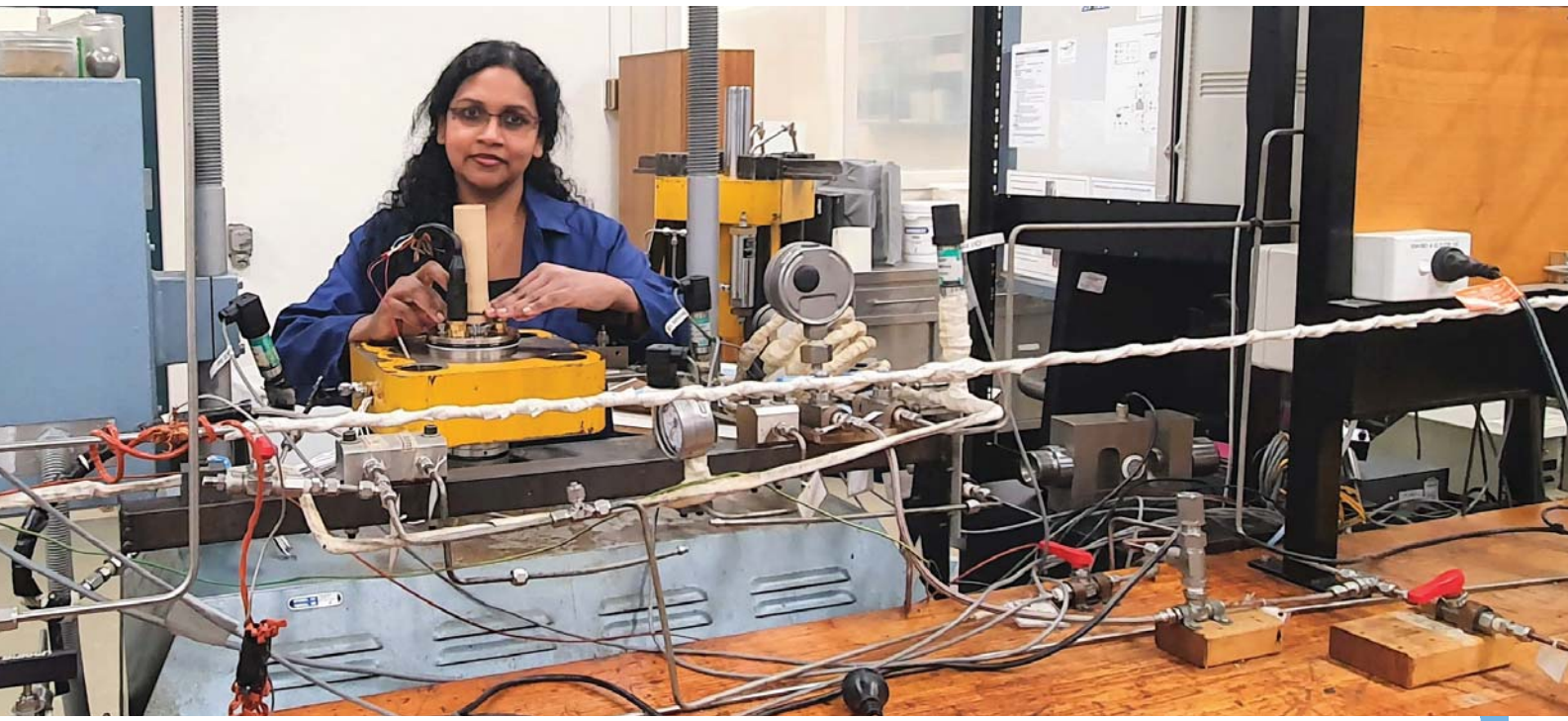
But there are also challenges. Coal mines are complicated structures with varied features. And when the coal absorbs carbon dioxide, there is a strain between the carbon dioxide molecules and the coal surface. Researchers call it "coal matrix swelling".

Carbon dioxide is typically injected more than a kilometre below the surface, where pressures are above 7.3 MPa and temperatures over 31°C.

Under these conditions, carbon dioxide transforms into a "supercritical" state, with properties between a gas and a liquid.

"It has a liquid-like density, gas-like viscosity," Perera says.

Perera discovered a unique interaction between supercritical carbon dioxide and the coal mass, resulting in significant coal matrix swelling. ➤



"There's significant changes that happen to the physical structure," she says. "The swelling is much, much greater compared to the gas or liquid carbon dioxide."

Perera says the swelling causes a significant reduction in strength and can create cracks on the coal mound.

"So CO_2 might leak through this crack," she says.

CAPTURE CONTROVERSY

Carbon capture and storage has been criticised by groups including sustainability non-profit the Climate Council. It argues the technology hasn't been tested at the scale required to tackle the climate crisis and is an expensive attempt to prolong the role of fossil fuels.

But Perera, who Stanford University named among the top two per cent of energy scientists in the world and won the Australian Academy of Sciences 2022 Dorothy Hill Medal for early career researchers, doesn't think we should shy away from it.

She sees sequestration as a way to limit emissions while economies shift to renewable energy.

"WE SHOULDN'T AVOID CARBON SEQUESTRATION, BUT IT'S NOT A STRAIGHTFORWARD PROCESS. WE HAVE TO CAREFULLY IMPLEMENT THIS."

"During this transition period we have to use a low-emission fossil fuel like natural gas," Perera says. "We are still releasing a significant amount of carbon dioxide. I think we need to get the support of carbon sequestration."

Perera believes we need more research to develop techniques that can reduce harmful effects.

She warns overseas experiences can't simply be replicated in Australia.

"I think we shouldn't avoid [carbon sequestration], but it's not a straightforward process. We have to carefully implement this," she says.

Perera says her research suggests that injecting an inert gas, like nitrogen, after the carbon dioxide can lessen the impacts.

"We can reduce about 20 to 30 per cent of the swelling, so it reduces the risks," she says. ●

ABOVE: Perera's experimental research into carbon sequestration.

HYDROGEN APPLICATION

University of Melbourne lecturer Dr Samintha Perera's work exploring carbon sequestration has parallels to underground hydrogen storage.

It's a way to store electricity from renewable sources like solar and wind that might peak at certain times of the day or year.

Perera says there is a lot of work happening to find suitable places to store hydrogen, such as depleted gas reservoirs. Her own research could be a valuable asset.

"We already have a lot of research on geology and flow behaviour and everything in the reservoir, so we can use that knowledge [for] hydrogen storage," Perera says. "But we have to be careful about the unit physical characteristics of hydrogen compared to carbon dioxide. It's a very light material and the interaction is different."

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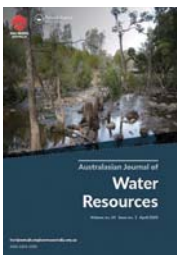
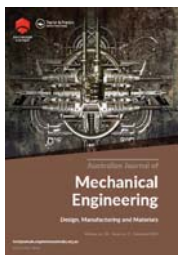


BIORETENTION PERFORMANCE: A REVIEW OF FIELD STUDIES

Journal: *Australasian Journal of Water Resources*
Authors: A. Hoban & C. Gambirazio

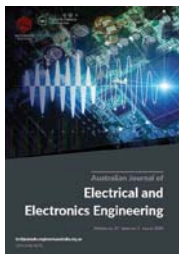
This research shows that bioretention systems perform more like sponges than filters, which can have a potentially large impact on urban hydrology by reducing the volume and frequency of run-off and helping attenuate minor flood events. Ultimately, this could lead to a better integration of the quality and quantity aspects of urban stormwater management.



OPTIMISATION OF MACHINING PARAMETERS FOR MINIMISING CUTTING FORCES DURING MACHINING OF Al ALLOY SiC PARTICLE COMPOSITES

Journal: *Australian Journal of Mechanical Engineering*
Author: R.K. Bhushan

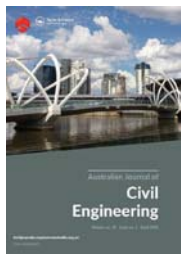
This paper's model describes the deviation of cutting force with an input of depth of cut, and contributions of an interaction effect between feed and depth of cut, a second order effect of feed rate and an interaction effect between speed and depth of cut. It obtains optimum value parameters at which cutting forces will be minimum and the performance and accuracy of machining will be improved.



SENSOR INTEGRATION FOR REAL-TIME DATA ACQUISITION IN AERIAL SURVEILLANCE

Journal: *Australian Journal of Electrical and Electronics Engineering*
Authors: W. Rahmaniar & A.W. Santoso

Unmanned aerial vehicles (UAV) have grown rapidly in popularity in recent years. However, an application to get real-time information from UAVs remains a challenging task. This paper presents an integration system to optimise the use of UAVs for aerial surveillance and explains the design and implementation of a UAV system consisting of on-board and ground stations.

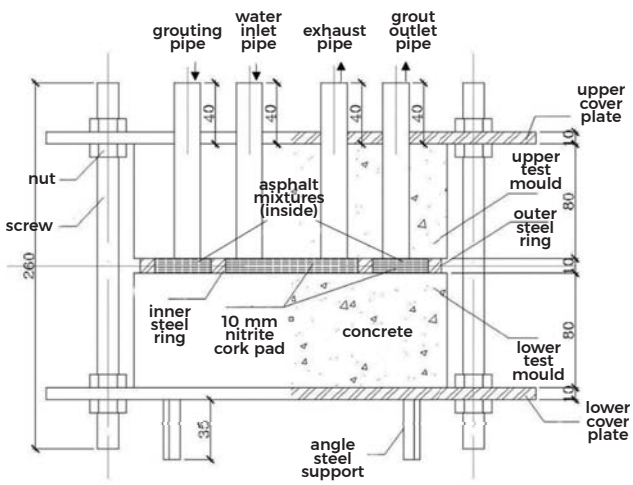


Waterproof performance of non-curable rubber modified asphalt material at deformation joints

Journal: *Australian Journal of Civil Engineering*
Authors: Z. Wang & Z. Lei

This study examined the waterproof performance of non-curable rubber modified asphalt material at deformation joints. The test simulated the grouting situation of non-curable rubber modified asphalt material in a deformation joint, studied the maximum opening amount of a deformation joint under the action of constant water pressure, and evaluated the corresponding waterproof performance. This research has considerable guiding significance for the waterproofing of tunnel engineering.

RIGHT: CROSS-SECTION DIAGRAM OF THE ASPHALT TEST DEVICE.



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Website: *engaus.org/Heritage2022*
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Registration open

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Location: Online and in-person *Melbourne (hybrid)*
Website: *aseconference.org.au*
With its theme "Engineering resilience", ASEC covers topics relevant to structural engineers, students, academics, researchers and industry specialist providers.
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Website: *hwrs.com.au*
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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.
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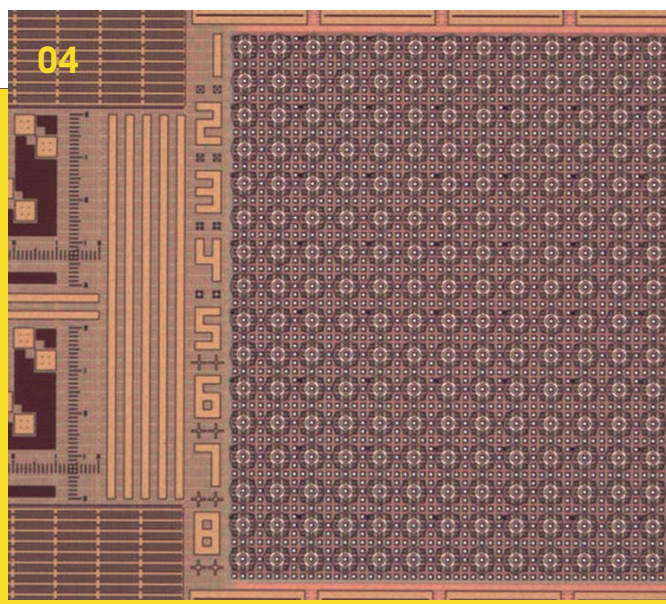
THE LATEST DEVELOPMENTS FROM AROUND THE WORLD.


02


01


04

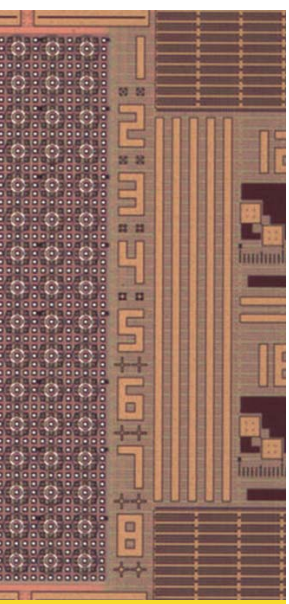

03

01

Biofilm sensor

This biofilm neck sensor measures mechanical signals from swallowing. Image: Liu et al.

A biofilm developed at the University of Massachusetts Amherst can be used to create electricity by harvesting energy from evaporation. The material, which is no thicker than a piece of paper, consists of a sheet of bacterial cells that are known to produce electricity. Unlike previous batteries made from the bacteria, however, these cells are dead and do not require feeding to produce energy. Instead, they operate using sweat from a user's skin — making them ideal for wearable technology. "The limiting factor of wearable electronics has always been the power supply. Batteries run down and have to be changed or charged. They are also bulky, heavy and uncomfortable," says Professor of Electrical and Computer Engineering Jun Yao. "This is a huge, untapped source of energy." Sensors made from the biofilm are produced by gathering mats of bacteria and etching circuits into them with a laser. The mats, which are flexible and breathable, are then encased in a soft polymer.



02

Octa-Glove

Researchers test the Octa-Glove in a Virginia Tech laboratory. Image: Alex Parrish for Virginia Tech

A team at US university Virginia Tech has created a glove inspired by octopuses that can securely grip objects underwater. Modelled on the adhesive bond created by the suckers on an octopus's tentacles, the glove is equipped with pliant rubber stalks that have soft-actuated membranes at the end. Ideal for flat and curved surfaces, these mechanisms can create a dependable bond even with a light application of pressure. "By merging soft, responsive adhesive materials with embedded electronics, we can grasp objects without having to squeeze," says Assistant Professor Michael Bartlett. "It makes handling wet or underwater objects much easier and more natural. The electronics can activate and release adhesion quickly. Just move your hand toward an object, and the glove does the work to grasp. It can all be done without the user pressing a single button." The technology could be useful for rescue divers, underwater archaeologists, bridge engineers and salvage crews, as well as finding applications in health care and soft robotics.

03

Anti-pathogen spray

The surface energy and shield effect of the anti-microbial coating pushes away the surrounding liquid. Image: Cesar Nicholas

Researchers at the University of Melbourne have developed a spray coating that can prevent common viruses and bacteria from transmitting infections on surfaces. The coating, made of super-tough plastics, creates an air-filled barrier that repels the microbes. Because the coating repels water, it traps the microbes inside droplets and away from the surface being protected. Nanomaterials in the coating can also release a burst of ions, adding extra protection. The spray has been tested for extended periods of time and has been subjected to high concentrations of pathogens. "The coating has been engineered through a simple and scalable technique with a careful choice of materials to provide ultra-durability," says Professor David Nisbet. "We also believe our explanation of the mechanism behind the antimicrobial and antiviral effects could significantly advance research in antipathogen technologies that could see affordable manufacture of an effective surface spray to protect people from viruses and bacteria."

04

Programmable pH

The dense array of microsites in this chip can locally control pH levels. Image: Donhee Ham Research Group/Harvard SEAS

Engineers at Harvard University have developed a technique that allows researchers to control the acidity of a solution at a local level, rather than transforming the pH level uniformly across an entire solution. Using a semiconductor chip, the technology induces microsites in which there are 100 to 1000 times the number of protons — which pH measures — compared to the rest of the substance, which could have applications for DNA synthesis. "In each activated electrochemical cell, we set up an electrochemical wall using the outer ring, which the acid generated by the inner ring cannot penetrate," says postgraduate student Han Sae Jung. "Since each cell is controlled independently by the underlying semiconductor chip, we can lower pH at any arbitrary subset of the 256 electrochemical cells we choose to activate. The unique cell structure we have developed on the semiconductor electronic chip enables this spatio-selective pH programming."

Sandra Lingbawan

CPEng, Senior Project Manager
Transport for NSW

AS AN ENGINEER WHO DEVELOPED HER TALENTS ON A NAVAL VESSEL, WORKING ON A MAJOR CITY'S TRANSPORT NETWORK TOOK SOME ADJUSTMENT FOR SANDRA LINGBAWAN.

HAVING TRAINED as an engineer at the University of New South Wales, Sandra Lingbawan returned to Australia after an eight-year stint in the Philippines Navy to oversee a number of projects for Sydney Trains, including delivering a life-extension program for the XPT service.

"When you're on the ship, it's like a small city — you have your own power plant, you make your own water, you cook your food there," she tells *create*.

"The Navy is very hierarchical, whereas Sydney Trains is more flat in its organisational structure. So there's also a difference in how you approach people and how you get things done."

But the work of a naval systems engineer requires managing finely tuned and complex systems, and that experience was something Lingbawan found useful in her civilian work.

"In terms of the skills, there are a lot of transferable skills — not just technical, but also dealing with stakeholders and being collaborative in order to do the job well," she says.

"Rail systems are very complex as well, and for my part, I'm only involved with rolling stock systems, and that's quite complex. There are a lot of cogs moving for the trains to roll and to be in service."

Her work on the XPT service is an example.

"The challenge is sometimes operation ... trumps maintenance," Lingbawan says.

"The challenge in managing the project is trying to line up everything so that the car is able to be repaired or maintained during the time that it's been programmed to go into life extension."

It was one of Lingbawan's managers who encouraged her to apply to become a Chartered engineer, and she says Sydney Trains was supportive of the process.

"It does add to your professional self-esteem, knowing that you have that qualification," she says.

"It aids you in maintaining a self-discipline of ensuring that your professional development is continuous. Otherwise, I think, for myself, if I didn't have it, I may not be that disciplined in keeping up to date with current engineering developments — whether in my field, or other fields."

But she believes that, as much as maintaining those professional skills is important, there is more to being a successful engineer.

"You're not isolated — you have to deal with logistics people, you have to deal with admin, you have to deal with people that are non-technical," she says.

"You don't only hone your technical skills, but you make sure to learn about your interpersonal skills as well." ●

03 TIPS FOR SUCCESS

1 Don't be afraid to ask questions or make mistakes.

2 Show your interest. People will notice and look to help you out.

3 Work hard to boost your technical proficiency and gain experience.

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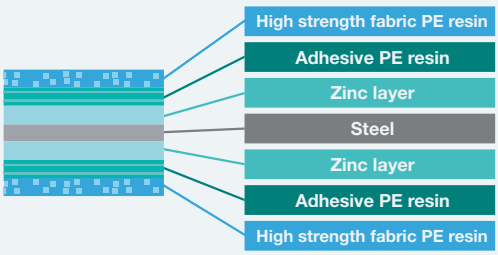

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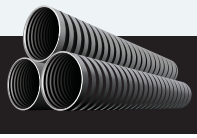

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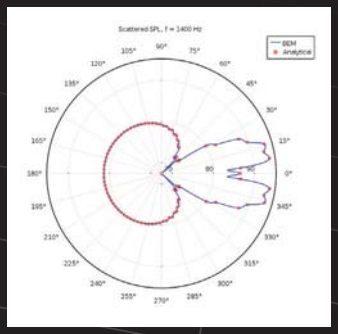

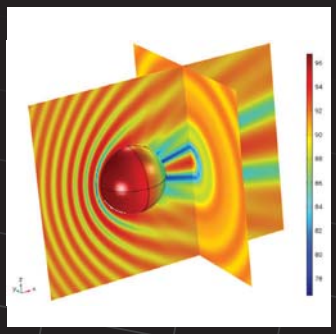

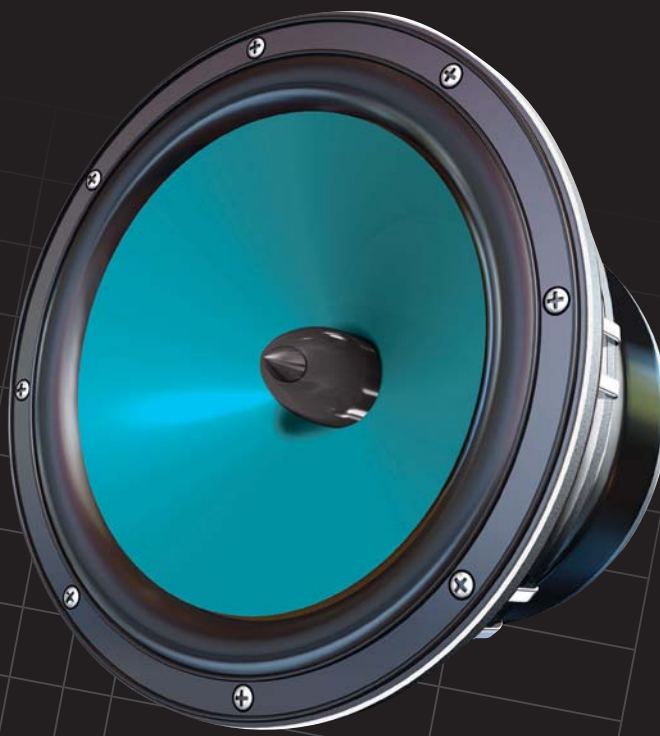

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