The University Of Sheffield. /AMRC Journal Issue 13

Driving sustainability in manufacturing

Twenty years of making things better -
This year marks the University of Sheffield AMRC's 20th anniversary of being at the cutting edge of innovation

Lifting the bonnet on Project ELLI -
Take a closer look at the complex assembly demonstrator showcasing the AMRC's electrification and lightweighting capabilities in Industry 4.0

Decarbonising heavy industry -
AMRC joins Zero Carbon Humber Partnership in bid to advance UK's first net zero industrial cluster

20 in 21 Twenty years of making things better

CATAPULT High Value Manufacturing

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Welcome to the

AMRC Journal

2021: A new hope

What a start to the new year that was. The first weeks of 2021 not only brought us a Brexit trade deal to digest but (as I write) the country is in the grips of a third national lockdown and dark clouds continue to gather over our economic recovery with official figures showing a 9.9 per cent drop in output for 2020. Despite this record slump, there was growth in the last quarter, 1 per cent, which should offer a sliver of optimism and go some way to easing concerns of a double-dip recession.

Yes, 2020 was a year of crisis but with the start of each new year comes new hope and renewed energy.

Covid-19 vaccines are being rolled out across the UK, giving us a real shot at getting ahead of the virus and we must do all we can to make sure that chance is not wasted. That means not losing sight, spirit or momentum on the huge challenge we face collectively as a global society with climate change but also those that strike closer to home here in the UK around productivity and sustainability, skills and training, and how to deliver on the government's plans for a green industrial revolution and zero-carbon future.

Here at the University of Sheffield AMRC we know the key role manufacturing has to play in overcoming these grand challenges and that's why our driving purpose and collective goal is to help make things better. We do this by standing shoulder-to-shoulder alongside our colleagues and friends in the High Value Manufacturing (HVM) Catapult so that together we can help deliver the cutting-edge, low-carbon innovations needed to power the engine room for a greener, cleaner and brighter future.

This year the AMRC marks its 20th anniversary. Our achievements over the past two decades do not fail to impress and tell a powerful story of industrial regeneration and collaboration; a lasting symbol for what is possible in other forgotten northern towns. And it's this which keeps us optimistic for the future.

A measure of that hope can be found here in these pages: from helping UK firms harness the potential of new digital technologies to remain competitive and productive, to the AMRC's important role in a £75m bid to accelerate decarbonisation of heavy industry in the Humber - supporting clean growth, future-proofing vital industries and protecting and creating new jobs.

We delve deep into our digital work to showcase AMRC projects that span rail maintenance, composite inspection, additive manufacturing for aerospace, and a digital awakening for construction. We also get under the bonnet of Project ELLI, a complex assembly demonstrator that uses a Caterham kit car to show how advanced technologies such as electrification and lightweighting can improve in-service efficiency, and that achieving sustainability doesn't have to cost lots of money - in fact, it can save you money. And if anything can bring new hope to business, it's the potential to save a bob or two.

Katia Harston
Editor

20 in 21 Twenty years of making things better

Got a story to tell? Contact:

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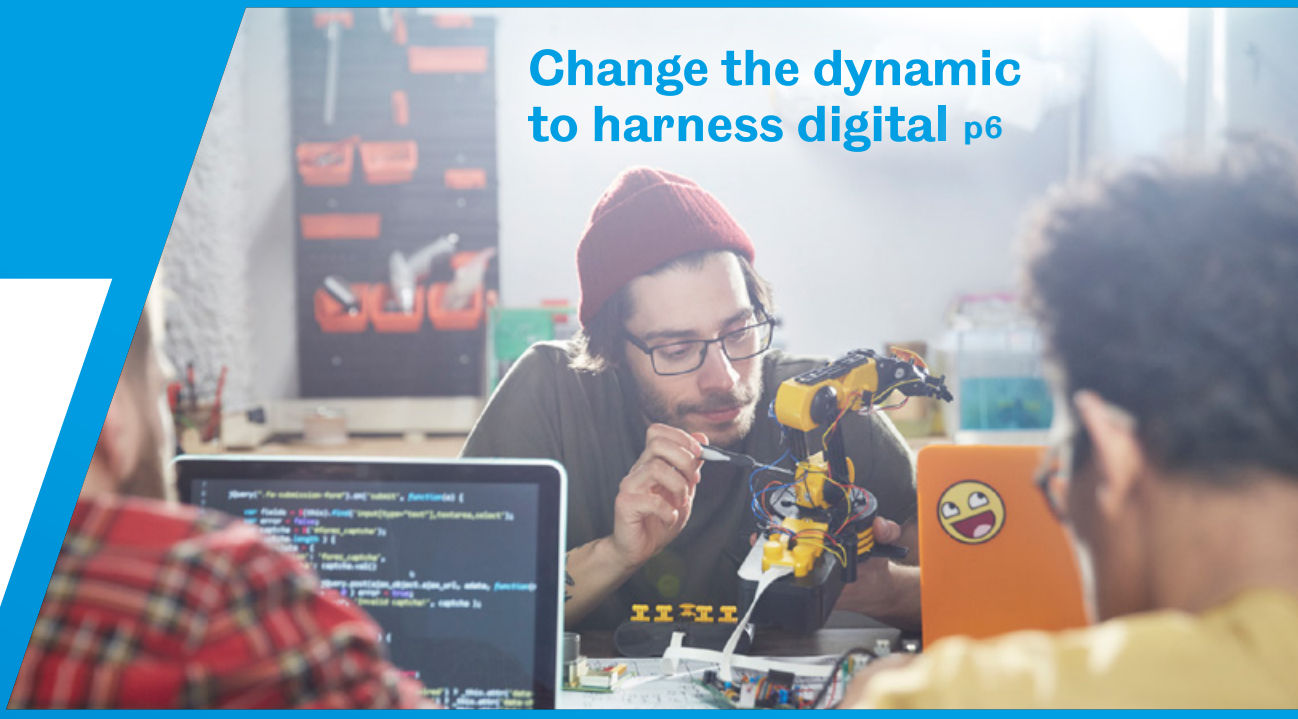

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Cover image: Project ELLI, the complex assembly demonstrator which displays the AMRC's world-class capabilities in mid-technology readiness level (TRL) research across multiple sectors and capabilities.

Recapture the Tech Start-up Spirit

By Steve Foxley,
AMRC CEO.

Earlier this year, as part of our work to define the next strategic direction for the University of Sheffield AMRC, we asked each of our stakeholders what they wanted to see from the organisation in this next decade. The feedback was incredible and fundamental in helping us shape the direction of our Chapter 2 strategy.

There was one comment submitted anonymously by an employee that has stuck in my mind throughout 2020 and into 2021. The message was simple, yet powerful: 'Consolidate and recapture the tech start-up spirit'.

The plea was for the AMRC to make sure that all this tremendous organisation has achieved over the past 20 years be consolidated and from this position, recreate the tech start-up atmosphere of old.

For me, the essence of a tech start-up spirit is captured by Ranjay Gulati in The Soul of a Start-Up written for Harvard Business Review. Gulati says: "There's an essential, intangible something in start-ups - an energy, a soul. It inspires enthusiasm and fosters a sense of deep connection and mutual purpose. While this spirit

> It is the people that make the AMRC... the lifeblood of the AMRC is the bright and brilliant minds who inhabit these buildings and find novel ways to solve manufacturing problems.

persists, engagement is high and businesses keep their edge."

With this in mind, the comment made by the anonymous employee has been my compass during what has been an exceptional 2020. So, as I look back over the past 12 months, how have we fared so far?

Well, there has been a huge amount of work done below the waterline to consolidate. We've looked back before planning forwards to make sure we've captured the code of the AMRC's success; we've defined a transparent and collective strategy for this next decade; we've aligned the substantial resources we have at the AMRC behind our Chapter 2 themes; we've reorganised to embrace a OneAMRC culture and we've revised the underpinning financial model to facilitate even greater collaboration and encourage more of the original start-up spirit.

None of this work wins awards but has been absolutely critical to consolidate and create strength in the foundations. And it is upon these sturdy foundations from which we are recreating the flexibility and agility of the tech start-up.

We now have more than 100 people from the AMRC who are directly involved in project teams that are implementing the Chapter 2 strategy; making sure we are developing innovations to tackle the grand challenges around sustainable manufacturing, future propulsion, digital architectures and solutions and supply chain resilience, while in parallel, ensuring application and impact is delivered by getting our innovations onto the production floor of manufacturers.

We've created a 'FerretWorks' approach (our Yorkshire slant on SkunkWorks) to incubate high risk/high reward ideas away from the typical business KPIs and constraints, creating a space where it's OK to fail, as well as putting money into the groups so they can make space for thinking.

And there's plenty to think about.

A new industrial strategy is on the way, which is touted to focus on science, technology and green initiatives, while prioritising the UK's underperforming regions. In 2020 we also heard many ambitious announcements where new innovations in manufacturing will be essential; from Jet Zero and Net Zero to greener, cleaner energy and decarbonisation of heavy industry, through to the promise of infrastructure and innovation to level-up the North.

We know the University of Sheffield AMRC, as part of the High Value Manufacturing (HVM) Catapult, has an important role to play in delivering on these ambitions, turning them into something tangible and real that has a meaningful impact on people's everyday lives.

Over the past twenty years, we have shown how effective our model of an academic-business partnership can be in delivering meaningful impact; we have become a powerful symbol for what is possible, whether that is regeneration, collaboration or inward investment.

Our strength lies in being part of the fabric of the places we operate, be that in the Sheffield City Region, Lancashire or North Wales. It is vital for us that we play a constructive and forward-looking role and act as a catalyst for bringing the manufacturing sector together across the North and beyond so it becomes greater than the sum of its parts, both in terms of practical development and innovation, and by bringing a strong collective voice to the national policy agenda.

But we also know that to successfully deliver on these goals requires much more than business models, systems, processes and structures. Sitting behind all of this is our people and the collective will we all share to make things better.

It is the people that make the AMRC. We're far more than the buildings and cutting-edge capabilities that often define us; the lifeblood of the AMRC is the bright and brilliant minds who inhabit these buildings and find novel ways to solve manufacturing problems.

We know our people are our greatest asset. It's vital we continue to bring in the new skills sets needed to help the AMRC grow and deliver on it's Chapter 2 strategy; and we must invest in our people if we are to drive forward innovations and industry-transforming solutions that will have real, meaningful impact for businesses. And we want that impact to be felt far beyond the shop floors of Sheffield, Rotherham, Preston and Broughton - it must spill out into their surrounding communities, not only to drive up skills, transform productivity and support sustainable economic growth, but to deliver hope and aspiration.

As Ranjay Gulati says, having the soul and spirit of a tech start-up is not only the secret to growth but also greatness. If we are to live that shared purpose of making things better, the AMRC's passion, authenticity, agility and personality will be at the heart of our success: the freedom to fail, to disrupt and ultimately, to innovate.

That's why, as we begin to write these crucial next pages of the AMRC's remarkable legacy, we must not only recapture the AMRC's tech start-up spirit, but preserve and safeguard it; we must put it at the front and centre of this next new chapter and make our story a best seller.

Change the dynamic to harness digital

The High Value Manufacturing Catapult's Chief Technology Officer, Professor Sam Turner, tells James Crossling how a new pilot involving the AMRC will help UK firms harness the potential of new digital technologies.

UK manufacturers faced unprecedented challenges during 2020. Across many sectors, accurate business forecasting and order books were ripped up and supply chains disrupted, exposing concerns over national resilience. Now, as a new year brings new energy, a huge number of manufacturers are looking at how to build more resilient supply chains, creating opportunities for domestic businesses.

"To remain competitive, productivity and agility are more important than ever," said Sam. "The ability to move quickly, to bring new products to market and rapidly scale or repurpose production facilities and supply chains will give a competitive edge to businesses wishing to exploit new markets, with automation and resource efficiency a key to reducing lead times.

"Industrial digitalisation will play an important role in enabling improved agility, productivity and resilience. The Made Smarter Review identified that artificial intelligence (AI), the Internet of Things (IoT), additive manufacturing, advanced robotics and visualisation have the potential to drive manufacturing performance up by 30 per cent across UK industry, while digitalisation can improve factory productivity, accelerate the ability to bring new products to market and develop new business offerings."

Sam says digital tools and technologies can also play an important role in resource efficiency and traceability of embodied carbon emissions.

A recent MakeUK report, Bouncing Back Smarter, found that 80 per cent of UK manufacturers now recognise that Industrial Digital Technologies (IDTs) will be a reality in their business within the next five years, but the UK is still falling behind its international peers, with UK investment lagging well behind key competitors.

"Many businesses struggle to understand the direct commercial benefits of bringing in new technology and will hesitate in the face of the perceived risks and barriers they could face such as cybersecurity and poor access to skills or trusted partners. Too often firms can feel that the business case just won't stack up for them," said Sam.

"To accelerate take-up of IDTs in UK businesses we need to change the dynamic. To make progress, that means starting with real industry problems and highlighting clear examples of how digital technologies can address them. Shared peer-to-peer use cases can be a powerful tool in shifting the perception of digital technologies but, crucially, firms also need a safe environment to explore and test the solutions that could be right for them."

To tackle this, the HVM Catapult will host the Made Smarter Smart Factory Innovation Hub

pilot scheme. The programme will offer 16 physical and virtual testbeds across the HVM Catapult's UK-wide network to give firms of all sizes, from all manufacturing subsectors, an opportunity to reduce the risks of implementing new digital technologies within their business.

The AMRC's Factory 2050 and Factory of the Future facilities, both on the Advanced Manufacturing Park in South Yorkshire, will host the Legacy Systems testbed. Factory 2050 will also be the Connected Factory testbed while the AMRC will additionally lead the Cybersecurity for Manufacturing testbed.

Sam continued: "One of the trends seen in the industrial digitalisation space is how manufacturing expertise is increasingly embedded in the manufacturing systems. As this trend continues, manufacturing businesses may find it challenging to differentiate themselves and the skills of manufacturing engineering in the marketplace, resulting in a greater dependency on the solution providers.

"While the UK's manufacturing technology sector has fallen into relative decline with a small share of the global and domestic market, the UK does have the largest tech community in Europe. There's real potential to attract that community into the manufacturing sector alongside resilient manufacturing equipment providers, integrators and starts-ups.

"The disruption we're seeing across the engineering world in electrification of transport, clean energy and digitalisation means that new products being brought to market will demand new manufacturing solutions. This provides an opportunity for UK manufacturing technology providers to enter the market, not with 'me-too' solutions, but with solutions that build on the strengths of our tech and manufacturing sectors and that address new market opportunities.

"A barrier for some of these domestic manufacturing solution providers, particularly start-ups or those coming from outside of the sector, is the ability to test and iterate their solutions in safe industrial type environments before taking them to market. That is why we have joined forces with Made Smarter to host the Made Smarter Smart Factory Innovation Hub pilot."

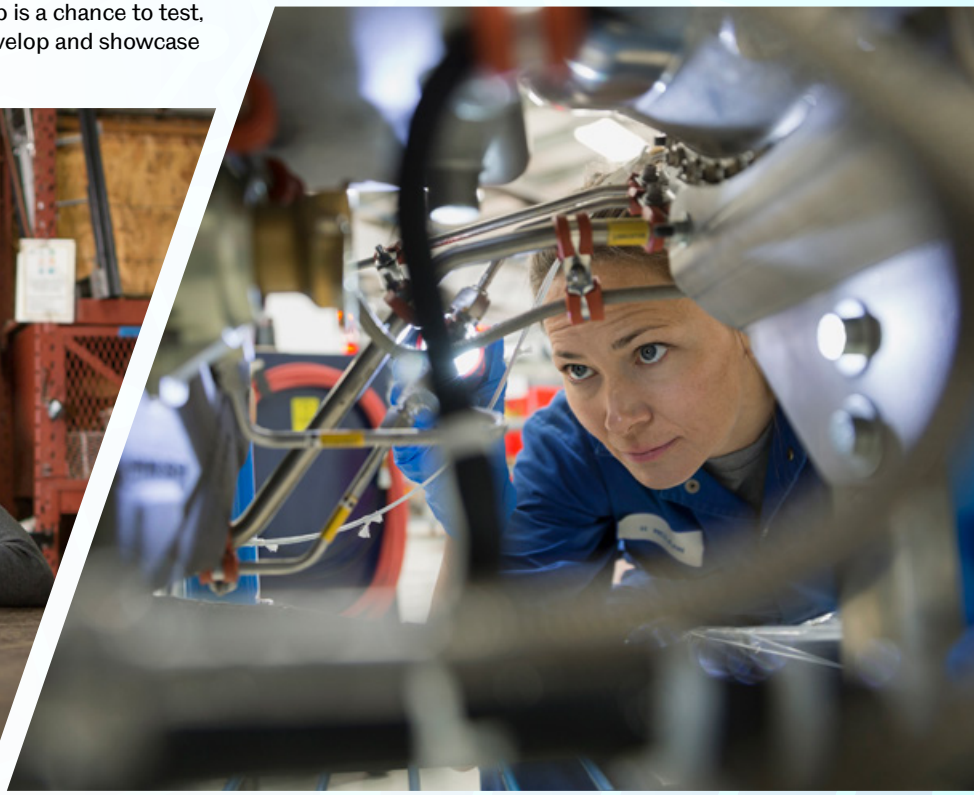
The hub will allow businesses to test quick-fire projects and early-stage technologies at one of its 16 testbeds - a safe, industry-like environment with expert support. For manufacturers, it will be an environment to test new integrated technologies and de-risk rapidly configurable projects. For technology providers, the hub is a chance to test, develop and showcase new technology solutions in a real industry setting.

"To encourage adoption, it's clear that we need to make digital technologies easier for businesses to engage with and provide an environment where UK manufacturers can explore digital manufacturing solutions and undertake quick-fire innovation projects before moving to deploy solutions within their businesses," said Sam.

"Technology providers will also have the opportunity to test, iterate and demonstrate their solutions. These environments will each have a sector or manufacturing process focus with a broad coverage of geographical locations. The hub will be 'plug and play' environments where a range of technologies can be evaluated by developers and users.

"Best of all, during the pilot phase, the Made Smarter Smart Factory Innovation Hub HVM Catapult service comes at no-cost for eligible companies thanks to funding from UK Research and Innovation through the Industrial Strategy Challenge Fund. We're breaking down barriers to digital adoption so that in 2021, manufacturers can fill the order books they ripped up in 2020."

For more information on the Made Smarter Smart Factory Innovation Hub pilot, turn to page 34.



Lancashire will be ‘innovation leader’

says regional growth minister as construction starts on AMRC North West.

By Katia Harston.

An artist’s impression of how the new facility will look.

Lancashire will be a leader in manufacturing innovation and sustainable economic growth, the UK’s regional growth minister said as he welcomed construction starting on the £20m University of Sheffield Advanced Manufacturing Research Centre in the North West of England.

Luke Hall, Minister of State for Regional Growth and Local Government, made the comments to mark the first steps in building the 4,500m2 applied research centre at the heart of the Samlesbury Aerospace Enterprise Zone in Preston, Lancashire.

“We are delighted to be backing the University of Sheffield Advanced Manufacturing Research Centre (AMRC) North West with a £20 million Local Growth Fund investment,” said MP Luke Hall.

“This project will place Lancashire as a leader in innovation-driven, sustainable economic growth and will act as a catalyst for further inward investment.

“It will also support the creation of highly skilled jobs, bringing opportunities and prosperity to the local community.”

The flagship facility is being built using a £20m grant from the Lancashire Enterprise Partnership (LEP) Growth Deal and extends the University of Sheffield AMRC’s footprint across the North. Due to Covid-19 restrictions, a turf cutting was held virtually bringing together key figures involved in the major development.

Steve Foxley, CEO, University of Sheffield AMRC, said that while the ceremony took place in the virtual world, the new facility will have real-world impacts for the region. “We’ve taken another huge stride in realising our vision to make things better, for Lancashire and for the North,” he said. “This state-of-the-art facility will keep the Lancashire region at the forefront of advanced manufacturing and technologies and support its

businesses to innovate and drive up productivity, leading industry towards a green recovery and a smart, sustainable and resilient future."

Professor Koen Lamberts, President and Vice-Chancellor of the University of Sheffield, said: "The University of Sheffield AMRC has a long history of driving manufacturing and productivity growth in the Sheffield City Region and we're really proud to be sharing our world-leading expertise and experience in Lancashire.

"AMRC North West is already having a significant impact in supporting businesses to innovate and strengthened by this new facility, will be a beacon for innovation and advanced manufacturing across the North. It is collaborations like this that will be crucial to levelling up the regions and supporting the country's post-Covid recovery."

Professor Dave Petley, Vice-President for Innovation at the University of Sheffield, added: "The University of Sheffield AMRC has a long-standing reputation for developing specialist regional hubs that provide engineering expertise and access to advanced capabilities tailored to the needs of local industry sectors. We are delighted to be expanding our tried and tested model for innovation to support local industry and the manufacturing sector in the North West."

Even before the first spade hit the dirt for the new facility, the creation of a high-performing technical R&D team at AMRC North West is already having impact, having supported more than 100 small and medium-sized firms across the region in the first year, and the recent announcement of a £10m funding win to put Lancashire and North West manufacturing at the cutting edge of 5G technology with the 5G-Factory of the Future programme. Led by AMRC North West, the programme will develop a 5G industrial testbed to unlock the potential of industrial digitalisation and improve the performance of manufacturers across the North of England.

James Hughes, Research Director for AMRC North West, said: "It is hugely exciting for everyone involved in the AMRC North West project to see our new facility becoming a reality. This new state-of-the-art building will really enable us to showcase the cutting-edge R&D we are conducting in advanced manufacturing. We are here to support the region's manufacturers with innovative solutions to their manufacturing challenges and welcome them to come and visit us, to see it in action for themselves."

Melissa Conlon, Commercial Director for AMRC North West, said: "Our new facility will help accelerate manufacturing growth, supporting the supply chains in the region to drive up productivity and attract inward investment to create a sustainable future for advanced manufacturing in the North West.

"AMRC North West is already having a significant impact in supporting businesses to innovate and strengthened by this new facility, will be a beacon for innovation and advanced manufacturing across the North."

Professor Koen Lamberts,
President and Vice-Chancellor of the University of Sheffield

Construction is underway on the £20m University of Sheffield AMRC North West in Lancashire as the steel frame of the building begins to take shape.

We have already worked with more than 100 Lancashire SMEs to accelerate their adoption of Industry 4.0 technologies to improve performance and quality and ensure that they are able to compete in the global economy."

Steve Fogg, Chair of the Lancashire Enterprise Partnership (LEP), said: "It is fantastic that work has started on the AMRC North West facility on the Samlesbury site. The Lancashire Enterprise Partnership has invested £20m from our Growth Deal programme as we are confident in the AMRC's ability to drive growth and increase productivity to ensure Lancashire remains at the forefront of innovative and cutting-edge technologies. Not only is the LEP confident that the AMRC can deliver a step-change to how our businesses operate, but the fact that they have decided to locate in Lancashire is testament to Lancashire's strong manufacturing and innovative heritage."

Stephen Young, Executive Director of Growth, Environment, Transport and Community Services at Lancashire County Council, said: "This is a prestigious investment for our Enterprise Zone, which is a strategically important employment site that will play a key part in the levelling up agenda for our region. The AMRC facility will stand proudly at the 'gateway' to the site as a beacon of excellence. We believe Lancashire is the perfect place for this investment. Manufacturing is in our DNA and we have the right environment, skills and businesses to work with high-value manufacturers."

"This is a prestigious investment for our Enterprise Zone, which is a strategically important employment site that will play a key part in the levelling up agenda for our region."

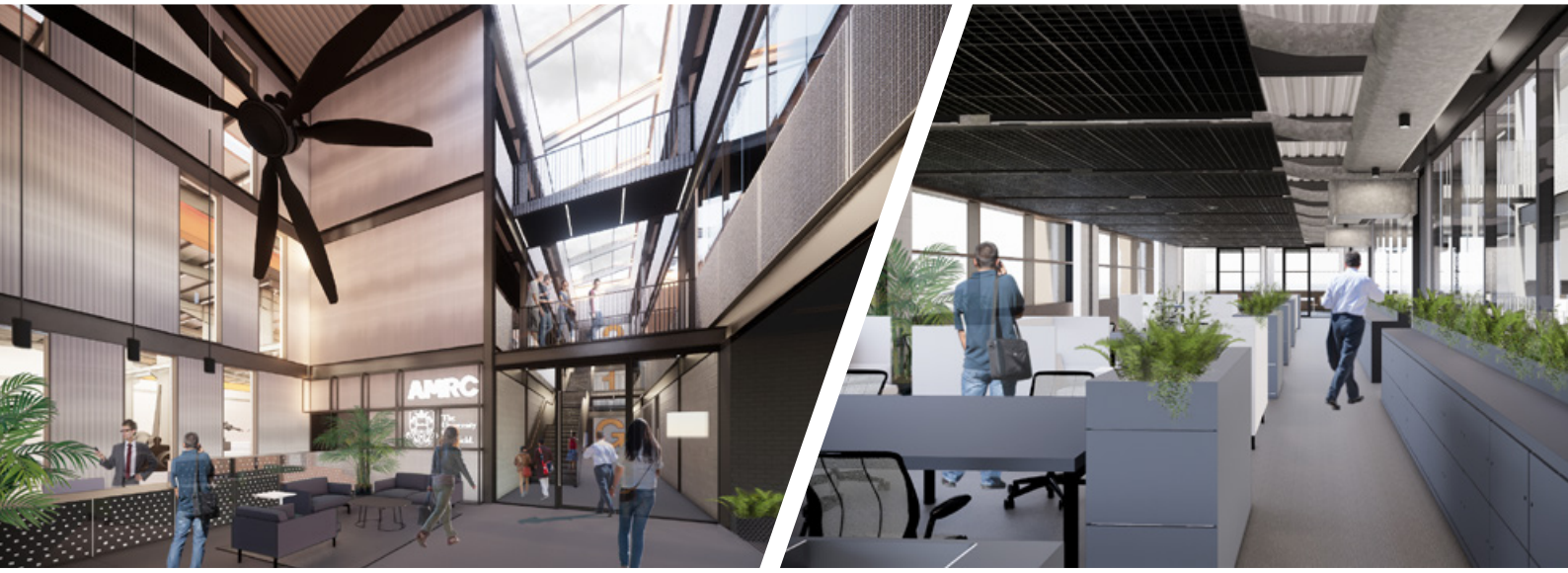
Stephen Young, Executive Director of Growth, Environment, Transport and Community Services at Lancashire County Council,

Robertson, one of the largest family-owned construction, infrastructure and support services businesses in the UK, was awarded the £11m construction contract for AMRC North West. Alongside Robertson, a full design team is in place, including Cartwright Pickard Architects, Curtins Engineers, Arup, Gardiner and Theobald, and Rex Procter and Partners. Work is expected to complete during the second half of this year.

Dirk Pittaway, managing director, Robertson North West, said: "Any start on site represents an exciting new chapter and the start on site at University of Sheffield AMRC North West heralds a host of new opportunities. With more than 80 per cent of our orders already placed with local supply chains and SMEs, the construction of the facility will play a fundamental role in boosting the local economy. We look forward to working with the entire team to deliver an outstanding facility which will be a showcase for both Lancashire and advanced manufacturing technology."

Currently operating from an interim facility provided by the University of Central Lancashire (UCLan) in the centre of Preston, the AMRC North West team's permanent new home will be a gateway development on the Samlesbury Aerospace Enterprise Zone which is part of the wider Lancashire Advanced Manufacturing and Energy Cluster.

The cutting-edge research centre will combine modern office workspace with a flexible high-tech workshop facility and a triple-height atrium will form the social hub of the office space where occupants can interact and exchange ideas. A 'social heart' space will overlook the workshop where innovation-led R&D will be carried out with a focus on digital and additive manufacturing, vehicle electrification, battery assembly and lightweighting technologies.



An artist's impression shows what the new facility will look like inside.

Food and Drink Federation announced as AMRC Cymru partner

Food and Drink Federation (FDF) Cymru, the organisation that represents Welsh food and drink manufacturers, has been announced as a partner to the University of Sheffield Advanced Manufacturing Research Centre (AMRC) Cymru.

The collaboration follows the announcement in 2020 of a £2m investment from Welsh Government to create a Food and Drink Packaging Sustainability Centre at the AMRC's facility in Broughton, the first High Value Manufacturing (HVM) Catapult centre in Wales.

Pete Robertson, Acting Director at FDF Cymru, said: "I'm delighted that FDF Cymru has been chosen effectively as a brand ambassador for AMRC Cymru. By working together, we will better understand the barriers food and drink manufacturers currently face when it comes to implementing newer technologies, and in doing so we hope to be able to support wider productivity gains across the industry."

The new partnership will see both organisations engage with businesses across the food and drink sector in Wales to scope out potential challenges in the adoption of emerging technologies. The outreach will involve collating demonstrator case studies to assist the industry in practice, as well as on-going webinars and networking events.

"I'm very much looking forward to putting in place a programme of engagement so we can begin speaking to as many businesses as possible," said Pete.

The sustainability centre will accelerate the adoption of waste-reducing eco-innovations by integrating Industry 4.0 technologies in the packaging industry.

In addition to prototyping and functional test equipment for new packaging solutions, the Food and Drink Packaging Sustainability Centre at AMRC Cymru will have a central demonstrator to exhibit the AMRC's capabilities in advanced automation, collaborative robotics, additive manufacturing and visualisation.

The demonstrator will be based on a conveyor system, which will be linked together with collaborative robots, automated guided vehicles (AGVs) and AMRC engineers wearing exoskeletons.

Bobby Manesh, AMRC Cymru's Food and Drink Technical Lead, said: "The team at AMRC Cymru is very much looking forward to working closely with FDF Cymru. The food and drink sector is a new area for the AMRC so having this partnership with FDF Cymru will be invaluable as we demonstrate that Industry 4.0 technologies can be easily implemented in a new manufacturing set up at relatively low cost but with significant rewards."

The latest figures show the food and drink supply chain in Wales employs 229,500 people and has an overall annual turnover of £22.1bn.

It's hoped the activities undertaken as part of the partnership will support the broader industry needs of the food and drink manufacturing sector in Wales, particularly as it deals with the impact of the Covid-19 crisis.

Sir Keir sees the future of manufacturing at AMRC Cymru

The future of advanced manufacturing in the UK hinges on investment in applied research, Labour leader Sir Keir Starmer said on a visit to the Welsh Government's £20m R&D facility in North Wales run by the University of Sheffield Advanced Manufacturing Research Centre (AMRC).

James Crossling reports.

Sir Keir toured the facility – next door to the Airbus wing manufacturing plant in Broughton – with the Welsh Government's First Minister, Mark Drakeford, and Shadow Chancellor, Anneliese Dodds, where the Labour leader discussed the future of jobs at the plant with Airbus executives.

He said the 'top class' R&D talents of AMRC Cymru are critical success factors for the future of both Airbus in North Wales and the UK manufacturing sector more widely.

"What you see at AMRC Cymru is the future of manufacturing and I think that is very inspiring," said Sir Keir. "If the research and development here is top class, which it is, then that means that those high-skilled jobs will stay in North Wales."

The Labour trio were shown presentations on how the AMRC is working alongside Airbus on its Wing of Tomorrow programme as well as how engineers at the AMRC utilised Industry 4.0 technologies, such as Discrete Event Simulation, automation and virtual reality (VR) to pivot their operation to mass-produce thousands of medical ventilators.

Andy Silcox, Research Director at AMRC Cymru, explains the AMRC's capabilities in robotics and automation to Labour leader, Sir Keir Starmer.

The AMRC is helping manufacturers in Wales adopt Industry 4.0 technologies.

An Airbus engineer manufactures a component of the Penlon ventilator at AMRC Cymru.

They were also shown the AMRC's capabilities in additive manufacturing, augmented reality (AR), hydrogen, composites, robotics and a new package of work being done alongside Food and Drink Wales.

"Places like this are really important - making things matters. It is incredible in terms of technology, development and testing but also critical to the importance of Airbus and what goes on here in North Wales in the long term. What's happening here hopefully ensures the future of manufacturing in ten years' time," said Mr Starmer.

"Manufacturing and advanced manufacturing is very important to the UK economy. My dad was a tool maker in manufacturing and he impressed on me the importance of making things. What I have been really pleased to see in the last few years is how manufacturing has moved on so much – it is why we need to work now to preserve those jobs.

"We have moved from a manufacturing sector that didn't, in my opinion, work particularly well decades ago, to a manufacturing system which is smart and world-leading; we need to retain that."

Mr Starmer said the key to that success is the research and development being done at places like the AMRC: "The manufacturing sector needs to be underpinned by R&D. We wouldn't be where we are without R&D and we won't be where we need to be in a decade without it. Without R&D you are actually suffocating manufacturing."

Darren Reynolds, Broughton Site Convenor for Unite the Union, said those effusive remarks about AMRC Cymru are reciprocated by engineers on the shop floor at Airbus as well.

"We can try things at AMRC Cymru that otherwise we would have to do on the shop floor, whether that is new tooling or new methods of working. What we have here is the ability to try it, test it, de-risk it and then put it into manufacturing," said Darren.

"It is vitally important for the future of manufacturing that we can learn from procedures before we go into production - it speeds everything up and keeps us one step ahead. You have to embrace new ways of working and for us to have this on our doorstep means we will use it to its full advantage and it will only be good for the site.

"The facility can only improve Unite members here in Broughton and put us one level ahead; it will give us more opportunity within the company and it will be fantastic."

AMRC Cymru was opened in November 2019, backed by a £20m investment from Welsh Government, and is the first High Value Manufacturing (HVM) Catapult centre in Wales. AMRC Cymru operates a 2,000 square metre open access research area with Airbus, the first major tenant with a platform to develop their next generation wing technologies aligned to its Wing of Tomorrow programme.

In March 2020 AMRC Cymru was transformed into a production facility for life-saving medical ventilators by the industrial consortium VentilatorChallengeUK. In fewer than two weeks, the state-of-the-art research institute was stripped out to allow 88 operators to work simultaneously, while maintaining safe social distancing and allowing shift breaks and lunch times.

Mr Starmer added: "What we learnt from the VentilatorChallengeUK consortium was the adaptability of manufacturing to go from building wings of aeroplanes to ventilators in a matter of days.

"On top of that, thinking through the supply chains in the middle of a lockdown was quite incredible."

Andy Silcox, Research Director at AMRC Cymru, said: "That Sir Keir Starmer asked to see AMRC Cymru on his first visit to Wales as Labour leader shows the importance of advanced manufacturing and our facility to the area.

"It was great to showcase our work as part of the VentilatorChallengeUK consortium, but we also wanted to demonstrate how we can work with Welsh manufacturers to adopt innovative manufacturing technologies and help them reach new levels of productivity and sustainability.

"The Covid-19 pandemic has demonstrated how agile manufacturers need to be to adapt to changing market demands and AMRC Cymru has the Industry 4.0 technologies to make that possible."

Exciting future for AMRC Cymru as it marks first year

The University of Sheffield AMRC Cymru in Broughton is looking ahead to an exciting future, according to Minister for Economy and North Wales, Ken Skates, as it marked the first anniversary since it opened for business.

The state-of-the-art centre, which was fully funded with £20m from the Welsh Government and is managed by the University of Sheffield, focuses on advanced manufacturing sectors including aerospace, automotive, nuclear and food. It is predicted the new facility could increase GVA to the Welsh economy by as much as £4 billion over the next 20 years.

Last year, AMRC Cymru played a crucial role in the manufacture of ventilators in response to the Covid-19 pandemic. Airbus workers were redeployed as part of the VentilatorChallengeUK consortium of UK industrial, technology and engineering businesses, which produced 13,437 ventilators for the NHS in record time.

Engineers at AMRC Cymru have also worked with Food and Drink Wales to produce a guide for safe productive manufacturing during the pandemic for the food and drink industry, building on experiences gained during the ventilator production.

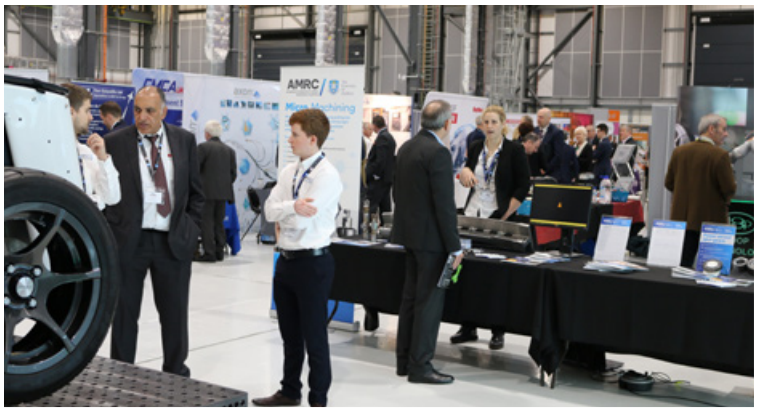
This year, AMRC Cymru will be establishing a Food and Drink Packaging Sustainability Centre in Broughton, following a grant award of £2m from the Welsh Government. As well as prototyping and providing functional test equipment for new packaging, the Centre will demonstrate the AMRC's capabilities in advanced automation, collaborative robotics and visualisation. It is also working with the Welsh Government innovation department on a number of pilot projects to introduce cutting edge technology into the manufacturing sector.

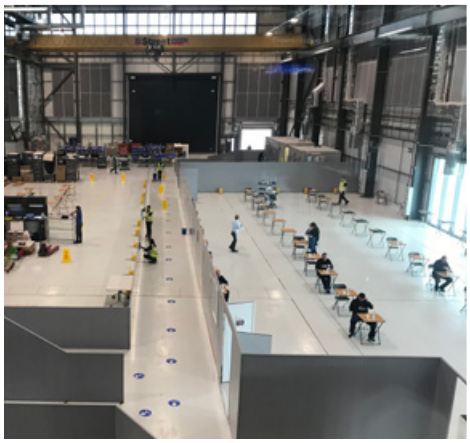
Welsh Government First Minister Mark Drakeford and Lord Barry Jones cut the ribbon to open the new facility in Broughton, Wales.

Airbus, AMRC Cymru's first anchor tenant, is continuing with the development of the Wing of Tomorrow programme at the centre, following the pause to produce the ventilators. Wing of Tomorrow is Airbus' largest research and technology programme taking place globally. It is a global partnership with the entire industry to develop and demonstrate the physical technology and digital capability needed to deliver the next generation of aircraft wing. In 2021, a major Wing of Tomorrow deliverable – to manufacture a 17 metre wing box demonstrator – will be realised.

Minister for Economy and North Wales Ken Skates said: "We funded this centre because we knew it could be a game changer for the region. In this unprecedented and difficult year, it rose to the challenge of rapidly manufacturing ventilators with its anchor tenant Airbus.

"This is a very challenging and difficult time for manufacturing. When I attended the official opening of AMRC Cymru a year ago we could not have foreseen what would have happened in 2020. But what is certain is that the establishment of AMRC Cymru gives hope and strength for the manufacturing sector in North





Clockwise, top left: Opening event exhibitions / Professor Koen Lamberts, President and Vice-Chancellor of the University of Sheffield speaks at opening event / AMRC Cymru in Broughton / Minister for Business and Industry, Nadhim Zahawi MP, tries out some of the technology on show at AMRC Cymru / Airbus employees using the Microsoft HoloLens kits on ventilator production lines set up at AMRC Cymru / Site operational during the pandemic.

Wales and further afield as it looks to the future.

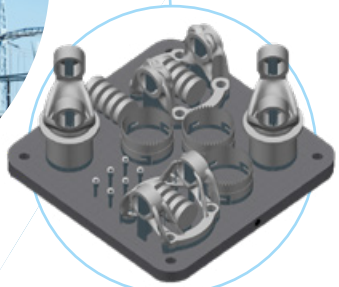
"I look forward to exciting developments here in the months and years to come which will help manufacturing recover from the significant effects of the pandemic."

Research Director at AMRC Cymru, Andy Silcox, said: "The entire team at AMRC Cymru was incredibly proud to be part of the national effort to produce life-saving ventilators, but our attention now is firmly back on helping manufacturers make step-changes in their manufacturing processes by de-risking innovation.

"The technologies we have at our disposal allowed us to pivot our operation to become a ventilator production facility and quickly adapt to a new way of working. Now we want to demonstrate to companies across Wales and cross-border how those same technologies can make a real impact on the way businesses operate."

Airbus Senior Vice President, Katherine Bennett, said: "Airbus was immensely proud to play its part in the VentilatorChallengeUK consortium that answered the government's call to produce 13,500 ventilators for the NHS in record time.

"It is testament to our talented employees at Broughton - with the help of colleagues at Siemens, Ford and McLaren - that they were able to use their engineering expertise to rise to this challenge. It is this expertise that will enable Airbus to succeed in its biggest research project - the Wing of Tomorrow - at this cutting-edge Welsh Government research facility in Broughton."



20 in 21

Supporting our partners to make things better

Are we planting the right seeds for both the future of UK manufacturing and our partners' needs?

The question, posed by the University of Sheffield AMRC CEO Steve Foxley at the start of the AMRC's Tech Fellows conference, has never been so relevant, writes Ben Morgan, AMRC Research Director.

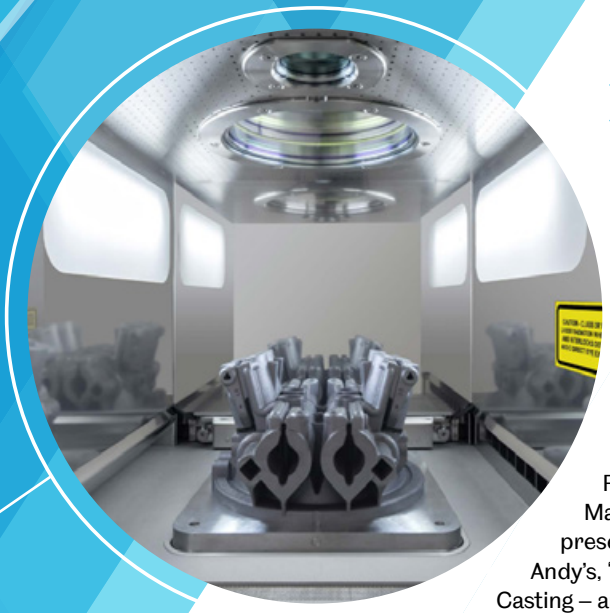
The impact of Covid-19 on the manufacturing sector is well documented and so the role of translational research centres like the AMRC are critical if we're to help our partners thrive in the months and years to come.

Traditionally, Tech Fellows is a highlight in our calendar. It is an opportunity for our partners to network and learn about our achievements of the last 12 months; but beyond that, it's our chance to demonstrate that we're putting our money where our mouth is. Although the virtual nature of last year's conference meant networking was off, I think our timetable of presentations proved how committed the entire organisation is to our key objectives of sustainability, levelling up, future propulsion, digital and supply chain resilience.

The AMRC's core competence has always been productivity. It is where we built all our strengths and will be key in building UK manufacturing to be competitive post-Covid. Now, as the net zero target gets closer, we are entering a period of more and more difficult choices, where productivity has to be thought of hand-in-hand with sustainability.

And for us, the two things don't have to compete against each other. What our engineers demonstrated during the two-day Tech Fellows was that by exploiting digital technologies and big data, we can meet the challenges of reuse, recycling and repurposing; all while ensuring that primary objective is always met: productivity.

And so to the presentations themselves, each one fascinating and relevant to our



objectives in their own way.

Dr Andy Bell, Design Strategy Manager in the Design and Prototyping Group, set the conference off on the ideal foot by explaining how the AMRC is creating an understanding of the new practices that we will need to deploy as sustainable manufacturers, such as how our designers will incorporate sustainability into their design philosophy and design choices.

As Andy said, our vision is to become a net zero facility – to be recognised for our climate stewardship and demonstrate how we do that to other people. We want to provide leadership to industry and government on net zero matters. Andy said it perfectly: 'We want to leave no trace'.

Principal Metallurgist Matthew Cawood's presentation immediately after Andy's, 'High Integrity Aluminium Casting – an opportunity for future platforms', embodied the translational work the AMRC is known for around the world by explaining the ways in which aerospace can learn from the automotive sector to make casting a much more reliable technology.

As I have said before, the AMRC's core objectives complement each other, so it was fantastic to see that first morning on sustainability, followed by an afternoon on productivity. Among so many other great speakers, Kieran Edge, Technical Lead for Machine Vision, passionately described how Factory 2050 is working hard to remain at the forefront of harnessing machine vision for new applications and delivering it into new industries; and the AMRC Composites Centre was extremely well-represented by Technical Lead, Jodie Turner, Research Fellow, Steffan Lea and Dry Fibre Development Manager, Dr Fatma Omrani with presentations on composite weaving, braiding technology and Tailored Fibre Placement (TFP).

As Professor Rab Scott, the AMRC's Head of Digital, said when opening day two of the conference: we want our strategic activities to mirror what is happening out in industry. When it comes to digital technologies, that means examining the potential applications of artificial intelligence (AI) in the cloud, digital twin and smart factories. Those topics and much, much more were covered as our attention turned to digital.

Indeed, it was interesting to hear from James Hunt, Head of Additive Manufacturing (AM) Strategy, at the end of the conference on the important part AM has to play within Industry 4.0. James showed how AI, computer vision, machine learning and cobots can all be applied to the post-processing stage of AM. As we see so often, the digital thread weaves its way throughout the AMRC.

What I hope our partners took from Tech Fellows this time around is that, despite the pandemic, the AMRC is still working very hard to drive innovation and support our customers to make things better. Our key themes of the conference - sustainability, productivity and digital - are important to us because they are important to our partners and UK manufacturing as a whole.

While part of Tech Fellows was about putting to one side the immediate challenges of Covid-19 and looking to the future, it was also about embracing the situation we are in. As I see it, while there is a lot of uncertainty in the world, there are a lot of opportunities as well and we need to work closely together through true collaboration to realise that.

It is an incredibly exciting time for the AMRC, as we move into the Chapter 2 strategy Steve introduced at the beginning of the conference, and to paraphrase the Ancient Chinese proverb Rab so brilliantly referenced: the best time to work with the AMRC was several years ago, but the second-best time is now.

A safer and sustainable path to better coolant use and management

The role of soluble coolant in machining processes is often overlooked, but the cost and impacts of use on health, productivity, and the environment are far-reaching writes Dr Claire Jeavons of Fluid Maintenance Solutions.

Traditionally, coolant checks are left to the supplier who typically undertakes weekly, monthly or ad-hoc periodic inspections to assess the condition of the coolant and record pH and concentration readings, amongst other things.

However, the longer the time between 'sump dumps', the greater the ratio of contamination in the coolant.

Tramp oils can be removed but how effectively is the 'skimmer' deployed?

Not only does the health risk increase, but also the risk to productivity. For example, component surface finish defects from fines within the coolant returned to the cut may occur and ultimately cause environmental impacts through hazardous waste disposal. Generally, coolants are disposed of too early or far too late and the disposal is usually because of the 'smell' and not because the chemistry has failed.

Setting aside the chemistry of the coolant, marginal gains can be made by

improving on the traditional approach to coolant condition monitoring and management.

According to Dr Andy Bell, Design Strategy Manager at the University of Sheffield AMRC, approximately 80 per cent of all energy used by manufacturing processes is consumed by non-productive operations.

"The management of cutting fluids is a significant contributor to this non-productive energy use, requiring constant circulation, filtration, chilling, and ultimately disposal," said Dr Bell. "Through improved maintenance and understanding of the role of the cutting fluid, we can keep cutting fluids in operation for longer and optimise the circulation and chilling systems, ultimately leading to improved energy consumption in the overall process."

Three steps can be taken to improve the sustainable use of soluble coolants: integrating digital technologies, reducing waste and non-value-added activities; and better training and knowledge sharing.

Let's look at the first - the integration of digital technologies.

In an antiquated industry, the addition of digital technologies to interconnect the sub-systems on modern machining platforms (i.e. conveyor tank, filter system, pumps, chiller & LEV, etc) creates the coolant ecosystem; combining low cost Industrial Internet of Things (IIOT) technologies with multiple sensors to connect to the cloud to deliver specific condition monitoring solutions.

BEIcLEAN - which stands for Back End Integration, Clean and Lean, pronounced 'Be Clean' - is one solution our company Fluid Maintenance Solutions has developed to improve operator engagement and create a robust and reliable digital coolant condition monitoring and reporting platform.

A key benefit of the solution is to enable smaller and medium-sized enterprises (SMEs) to adopt and deploy digital technology to multiple machine tools.

Proof of concept trials of BEIcLEAN were completed at the University of Sheffield AMRC with ongoing work analysing data from Carbon Fibre Reinforced Polymer (CFRP) machining. This is particularly interesting given the lack of insight into long-term health impacts from wet machining of such materials.

A known but overlooked issue with coolant use is the number of 'gases' generated from bacterial growth in coolants.

The 'Monday morning' rotten egg smell is Hydrogen Sulphide and may be noticeable from a concentration as low as 0.5 parts per billion. Asthmatics could be affected by concentrations as low as two parts per million. One problem with this gas is that operators may become 'nose-blind' and be oblivious to continual exposure.

From the Operator Environment Module, which contains a number of digital sensors to monitor the area outside the machine door where the operator may be exposed to hazards, the monitoring of a number of gases as well as temperature, humidity, noise and particulates can be analysed to determine risk to operators and maintenance staff.

An example of how the ecosystem can be connected is by interrogating the door opening relative to the Local Exhaust Ventilation running - is the door being opened prematurely to 'do the job quicker' but risking mist and particulate exposure?

Further collaboration with the University of Sheffield AMRC, utilising the Smart Factory Innovation Hub test bed, will develop BEIcLEAN further, for example integrating energy harvesting to boost the battery powered modules.

Now let's look at reducing waste and non-value-added activities.

Typically, seven to 20% of production costs could be related to coolant activities, many of them non-value-added. A step towards sustainability is to identify the opportunities and implement new procedures to reduce costs relating to the traditional use and impact of coolant.

By reviewing current state activities, from the simple analysis of how coolant is prepared and dispensed on the shopfloor to evaluating the true cost of coolant, greater value may be created through developing a future state plan.

An example of this is how a Tier 2 automotive supplier may divert ~350 metric tonnes of grinding swarf, annually sent to hazardous landfill, into a recyclable product to be reused for automotive transport applications.

Attention must also be given to better training and knowledge sharing. Given there are cases of prosecutions and employees being compensated for health impacts relating to coolant use, building from the ground up with better training should be the start of a sustainable journey.

The Health & Safety Executive is concerned by poor coolant conditions impacting on the health of employees, especially with regards to SMEs. New insights are demonstrating that the traditional approach to coolant management needs to improve to reduce risk and create a safer working environment.

By improving the practical knowledge base of operators and maintenance staff, then greater understanding of the risks and impacts of coolant use will be realised.

Fluid Maintenance Solutions is a Tier 2 partner of the University of Sheffield AMRC. Its primary focus is to improve the sustainable use of coolants used in machining platforms, creating a cleaner, leaner, safer and smarter environment.

Operator Environment Module in the BEIcLEAN range.

Getting fit for net zero

Ben Morgan,
AMRC Research Director

Fit 4 Net Zero is being launched by the University of Sheffield AMRC and Nuclear AMRC to help UK manufacturers get ready to bid for work in the emerging net zero supply chain. The first task will be to support the Zero Carbon Humber project, a £75m bid to create the world's first carbon neutral industrial cluster by 2040.

AMRC Research Director Ben Morgan speaks to the Journal's Katia Harston to explain more.

As the world looks to recover from the impact of coronavirus on lives, livelihoods and economies, the UK government has set out its approach to 'build back better', publishing its Ten Point Plan for a Green Industrial Revolution to invest in making the UK a global leader in green technologies, support green jobs and accelerate the path to net zero - putting the country at the forefront of clean, green technology.

Central to the plan is a commitment to driving the growth of low carbon hydrogen and investing in Carbon Capture, Usage and Storage (CCUS) industries by creating zero carbon industrial clusters. Government has outlined plans for two to be built in the UK within five years, one in 2025 and another by 2030; placing the concept at the heart of net zero transition.

Enter Zero Carbon Humber: a consortium of leading energy and industrial companies with a shared vision to transform the Humber region into the UK's first net-zero carbon cluster by 2040.

Their ambitions couldn't be more timely.

Together Drax, Equinor, National Grid, SSE Thermal, Associated British Ports, British Steel, Centrica, Mitsubishi Power, PX Group, Triton Power, Uniper and the University of Sheffield AMRC are working to deliver essential CCUS and hydrogen infrastructure that will enable large-scale decarbonisation across the country's most carbon intensive region - the Humber Estuary.

"Without a complete decarbonisation of heavy industry, we can't achieve net zero emissions targets, neither here in the UK or globally," says Ben Morgan, Research Director at the University of Sheffield AMRC.

"Our role in Zero Carbon Humber will be to model the wider economic and supply chain opportunities in the UK provided by these new technologies. We're going to work alongside the project to really galvanise the UK supply chain to make sure the UK is in a position to take as much advantage of these new markets as possible.

Image: Zero Carbon Humber Partnership.

Image: Drax

"Fundamental to the programme is engaging businesses and we're going to do that through a brand new programme we're launching called Fit 4 Net Zero. This will develop and highlight to businesses potential new contracts in this nascent market.

"Fit 4 Net Zero will build on a tried and tested model for the nuclear industry that our sister centre, Nuclear AMRC, has delivered successfully for the last six years called Fit 4 Nuclear. Over that time businesses they have engaged with have delivered about £1.9bn of new contracts and created almost 8,500 jobs.

"This is a fantastic opportunity and our role is to help the UK's supply chain, maximise the impact for them and as a result become more competitive and create more jobs."

As the Committee on Climate Change (CCC) has made clear, decarbonising industry is not just an option, it is a necessity if the UK is to reach its goal of achieving net zero greenhouse gas emissions while delivering economic growth. Zero Carbon Humber believes the Humber Estuary and surrounding regions offer the opportunity to deliver the UK's first zero carbon cluster and help position the North of England at the heart of the global energy revolution.

Zero Carbon Humber knows its ambition is big, but says the potential is bigger: helping the UK achieve a net zero carbon economy by 2050. It has submitted a £75m public/private sector bid for funding from Phase 2 of the government's Industrial Decarbonisation Challenge, part of the Industrial Strategy Challenge Fund, with significant investment also coming from the companies within the partnership.

Morgan said: "The objective for the AMRC is primarily to secure new manufacturing work, anchoring it in the UK. If British companies can secure these high-value, world-first opportunities, it will drive innovation through the supply chain and enable this sector to thrive going forward.

Our role in Zero Carbon Humber will be to model the wider economic and supply chain opportunities in the UK provided by these new technologies

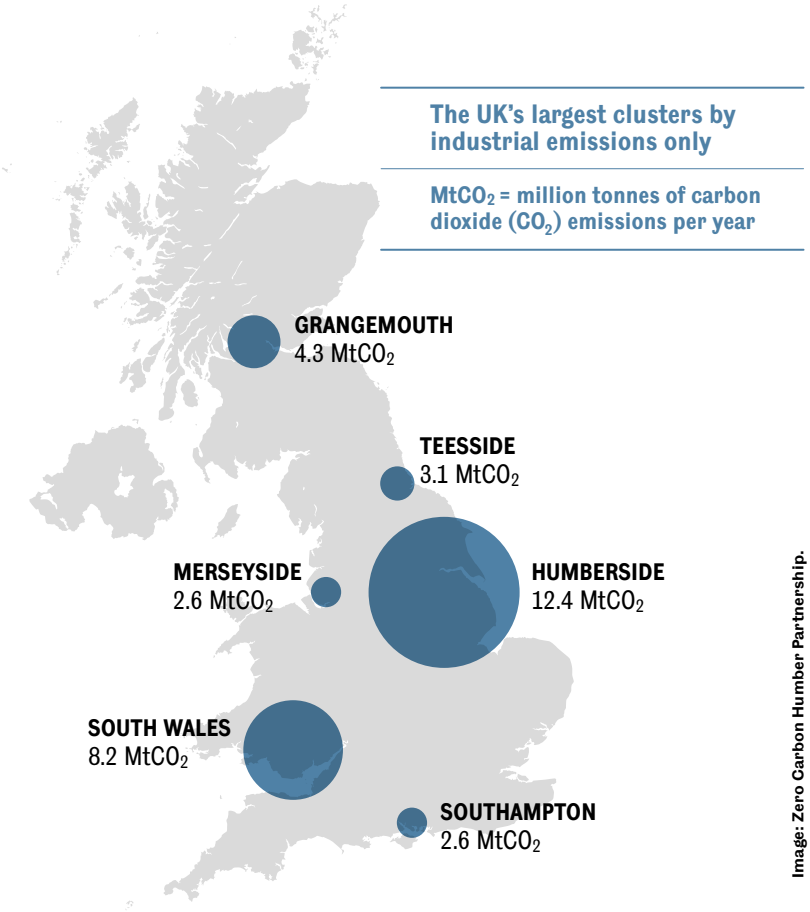


Image: Zero Carbon Humber Partnership.

The British Steel plant at Scunthorpe.

"Really, as an offshoot of that, we have an opportunity to create an exportable business that can benefit the UK economy.

"Initially, we will look at the infrastructure, look at the components and run an engineering analysis to identify maximum value components and concurrently we will be mapping the UK supply chain, concentrating on businesses that have potential to deliver the objectives of Zero Carbon Humber and broader opportunities in the UK.

"Parallel to that we will be developing codes and standards with regulatory bodies. The AMRC will work with regulatory bodies to understand the codes and the standards that operators and suppliers will need to achieve in order to feed into the ultimate solution and that is where the Fit 4 Net Zero programme will come into its own, which is about getting those businesses fit to compete for contracts in the emerging markets around net zero."

> We de-risk technology and drive innovation into industry

Morgan says there is a clear need to 'raise all the bows simultaneously' if the project is to deliver on skills and job creation. He added: "We can work on the demand and development of the supply chain but clearly we need the skills at the same time. This is part of a further programme of work needed to understand from business some of the skills that they will need; whether that's CPD to support skills training or apprenticeships to bring young talent in and develop the business."

He also sees wider benefits and impact for the region, with a huge opportunity for SMEs to get involved in Zero Carbon Humber and the wider net zero agenda.

"The AMRC is good at connecting large companies to smaller businesses so they can work together. When we've held large partner and supplier events previously, we've had upwards of 250 local businesses, many of them SMEs, come in and hear from large businesses what's needed for a new facility or a new manufacturing supply chain. A great example of this is with Boeing and McLaren in Sheffield and Rotherham - many of their suppliers are local businesses, or local SMEs, and that has developed job creation, skills and wealth for the region. I would see that being replicated on the Humber."

He also believes there is a path to significant cost reduction from CCUS and hydrogen technologies that, over time, can be developed at scale and be made more competitive. He said the AMRC has a proven track record of working with businesses to sharpen their competitive edge.

"We de-risk technology and drive innovation into industry and try to make industry more globally competitive. It is through driving innovation, digitalisation, new methods and processes and employing state-of-the-art technology that shows the UK, when we apply ourselves, can do this and maintain our position at the forefront of the climate change challenge."

Image: Zero Carbon Humber Partnership.

Zero Carbon Humber Partnership submits £75m bid to advance

UK's first net zero industrial cluster

The University of Sheffield Advanced Manufacturing Research Centre (AMRC) together with 11 leading companies and organisations across the Humber have jointly submitted a public and private sector funded bid worth around £75 million to accelerate decarbonisation in the UK's most carbon intensive industrial region, helping to support clean growth, future-proof vital industries and protect and create new jobs.

The Zero Carbon Humber (ZCH) Partnership brings together international energy companies, heavy industry, leading infrastructure and logistics operators, global engineering firms and academic institutions in a plan to create the world's first net zero industrial cluster by 2040 through low carbon hydrogen, carbon capture and negative emissions, known as carbon removal technology.

The scheme is enabled by shared infrastructure that includes a pipeline network to carry hydrogen to industrial customers and carbon dioxide from power generation and industrial emitters to permanent storage in an offshore aquifer below the seabed in the UK's Southern North Sea.

Zero Carbon Humber could reduce the UK's annual emissions by 15 per cent and save industry around £27.5 billion in carbon taxes by 2040. It will also help to secure the future for the Humber's traditional heavy industry and related supply chains by enabling decarbonisation and creating opportunities for growth in new technologies. It could safeguard 55,000 existing jobs in the region, whilst creating thousands of new STEM roles and developing skills, apprenticeships and educational opportunities in the area.

The ZCH Partnership includes Associated British Ports, British Steel,

Centrica Storage Ltd, Drax Group, Equinor, Mitsubishi Power, National Grid Ventures, px Group, SSE Thermal, Saltend Cogeneration Company Limited, Uniper, and the University of Sheffield Advanced Manufacturing Research Centre (AMRC).

Ben Morgan, Research Director of University of Sheffield AMRC, said: "We are excited to be part of the Zero Carbon Humber project. Bound by a common objective of reducing carbon emissions across Yorkshire and the Humber, we bring to the project a wealth of experience in advanced manufacturing innovation and supply chain development.

"As part of the High Value Manufacturing (HVM) Catapult, we have strong partner networks and proven supplier engagement models which will enable the ZCH project to anchor large sections of this nascent industry supply chain in the UK. This in turn will provide long term sustainable wealth and support levelling up of the UK economy."

The ZCH Partnership has applied for funding from Phase 2 of the Industrial Decarbonisation Challenge, which forms part of the Industrial Strategy Challenge Fund, with significant investment also coming from the companies within the ZCH Partnership. The bid builds on the Humber's successful application for Phase 1 funding, which was announced in April.

The bid's anchor project is the Equinor-led Hydrogen to Humber (H2H) Saltend project, which will establish the world's largest hydrogen production plant with carbon capture at px Group's Saltend Chemicals Park. H2H Saltend will convert natural gas to hydrogen and capture the carbon dioxide (CO2). In the first phase, this could reduce emissions by circa 900,000 tonnes per year as industrial customers switch fuel to low-carbon hydrogen and Triton Power's gas power plant blends hydrogen into the fuel supply via its upgraded Mitsubishi turbines. H2H Saltend is expected to grow over time, contributing to further emissions reductions from the Chemicals Park and across the Humber.

A pipeline network, developed by National Grid Ventures, will link H2H Saltend to energy-intensive industrial sites throughout the region, enabling further decarbonisation as additional businesses switch to low carbon hydrogen and capture their CO2 emissions. The CO2 will be compressed at Centrica Storage's Easington site and stored under the Southern North Sea using offshore infrastructure shared with the Teesside industrial cluster.

The bid for matched funding covers obtaining land rights, development consents and front-end engineering design for H2H Saltend and the onshore pipeline infrastructure for CO2 and hydrogen, enabling the scheme to move towards a final investment decision on construction during 2023, with H2H Saltend and associated infrastructure expected to come online around 2026.

At Selby in North Yorkshire, Drax Power Station would connect to the completed CO2 pipeline network, underpinning the ZCH scheme with bioenergy with carbon capture and storage (BECCS) – a vital negative emissions technology that Drax is pioneering and which will be essential to decarbonising the Humber Cluster and helping the UK achieve its legally binding 2050 net zero carbon target.

The pipeline network will also run via SSE Thermal's Keadby site, where it is developing Keadby 3. This could become the UK's first gas-fired power station equipped with carbon capture technology by the mid-2020s, providing decarbonised flexible power to complement intermittent renewables generation and maintain security of supply. The network will also run via Immingham, where Uniper is planning to add to its European hydrogen ambitions by developing clean hydrogen production at its Killingholme site, in line with Uniper's pledge to be carbon neutral in Europe by 2035.

As one of the UK's leading steel manufacturers, and a significant local employer, British Steel could benefit from the ZCH infrastructure as part of its drive to lower emissions. ABP, the major ports and logistics provider for the region, will support the global reach of the low carbon products and chemicals produced at Scunthorpe and at Saltend.

The ZCH projects are supported by the University of Sheffield's Advanced Manufacturing Research Centre, which models the wider economic and supply chain opportunities in the UK provided by these new technologies.

In addition to the key sites that are part of the ZCH scheme, there is further potential for other future projects to attract inward investment and cement the Humber's reputation as the UK's Energy Estuary and a world-leading net zero region. These include integrating offshore wind power into hydrogen production, decarbonising the regional gas grid, supplying hydrogen transport fuelling hubs, providing CO2 storage services to other industrial clusters and creating the world's first sustainable maritime refuelling port.

Please view the project website at **zerocarbonhumber.co.uk**

THE STRATEGIC IMPORTANCE OF THE HUMBER TO THE UK ECONOMY

South Yorkshire

has the largest concentration of steel conversion companies and precision forgers in the UK.

The region contributes

£18bn

towards the UK economy each year, driven largely by its deep expertise in industrial processes such as refining, **petrochemicals and manufacturing**

The steel industry employs

10,000 people

with an average wage of **£35,000**

The Humber's chemical sector includes around **100 chemical and refining companies** whom employ approximately

6,000 people

and generate a combined annual turnover of **£6bn.** This accounts for **12% of the UK chemicals employment,** second only to North-West England.

The Humber Ports (Grimsby, Goole, Hull, Immingham) together handle more than

77 million

tonnes of cargo annually

(worth approximately £75bn), supporting over 33,000 jobs in the region and contributing £2.5bn to the UK economy.

Overall, there are approximately

29,000 businesses

in the region providing over 400,000 jobs for the local area.

The Humber is home to several power stations and **two** of the UK's **six** major oil refineries providing

27% of the UK's oil refinery production

19,000 people

are employed in the energy sector, **5%** of employment in the region.

55,000

people are employed in manufacturing and engineering, **15%** of employment in the region.

The region has over **20+** onshore windfarms, which alone provide power for over **200,000** UK homes and provides access to over **400 offshore wind turbines.** It currently deploys **1.87GW of power** with a further 11GW to be commissioned by 2030, **85% of the UK's planned development**

Image: Zero Carbon Humber Partnership 'Capture for Growth' report.

Driving sustainability in manufacturing

"Don't think of Project ELLI as a vehicle," says James Lindsay, Project Engineer at the AMRC's Factory 2050 and who is leading the programme. "It is a complex assembly demonstrator which displays the AMRC's world-class capabilities in mid-technology readiness level (TRL) research across multiple sectors and capabilities.

"ELLI is an example of how advanced technologies, such as electrification and lightweighting, can improve in-service efficiency, and that achieving sustainability doesn't have to cost lots of money; in fact, it can save you money.

"It just happens to be centred around a Caterham sports car."

There is, however, no doubt that the Caterham 7 racing car is a huge part of Project ELLI's kerbside appeal.

That was certainly the case at MACH 2018, the Manufacturing Technologies Association's (MTA) biennial five-day exhibition attracting 600 exhibitors and more than 25,000 visitors. Then, manufacturers were drawn to the AMRC's Project RAID (Reconfigurable Assembly Integrated Demonstrator) and its twin attractions of the Caterham and the retrofitted 1956 Colchester Bantam Lathe.

Indeed, hundreds of visitors to Factory 2050 in Sheffield – from government ministers to schoolchildren - have gravitated to the car ever since to see it demonstrate the latest in digital and intelligent assisted technologies.

Now though, Project RAID has evolved into something much more: Electrification and Lightweighting in Industry 4.0. Or Project ELLI for short, standing proudly on display in a new cell

AMRC engineers James Lindsay, Dan Smith, Stephen Bowles, Abdul Haque and Oliver Jackson, all of whom worked on Project ELLI.

at Factory 2050.

"Our goal with Project RAID was to demonstrate how Industry 4.0 could assist in manufacturing assembly; essentially improving how the product is put together," said James. "ELLI builds on that by exploring what we could do to develop the final product itself. We asked ourselves: can we improve the product so those instructions we were using can be better utilised?"

ELLI encompasses the strengths and skills of five different AMRC capabilities: lightweighting, battery pack assembly, automation, additive manufacturing and advanced machining - each having demonstrated the advanced manufacturing capability showcased on the ELLI demonstrator.

"ELLI is the AMRC in one demonstrator: different teams, groups and geographical sites working together to achieve a common goal, and it has been so much fun," added James.

ELLI's road to going on display in Factory 2050 has been far from smooth however. Originally planned to be the AMRC's centrepiece at MACH 2020, which was postponed until January 2021 before being finally cancelled, James says it would not have been fair to keep it under wraps until the next MACH exhibition in 2022.

"It's a real shame that MACH hasn't gone ahead as the week at the NEC in Birmingham is much more than just a trade show to us, it's a chance to see the best of advanced manufacturing technology under one roof. We decided to demonstrate ELLI at Factory 2050 instead to offer anyone interested the chance to catch a glimpse of the demonstration."

So where does a team of research engineers begin to further develop designer Colin Chapman's 'lighter, simpler' classic sports car?

Firstly, with the engine.

The Caterham's 1.6L Ford Sigma petrol engine has been replaced with an electric motor, supplied by AMRC member Siemens, turning the car into an electric vehicle. But the electrification of Project ELLI doesn't stop there, the innovation has been continued at AMRC North West in Preston with its intelligent Battery Pack Assembly Workbench.

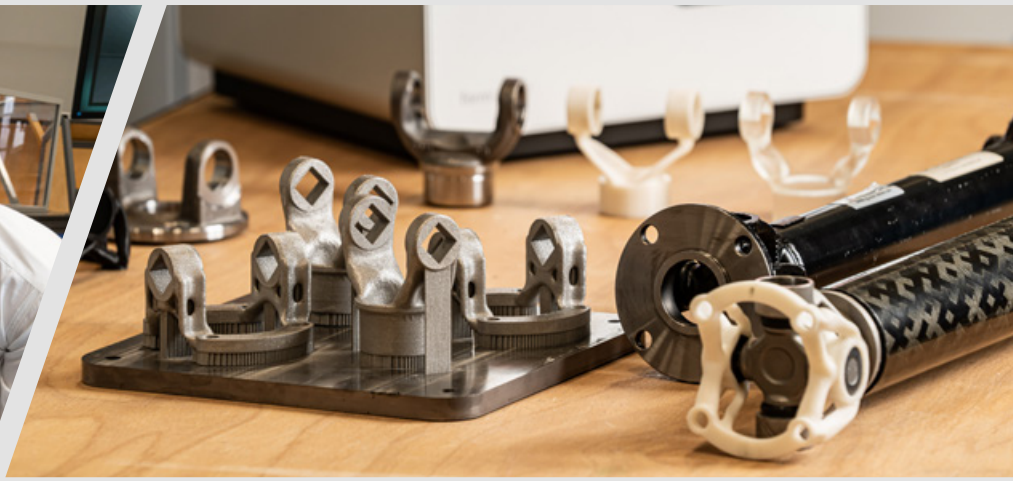
Richard Heggie, Technical Fellow in Battery and Electrification at AMRC North West, said: "We have developed a flexible battery module and pack assembly capability, embedded with the capture of process data for key attributes to generate a digital twin of the pack.

"Knowledge of the electrical characteristics of individual cells and joints within the pack enables highly accurate modelling of pack status and health, leading to safer and effective use of battery packs."

Dr Aparajithan Sivanathan, who has led the software development of the Battery Pack Assembly Workbench at AMRC North West, added: "Our team has developed a binary-based ultra-lightweight communication protocol for connecting various circuits, computational modules and digital twins with low latency. This protocol is specifically designed for real-time high bandwidth data transfer, for example coupling physical battery packs with their digital counterparts."

With the new electric motor installed, itself lighter than the petrol engine predecessor by 31kg, AMRC engineers then began investigating how else the Caterham could be made even lighter than Chapman's original design with

A team at the AMRC's Factory of the Future investigated nested pocketing machining methodologies as part of Project ELLI.



Left: James Lindsay uses a smart tool to assemble the Caterham racing car. Right: The Constant Velocity (CV) joints were topologically optimised and additively manufactured.

potential for improvement identified by the AMRC Composite Centre and additive manufacturing (AM) teams on the car's drive shaft and Constant Velocity (CV) joints.

For the former, composite engineers achieved a 60 per cent reduction in weight by replacing the current steel component with a carbon fibre composite member. Advanced robotic filament winding technology was used to create an optimised carbon fibre tube and CV joints were bonded onto the ends of the tube to form a hybrid drive shaft.

The CV joints themselves, traditionally cast in steel and then machine finished, were topologically optimised through a generative design process to remove material from non-critical regions of the geometry but to still conform to the performance requirements of the design. AM allowed the material to be placed precisely where it was needed to support critical load paths and a Laser Powder Bed Fusion (LPBF) process called Selective Laser Melting (SLM) was chosen to print the optimised components.

The result: another 60 per cent weight reduction when compared to the original assembly, and maximising material utilisation.

But, as James said, Project ELLI is more than just the Caterham 7 sports car.

"From the start, Project ELLI was about displaying the very best capabilities of the AMRC. We have drawn on learnings from aerospace and our experience in machining to tie in so many aspects of advanced engineering. That's why what is on display outside of the Caterham is as important as the work we have done under the chassis," said James.

The novel machining work from the AMRC's Factory of the Future, led by Technical Fellow in the Structures Team, Dan Smith, has investigated nested pocketing machining methodologies as part of Project ELLI, comparing the machinability of varying shapes and wall thicknesses. Specifically, the project compared the achieved level of conformity of extremely thin walls (less than 3 mm) with that which is currently accomplished for standard walls of 3 mm thickness and above for aerostructures.

"With the goal of net zero, it is expected that electrification will be at the forefront of future propulsion, and with this technology will come greater emphasis on the weight of component parts," said Dan.

"With ELLI, we are demonstrating translational research from aerospace where, to assist the net zero goal, lightweighting projects will undoubtedly involve the radical redesign of aerostructure components to reduce their mass. To lightweight an aerostructure today, it is felt that simply thinning the existing structure down would be the least turbulent technology for aerostructure developers to deploy. However, it is understood that to maintain the original design intent of structural components, simply thinning them down will only go so far to meeting Aerospace Technology Institute (ATI) goals before more radical approaches are required."

The Project ELLI cell also displays the AMRC's work on the 'Full Monty' project, based around a 15-year-old Cincinnati H5-800 machining centre in the Factory of the Future facility, which was one of the first five-axis platforms owned by the AMRC. The machine tool's electrical and mechanical systems have been completely refurbished, ensuring it is Industry 4.0-ready, has sensing capabilities beyond any other platform available at the AMRC, and is, mechanically, brand new. But at a fraction of the price.

Technical Fellow for the Process Monitoring and Control Team, Jon Stammers, added: "Over 75 sensing devices have been installed including ambient monitoring, industry-leading spindle monitoring and integrated with AMRC technology.

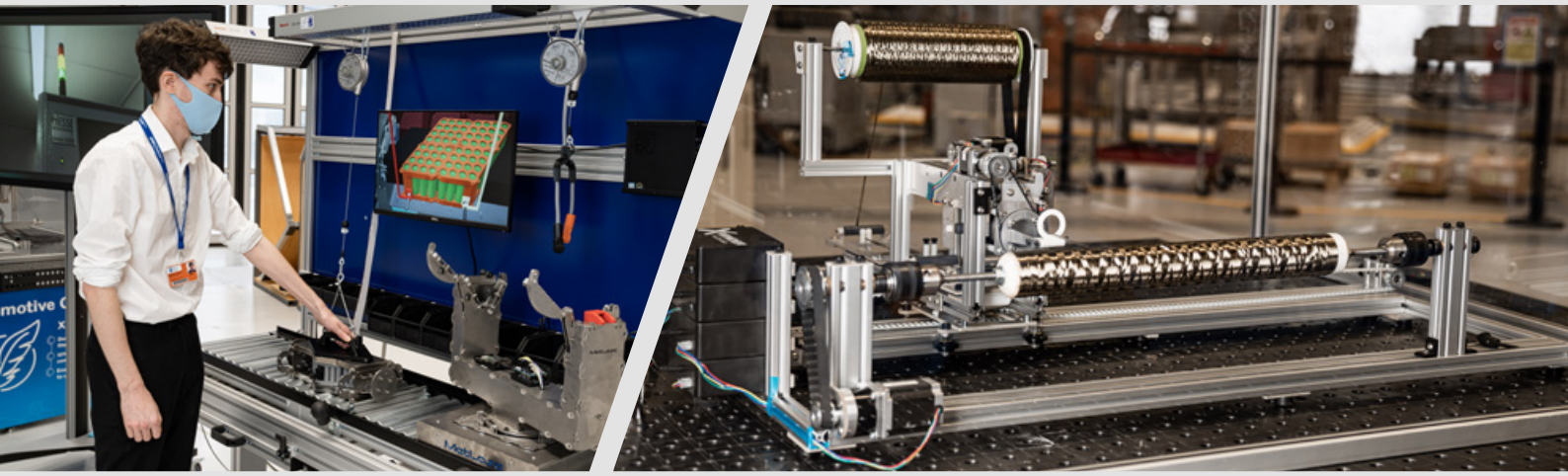
"Sustainability of machining has been achieved through improved processes, leading to lower energy use and less waste. Additionally, we have superior sustainability in the machine tool with predictive maintenance reducing energy consumption and better servitisation meaning parts are used more effectively. Repairing and upgrading the Cincinnati H5-800 has extended its useful life, which is far more sustainable than scrapping it off and investing in a new machine."

As James said: improving sustainability doesn't have to cost lots of money.

A huge part of Project ELLI is to demonstrate the importance of Industry 4.0 to sustainable and productive manufacturing. That concept is exhibited through Model Based Enterprise (MBE) digitally connecting design, manufacture and inspection using a 3D model.

Technical Lead, Stephen Bowles, said the MBE display proves that by using a digital thread to unify the manufacturing process and using a 3D model as a 'single source of truth', improvements in terms of time, quality and cost can be attained.

"By updating this model in real time with



Left: Oliver Jackson, part of the AMRC NW team, at the intelligent Battery Pack Assembly Workbench. Right: A carbon fibre drive shaft was manufactured using advanced robotic filament winding technology.

all design changes, inspection reports and other relevant information, all stakeholders have immediate access to the latest part production information. The AMRC is investigating the best methods for MBE implementation across the supply chain, into both new and legacy production lines."

So there it is: Electrification, Lightweighting and Industry 4.0 in one assembly demonstrator.

"Project ELLI really is the best capabilities from across the AMRC. It illustrates that different facilities and different teams with separate skill sets can collaborate on a combined vision, which is improving the efficiency of manufacturing and the in-service performance of the product," said James.

"Whether it is maximising material utilisation in redesigning the Caterham's drive shaft, or the 'Full Monty' project proving how energy use can be reduced in the manufacturing process, we want people to look at ELLI and see the possibilities.

"At the AMRC, we have the ability to do the de-risking for manufacturers, to lower that initial investment cost and to ultimately encourage our partners to view improving the sustainability of manufacturing like we do: something that doesn't cost lots of money but can lead to significant time and cost savings."

But it is also true to say that, like Colin Chapman's very first sports car design, such is the scope of what Project ELLI displays, different people take from it different impacts depending on their own passion.

For Professor Rab Scott, the AMRC's Head of Digital, ELLI highlights the potential of digital technologies to the manufacturing sector: "At MACH 2018 we demonstrated that Industry 4.0 didn't have to be scary or expensive, and that getting started on the industrial digitalisation journey could be relatively easy.

"Since then, the world has moved on in so many ways and yet one of the things that hasn't moved as fast as others is the rate of industrial digitalisation within the UK. The Made Smarter Review of 2017 is still as relevant, if not more so, in today's post-Covid-19 climate and digitalisation will really be a game changer for UK manufacturing.

"To paraphrase an old Chinese proverb: while the best time to start your digitalisation journey was last year, the second-best time to start on that journey is now."

Stuart Dawson, the AMRC's Chief Technology Officer, says Project ELLI is a demonstration of some of the AMRC's key capabilities in electrification, but by no means the extent of it.

"The AMRC has an important role in the Future Electrical Machines Manufacturing (FEMM) Hub which is exploring the flexible automated assembly of electric machines and the safe assembly of high-voltage battery packs – work that is truly cutting-edge for high-performance, high integrity and low-volume applications," said Stuart.

"The government has set an ambitious target of net zero carbon emissions by 2050 and is banning non-electric cars by 2030. It is likely that within 20 years, all new land-based transport will be electric – whether that's battery electric, hydrogen fuel cell or hybrid electric. With that in mind, future propulsion is a core theme of the AMRC's strategy which will provide industry with globally competitive manufacturing solutions for battery pack assembly, hydrogen fuel cells and electric machines."

Clara Frias, Head of the AMRC Composite Centre, said, crucially, the carbon fibre drive shaft developed by engineers doesn't compromise performance and offers improved durability because carbon composite materials can be more resistant to fatigue.

Clara said: "The global automotive and aerospace industries continue to face significant challenges in meeting the future needs of the mobility sector such as improved fuel efficiency, reduced emissions, electrification of powertrain, autonomous driving and connectivity.

"For the automotive industry, one of the biggest opportunities in rising to these challenges comes through the selection of the right materials in the right places within the vehicles. High-performance textile technologies such as weaving, stitching and braiding, aligned with automation, will play an important role in enabling industry to tackle one of the biggest barriers to greater adoption of lightweight composite materials in the automotive and aerospace sectors: cost."

What will we see at MACH 2022 then? According to James, not the Project ELLI we see today.

"The Caterham as a demonstrator has changed a lot since MACH 2018 and it will evolve again in the next year. For us, ELLI is the first step of what is possible, not the final product; I want to really push the boundaries of what we can achieve in additive manufacturing, composite manufacturing and lightweight machining.

"We, as engineers and innovators at the AMRC, want to take risks. We don't always get it right, but failure leads to learning and only by taking a risky approach to our research will we be able to push the boundaries of manufacturing."

Rail maintenance on track for digital transformation

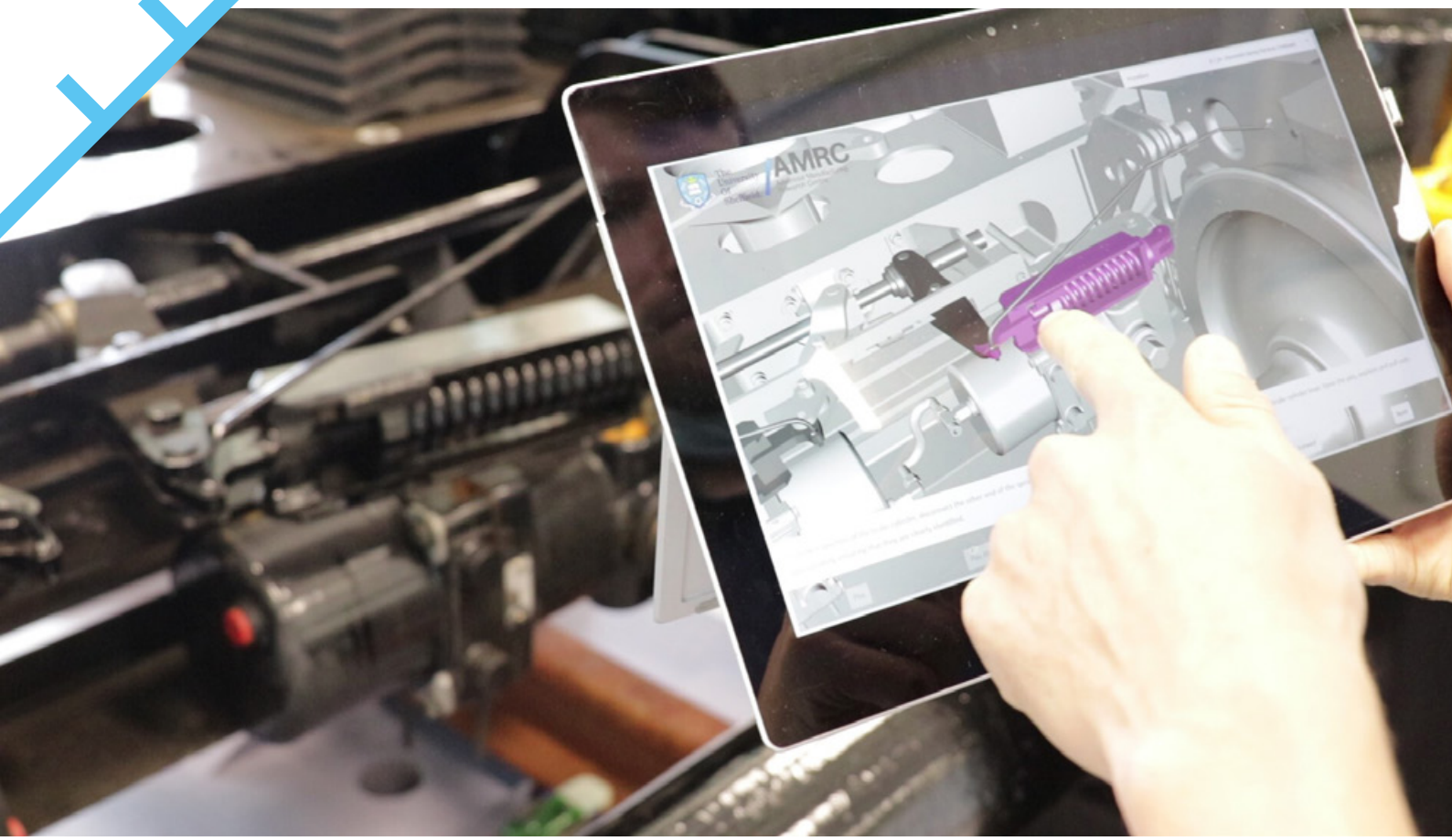
By Katia Harston

A powerful suite of smart technologies is harnessed to rail maintenance innovations in a new lighthouse demonstrator at the AMRC to drive digital transformation of the rail sector and deliver operational gains.

The Maintenance 4.0 cell is being developed by engineers at the University of Sheffield Advanced Manufacturing Research Centre (AMRC) at its Factory 2050 facility to shine a light on the range of growing Industry 4.0 technology solutions that can unlock productivity, quality and sustainability improvements for maintenance activities in rail.

Horizontal innovation shows the art of the possible for rail Maintenance, Repair and Overhaul (MRO), by bringing AMRC knowledge and expertise learned from aerospace and automotive and applying it to rail. The goal is to inspire visitors and to demonstrate how these technologies can deliver operational

Richard Gardiner, AMRC rail sector lead, and the Maintenance 4.0 demonstrator at the University of Sheffield AMRC.



Augmented reality is one of the technologies deployed in the demonstrator to drive up digital capabilities for the rail maintenance sector.

gains across rail MRO.

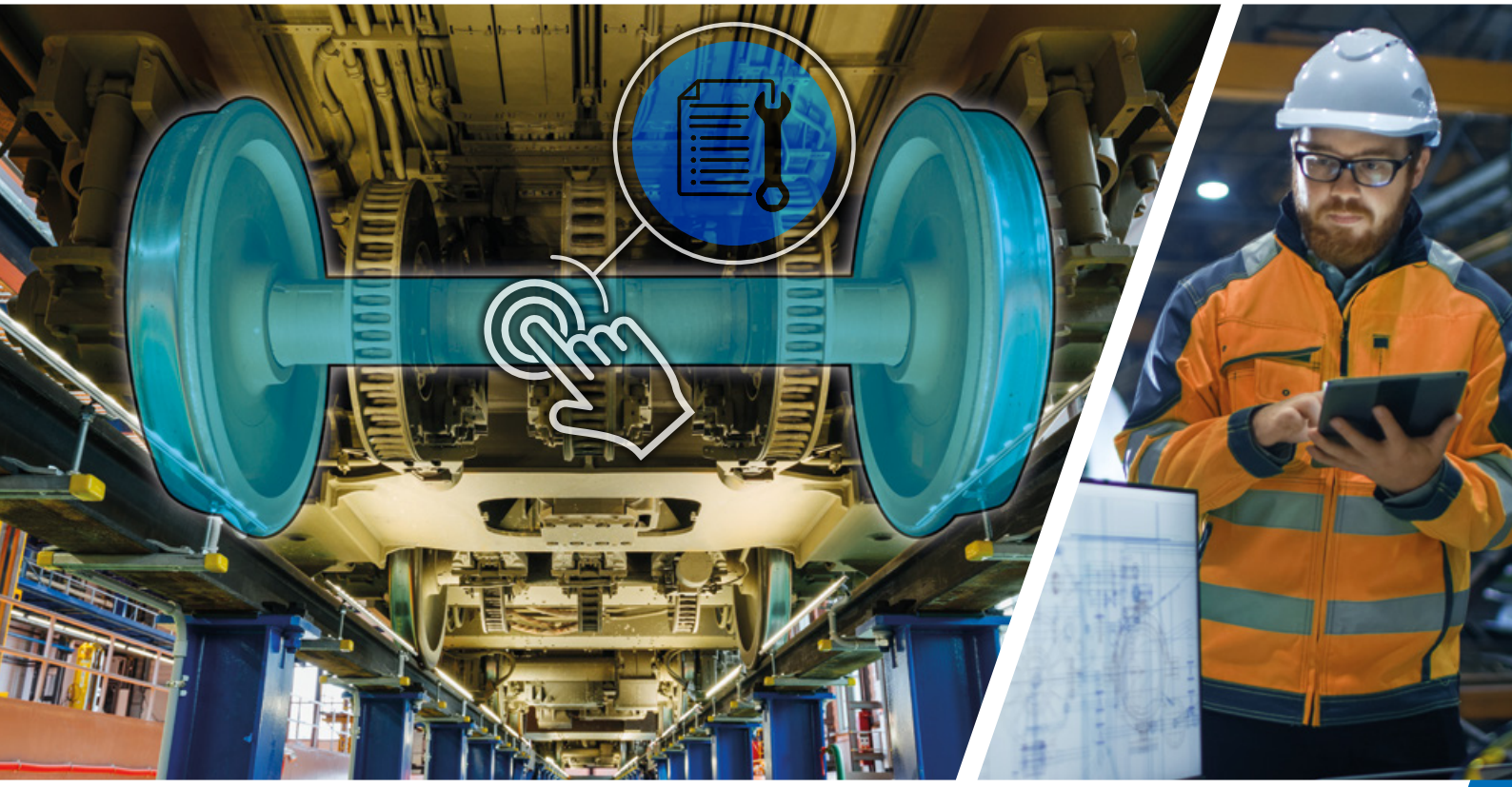
It shows how the adoption of digital technologies can be employed in safety-critical maintenance operations, adding value to paper-based technical information and using smart technologies like augmented reality, vision inspection and data insights to chart a clear path to industrial digitalisation and the benefits of digitised technical publications, remote assistance and faster skills training.

Richard Gardiner, sector lead for rail at the University of Sheffield AMRC, said the AMRC is proud to be building its reputation and prowess in rail, which has a rich heritage in South Yorkshire; Doncaster played a key role in the early days of steam - it's where The Flying Scotsman and Mallard locomotives were built - and is today home to a cluster of world-class rail businesses.

"We understand how important rail is to the wider economy, contributing £36 billion annually," says Gardiner. "The UK's rail network is undergoing the biggest programme of modernisation since Victorian times - tens of billions are being invested in infrastructure and capacity improvements, including here in South Yorkshire through HS2 and Northern Powerhouse Rail initiatives - so it's crucial we build our knowledge in the sector and nurture relationships with rail SMEs and OEMs to further MRO technologies that can improve operational efficiencies and ultimately help them remain competitive."

> "It will show that the University of Sheffield AMRC is the go-to place for companies wanting to access smart digital solutions that can help them improve productivity, quality and contribute to their sustainability efforts."
>
> **Richard Gardiner**

Gardiner says the cell's benefits are four fold: it will enhance quality and reduce life cycle costs by harnessing the



power of data; support sustainability by significantly reducing wasted resources; create step changes in productivity by facilitating smart resource allocation; and boost the UK economy by removing barriers to digital adoption.

The project not only develops the AMRC's understanding and capability in the rail industry but, crucially, it will inspire the rail supply chain with the confidence they need to invest in innovative solutions.

Gardiner added: "We will create a platform that can be used by our rail partners to develop systems and de-risk the adoption of new digital tools and processes. The goal is to minimise barriers to digital adoption in rail maintenance by using readily available consumer software and off-the-shelf hardware, making the cell accessible to companies of all shapes, sizes, sectors and budgets.

"It will show that the University of Sheffield AMRC is the go-to place for companies wanting to access smart digital solutions that can help them improve productivity, quality and contribute to their sustainability efforts."

Augmented reality (AR), which played a vital role in retraining 3,500 automotive and aerospace operators to build life-saving devices for VentilatorChallengeUK, is one of the stars of the smart-assisted maintenance

> "We will create a platform that can be used by our rail partners to develop systems and de-risk the adoption of new digital tools and processes."
>
> **Richard Gardiner**

demonstrator. Other features include optical projection, S1000D technical document management, a user-friendly but data-packed digital MRO dashboard, camera inspection and verification, and asset management tracking systems.

Maintenance 4.0 is funded by the High Value Manufacturing (HVM) Catapult and developed with support from technology company PTC, complex critical content experts GPSL, global freight and rail provider Wabtec Corporation, rail fastenings manufacturer Pandrol, rail logistics company VTG and digital visualisation content creators, Bloc Digital.

Gordon Innes, of Wabtec, said: "As a leader of a team of remotely deployed field service operatives it's important to me that we look to harness the power of technology to provide the best possible support to the operatives in the field ensuring standards are being met and safety is assured.

"I have a keen interest in the overlap between maintenance standards and the platforms for enhanced maintenance service delivery; incorporating technology such as AR into maintenance documentation is a key area of interest especially as we look to introduce new and modified products into the rail market.

"Tracking material usage automatically, as well as machine vision systems for inspection, are key areas of interest. The MRO technology demonstrator cell at the AMRC represents an opportunity for Wabtec to continue to explore these technologies while supporting the industry, understanding the art of the possible as well as any practical limitations."

The art of the possible was premiered to a captive audience of global leaders in aerospace, defence and space at the TDW-Live last year, and the cell is expected to be fully up-and-running at the Factory 2050 facility this year.

Arthur Kershaw, senior project engineer at the AMRC, says the technologies powering the demonstrator have the potential to unlock big benefits for both smaller businesses and OEMs looking to advance their MRO capabilities and improve operational efficiencies.

"A key feature is the operator guidance, empowering those carrying out a task with up-to-date, in-situ information. The live digital dashboard that will take data from various sources and present it in a way that enables supervisors and managers to capture and solve problems before they become an issue.

"An asset tracking system enables businesses to benefit from seeing the movement of high-value items - detecting who has taken or replaced a component, what component, and when. This allows the management of unsecured materials that may have previously been difficult to quantify.

"It will also have camera verification of certain processes, projected in-situ. We've refined it to just highlight the manual brake state for this demonstrator, but the methodology developed could be rolled out to any component with a detectable state, through optical recognition or other sensor output."

PTC's Vuforia software technology will underpin the AR experiences that will be seen in the demonstrator. Paul Haimes, vice president for field engineering at PTC, said the immersive technology is already being used to address manufacturing challenges with measurable value, including remote worker assistance, knowledge capture for training and digitised standardised operating procedures.

"That's the focus of the project at the AMRC for us - the ability to augment the users' view with CAD data and information that then shows how to assemble, disassemble or change over equipment, whatever it might be; those types of activities lend themselves very neatly to the augmented reality space," said Paul.

"With remote assistance, we're seeing 40 per cent fewer physical visits which has a huge impact on a company's costs for maintaining products; for digital standard operating procedures we're seeing individuals work faster and more consistently with training times reduced between 20 to 40 per cent and up to a 20 per cent reduction in errors that individuals are making.

"Five years ago, a lot of companies were exploring whether AR works and how it adds value. Today, we see bigger companies move from a more general level of assessing technologies, such as proof of technology and proof of value, to scaling AR to suit their requirements."

The University Of Sheffield. AMRC Advanced Manufacturing Research Centre

CATAPULT High Value Manufacturing

ptc

VTG

Wabtec CORPORATION

GPSL

bloc digital

PANDROL

AMRC to host Smart Factory Innovation Hub

The University of Sheffield Advanced Manufacturing Research Centre (AMRC) has been chosen to jointly host the Smart Factory Innovation Hub as part of a pilot scheme to accelerate growth in the manufacturing sector through better use of digital technologies.

The High Value Manufacturing (HVM) Catapult and Made Smarter, the UK's manufacturing digitalisation movement, have announced the HVM Catapult-led Made Smarter Smart Factory Innovation Hub pilot. It will see the HVM Catapult network, which includes the AMRC and Nuclear AMRC, offer companies the opportunity to reduce the risk of implementing new digital manufacturing solutions within their businesses.

"The Smart Factory Innovation Hub presents an exciting opportunity to apply the HVM Catapult's deep industry knowledge and expertise to projects which require increased speed and agility," said Dick Elsy, CEO of the HVM Catapult.

"We are uniquely positioned to service quick-fire feasibility projects for manufacturers and give manufacturing technology providers a chance to develop, demonstrate and test new applications.

Allowing businesses to test quick-fire projects and early-stage technologies in a safe, industry-like environment with expert support

Working together with Made Smarter and businesses of all sizes, we look forward to stimulating growth through better use of digital technologies in manufacturing."

The 16 physical and virtual testbeds will allow businesses to test quick-fire projects and early-stage technologies in a safe, industry-like environment with expert support. The Made Smarter offering, delivered by the HVM Catapult, will give businesses from sectors like food and drink, pharmaceuticals or aerospace an opportunity to see how they can address live business problems using industrial digital technologies.

The AMRC's Factory 2050 and Factory of the Future facilities, both on the Advanced Manufacturing Park in South Yorkshire, will host the Legacy Systems testbed. Factory 2050, the UK's first state-of-the-art digital factory entirely dedicated to conducting collaborative research into reconfigurable robotics, digitally-assisted assembly and machining technologies, will also be the Connected Factory testbed.

Additionally, the AMRC will lead the HVM Catapult work on the Cybersecurity for Manufacturing testbed.

Ryan Diver, Head of the AMRC's Factory 2050, said: "This is such a fantastic programme and comes at a crucial time for UK manufacturing. The Connected Factory and Legacy Systems testbeds open up many opportunities for companies to discover how digital technologies can drive their manufacturing environments forward into Industry 4.0.

"In partnership with our Digital Meets Manufacturing campaign, which introduces digital technology providers to manufacturing challenges, companies will be able to develop, de-risk and then validate solutions in the manufacturing testbed environment here at the AMRC."

All 16 testbeds will offer manufacturing and technology providers the following benefits:

For manufacturers:

- An environment to innovate, develop and de-risk rapidly configurable projects and industrial digital technologies before investing within their own businesses;
- An opportunity to experience new, integrated technology solutions on real-industry use cases and with expert HVM Catapult support;

For technology providers:

- An opportunity to test, develop and showcase new technology solutions on real industry examples and source feedback to improve their technology offering for the sector.

The Innovation Hub pilot will come at no cost for participating companies. The funding has been awarded by UK Research and Innovation through the Industrial Strategy Challenge Fund.

Juergen Maier, Co-Chair of Made Smarter, said: "As businesses fight their way through this third lockdown, speeding up the uptake and development of new ground-breaking digital technologies has never been more important.

"The new Made Smarter Smart Factory Innovation Hub will give smaller companies access to world-class expert support to turbo-charge new digital innovation and projects. This will deliver that much needed boost to both individual businesses and the economy as a whole, as companies push forward to create the new 'must have' technologies of the future in order to compete in the global marketplace."

Chris Courtney, Manufacturing Made Smarter Challenge Director, said: "Digital technologies have the power to radically transform how we manufacture and deliver the products and services of today and the future. This is more vital than ever given the current challenges of the pandemic and climate change and there are enormous opportunities to innovate across all manufacturing sectors.

"We have world-leading industries, a powerful scientific and research community, a vibrant technology sector and these innovation hubs are being designed to bring that powerful coalition together."

The pilot programme will inform the wider roll-out of the Made Smarter Smart Factory Innovation Hub scheme.

For manufacturers or technology providers wishing to learn more or access the hub please get in touch at: **madesmarter@hvm.catapult.org.uk**

A central demonstrator will be based on a conveyor system linked together with collaborative robots, automated guided vehicles and other Industry 4.0 technologies.

The AMRC's £2m sustainable food packaging hub

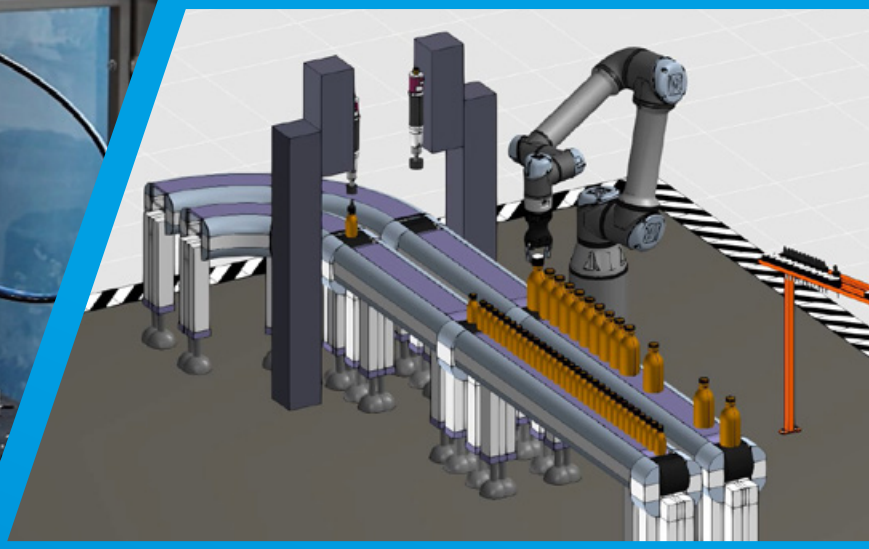
By James Crossling

A rising star of the Welsh economy – the £22bn food and drink industry – is to get a productivity and sustainability boost from the University of Sheffield Advanced Manufacturing Research Centre (AMRC), following a £2m award by the Welsh Government to build a Food and Drink Packaging Sustainability Centre.

AMRC Cymru has secured the BITES (Business, Innovation and Tourism Escalator Scheme) funding to develop an emerging technology demonstrator specifically for the food and drink sector that will accelerate the adoption of waste-reducing eco-innovations by integrating Industry 4.0 technologies in the packaging industry.

Lesley Griffiths, Minister for Environment, Energy and Rural Affairs, said: "Our ambition is to raise Wales' international profile and proactively market our innovation in quality food and drink to the world. I believe the innovations we are exploring at AMRC Cymru can deliver a range of measures to future-proof the industry in Wales.

"We want to see the food, drink and packaging industry reducing its reliance on manual labour and increase skill levels within the sector so we are extremely interested in exploring innovation in processes. This will drive



forward the industry into a new era of green growth in the Welsh economy and it is vital the sector responds to these high potential opportunities. This can only be achieved by urgently developing new processes and incorporating the new technologies to tackle single-use plastic and recycling."

Food and Drink Wales believe the sustainability centre will become a hub for the uptake of emerging technologies and materials in the food and drink packaging supply chain. Beyond that, Welsh Government wants the AMRC to take a lead on the adoption of waste-reducing eco-innovations in the sector that work towards increased productivity and lower Life Cycle Assessment (LCA).

The demonstrator will exhibit the AMRC's capabilities in advanced automation, collaborative robotics, additive manufacturing and visualisation; there will also be prototyping and functional test equipment for new packaging solutions and ideas.

"These technologies are widely used in other industries but don't really exist within food and drink. There are new challenges for us as food and drink packaging companies work in a high-speed, low-cost environment, so the demonstrator will display how the technologies can be implemented in a different manufacturing set up," said Bobby Manesh, AMRC Cymru's Food and Drink Technical Lead.

The £2m funding will be used in two key areas at AMRC Cymru: the development of an emerging technology demonstrator that comprises a re-configurable, modular system for prototyping production processes; and equipment infrastructure that supports the progress of new designs, materials and processes.

"The hub will have a central demonstrator based on a conveyor system which will be linked together with collaborative robots, automated guided vehicles (AGVs) and our own engineers wearing exoskeletons. Everything will be visualised and tracked through cameras so we will have a digital twin of the process that can be viewed on a screen in real time," said Bobby.

Welsh Government, in partnership with the Food and Drink Wales Industry Board (FDWIB), have set out a vision to develop Wales as a 'food nation'. A key part of this plan is a commitment to innovate the food and drink sector across Wales, the UK and internationally.

Objectives of the Food and Drink innovation programme include reducing single-use plastics and replacing them with environmental-based alternatives, data capture, real-time monitoring and introducing Industry 4.0 technologies.

Situated on the Deeside Enterprise Zone and opened in November 2019, AMRC Cymru is a £20m state-of-the-art research and development facility paid for by Welsh Government. The first High Value Manufacturing (HVM) Catapult centre in Wales, AMRC Cymru operates a 2,000 square metre open access research area.

Airbus is the first major tenant and will have a platform to develop their next generation wing technologies aligned to its Wing of Tomorrow programme, which is part of a global Airbus investment in research and innovation.

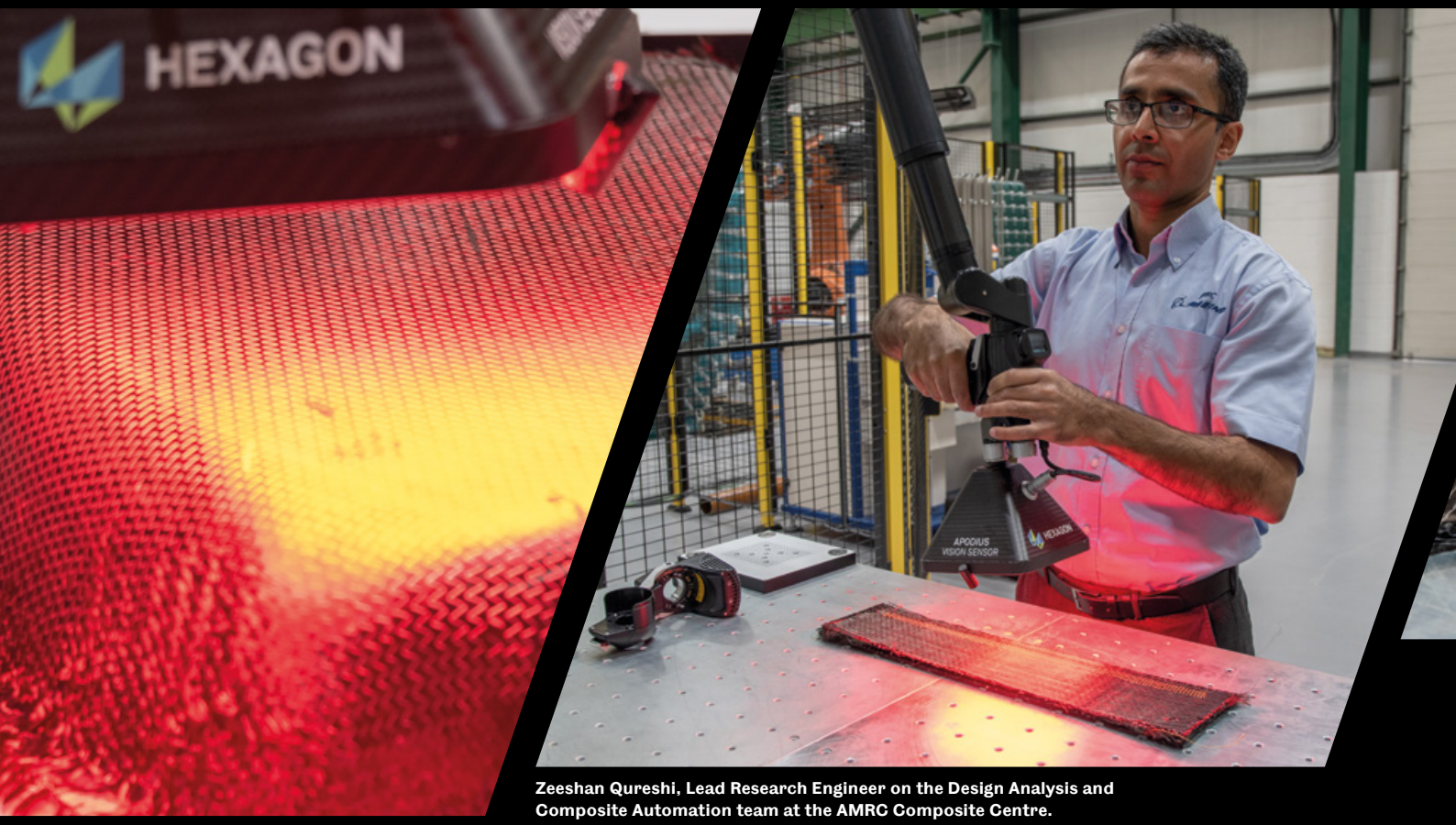
AMRC Cymru's Operations Director, Jason Murphy, said: "The conversion of our facility to producing medical ventilators in March last year has unfortunately delayed the completion of the Food and Drink Packaging Sustainability Centre. However, that delay has given us the time to model the demonstrator virtually and consider how we can best set it up so that visiting SMEs can gain the most from it.

"This will hopefully be one of our key strength areas at AMRC Cymru and nearly all of our engineers here in Broughton will be working on aspects of the demonstrator. Ideally, we would like to be able to invite visitors in to see it sometime in 2021."

The food and drink industry is a rising star in the Welsh economy and in 2014, the Food and Drink Action Plan stated an ambitious target to achieve growth for the sector of 30 per cent by 2020. The latest figures show the food and drink supply chain in Wales employs 229,500 people and has an overall annual turnover of £22.1bn.

Minister for Economy, Transport and North Wales, Ken Skates, said: "North Wales has the operational capabilities to maximise the opportunities to deliver and drive forward innovation in the food and drink sector.

"The successful delivery of the Food and Drink Packaging Sustainability Centre will create a more resilient Welsh economy, which helps develop companies that are profitable and sustainable. The state-of-the-art facilities at AMRC Cymru will be key in developing unique technological solutions which will enhance the global competitiveness of Welsh firms, reinforcing our food and drink sector's world-leading reputation."



Zeeshan Qureshi, Lead Research Engineer on the Design Analysis and Composite Automation team at the AMRC Composite Centre.

Pioneering composite inspection technology

By James Crossling

A vision inspection system using 3D modelling could save composite manufacturers valuable time and money by eliminating the manual inspection process of composite materials and parts, according to researchers at the University of Sheffield Advanced Manufacturing Research Centre (AMRC).

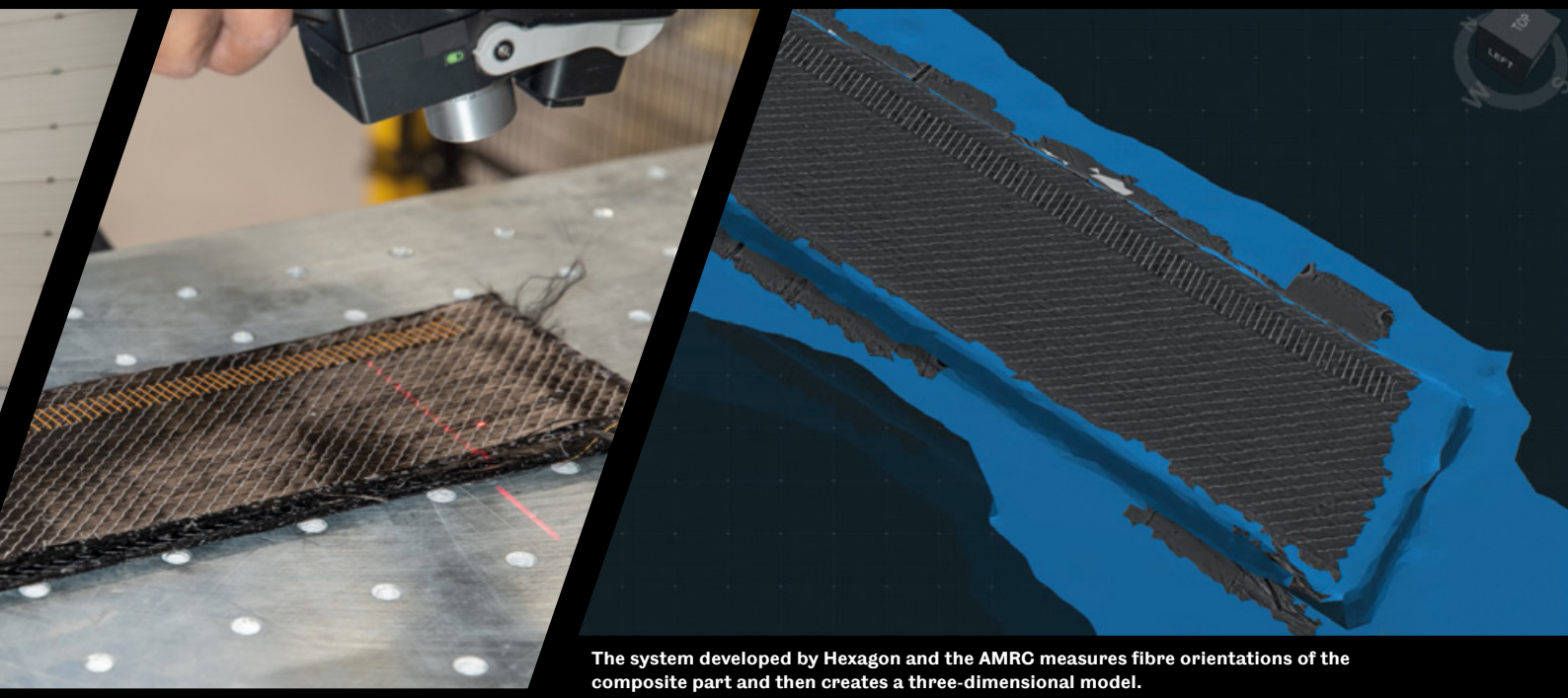
"Quality checks during the lay-up process are vital but can take 70 per cent or more of total machine time," said Zeeshan Qureshi, Lead Research Engineer on the Design Analysis and Composite Automation team at the AMRC Composite Centre.

"It is a huge cost to our partners so we're investigating automated in-process inspection systems that could help significantly decrease, or even eliminate entirely, manual inspection in order for them to achieve higher productivity in their factories."

Composite components are made by layering plies of unidirectional fibres or woven fabrics, which are then cured to produce a final solid part. The strength of the part is dependent on the correct alignment of the fibres from which it is made; fibres which are laid incorrectly can result in a range of defects that affect the structural integrity of the final part.

Detecting such defects, from gaps and overlaps to the presence of foreign objects and debris, at the relatively early lay-up stage of production is much more efficient and cost effective than identifying unacceptable weak points in the material once it is part of a completed component.

Zeeshan said the Composite Centre



The system developed by Hexagon and the AMRC measures fibre orientations of the composite part and then creates a three-dimensional model.

researched what systems were being successfully employed in related applications, which identified the capabilities of the Absolute Arm and its laser scanner options - which are products developed by Hexagon's Manufacturing Intelligence division.

"We discovered that Hexagon have developed a composite inspection system specially for measuring fibre orientations, which we believed could be a potential candidate for solving some of our inspection problems. They were quickly able to bring one such system to the AMRC to perform a case study – an Absolute Arm with RS5 Laser Scanner and a Vision System 3D," said Zeeshan.

The Vision System 3D is a camera-based sensor that can accurately detect the orientation of composite fibres using pixel based algorithms. The system uses a metrological Absolute Arm for position referencing and, combined with scans made using the arm's laser scanner and camera functionalities, this fibre orientation data can be mapped onto a three-dimensional model of the part being inspected using the dedicated Explorer 3D software platform.

"The system lets us validate the design and simulation work that we do at our desks to make sure our design intent is being manufactured, so it becomes a good validation step for our design and manufacture process," said Zeeshan.

"We're primarily using the system for weaving, braiding and preforming processes. Once we perform that initial manufacturing process, we can bring the part to the workstation and we would use the new inspection system to do a scan of the part to generate the 3D profile of the part we have.

"Using some of the advanced algorithms that are built into the software, we're then able to determine fibre orientations that can give us an indication of some of the defects that are present in the part.

"We can take that information back into our design and analysis software to update our models with the data from the as-manufactured part in order to perform an analysis which we can then compare against the as-designed part. This provides valuable information for comparing the 'real' and 'virtual' environments in which we work."

The Vision System 3D is one of a number of solutions for composite fibre inspection that has been developed by Hexagon's Vision and Composites product group in Aachen, Germany.

"Working closely with the AMRC Composite Centre has been incredibly valuable to us here at Hexagon," said Alexander Leutner, Director Vision at Hexagon. "It's great to see our Vision System technology being used to enable the next leaps forward in the industrialisation of composite production, and the feedback we receive from the AMRC team has been invaluable to us as we continue to develop and improve our solutions.

"We're in regular contact with Zeeshan and his team, and that close partnership has helped us to develop system enhancements, new software modules and applications that we hadn't previously thought about.

"It's also been incredibly interesting to work with the AMRC in taking this research into the world of automation, with inspection built into the fibre placement or tape laying processes. I'm really looking forward to seeing our partnership develop even further, especially with the studies the team are now performing with our automated AFP Inspection System."

Zeeshan said the next stage of the project is to investigate how the technology can be applied in other areas: "This is the first time we've had a metrology inspection system in-house. Now we're hoping to help further develop both the hardware and software systems to make them robust enough to pick up some of the more complex defects for which we're hoping to achieve solutions in the near future.

"One of the advantages of having this system is that the sensor can be integrated with other composite lay-up machines as well, such as the AFP machine, braiding, stitching, or 2.5D or 3D weaving machines that we have at the AMRC with the aim of achieving online inspection systems."

The Future of Propulsion

We are living in historic times in terms of propulsion for both aviation and ground-based transport. The necessity to reduce emissions is driving the development of entirely new types of propulsion system, *writes Stuart Dawson, Chief Technology Officer for the University of Sheffield AMRC.*

The last couple of months have seen the first hydrogen fuel cell powered flight by ZeroAvia, the announcement by Airbus that it is developing three new 'hybrid/ hydrogen' concept aircraft with a target entry into service of 2035 and the announcement by Rolls-Royce that it has begun testing their Trent engines to run with 100 per cent sustainable aviation fuel.

These events represent the beginning of the end for kerosene burning gas turbines in commercial aviation – a reign which has lasted more than 70 years since the first De-Havilland Comet entered service in 1952.

It is easy to understand why kerosene has dominated for so long: as a hydrocarbon its gravimetric energy density is high enough to power large aircraft over long distances and as a liquid its volumetric energy density means it takes up minimal storage space and does not require pressurised containers. And thirdly, it's very cheap: the sheer economies of scale from producing millions of tonnes of kerosene every year means that Jet-A1 aviation fuel typically costs less than 50 pence per litre[1].

But of course, being a hydrocarbon it has the huge disadvantage of producing CO_2 during combustion: for every tonne of kerosene burnt, around three tonnes of CO_2 emissions are generated. Globally, in 2019, flights emitted more than 900 million tonnes of CO_2 from burning some 300 million tonnes of kerosene[2]. That's about 2 per cent of all human-induced CO_2 emissions in 2019[3]. Essential though it is to reduce CO_2, kerosene burning gas turbines also produces emissions such as nitrogen oxides (NO_x), particulates and condensation trails that also contribute to climate change. Together with CO_2, these put the estimated climate impact of aviation closer to 3.5 per cent.

Currently, aviation represents about 12 per cent of all CO_2 transport emissions. But with the expected widespread electrification of ground transport and the predicted growth in passenger numbers, aviation is projected to be the highest emitting transport sector by 2050. Consequently the aviation industry is under huge pressure to develop and deploy new propulsion systems that minimise emissions.

In contrast to 'setting fire to hydrocarbons', battery electric propulsion produces zero emissions in use. Similarly, hydrogen fuel cells and hydrogen combustion only emit water vapour. And sustainable aviation fuel is 'net zero', i.e. it only emits CO_2 that was originally captured from the atmosphere.

Over most of the 20 year history of the AMRC, we have worked on developing new methods of manufacture for hydrocarbon burning gas turbines – from step change improvements in fan disc productivity to radically increasing the metal removal rates for new heat resistant super alloys.

Similarly, the development of next generation aerospace propulsion systems will open up a huge range of new manufacturing challenges for us to tackle, from producing high power to weight ratio fuel cells, electric machines and heat exchangers to the development of lightweight hydrogen storage tanks and the development of new machining techniques for temperature resistant materials such as ceramic matrix composites.

Change is not only happening in the air. Ground transport is also rapidly transitioning towards net zero propulsion - and even faster than aerospace as it does not have such onerous power-to-weight and energy-to-weight ratio challenges to contend with. Within the next decade, almost all new ground transport will be propelled by electric motors, powered by either batteries or hydrogen fuel cells.

And it won't just be cars – it will be practically all ground-based transport from trains to buses, trucks, heavy goods vehicles, off highway, public service vehicles - the list goes on. This trend is also being driven by UK government policy with new petrol and diesel cars being banned by 2030 and diesel trains by 2040. The huge projected increase in the electrification of heavy, long-range vehicles fits perfectly with the strategy of our EPSRC Future Electric Machines Manufacturing Hub which is to focus on higher power, lower volume, flexibly manufactured electric machines.

So these are historic times for the development and deployment of new propulsion technologies. For us, it represents a wide array of new manufacturing challenges from electric machine assembly and the development of lightweight hydrogen storage tanks to the development of ultra-high power-to-weight ratio heat exchangers, to name but a few. And crucially, as our mission at the AMRC is to 'Make Things Better', this is an opportunity to play our part in the national and global endeavor of decarbonising transport.

1. Depending on the oil price at the time. 2. ICCT data 2019: https://theicct.org/sites/default/files/publications/ICCT_CO2-commercl-aviation-2018_20190918.pdf
3. ATAG estimates, 2018: https://www.atag.org/facts-figures.html

Machine learning making light work of AM aerospace alloys

Machine learning technology will be used to make the additive manufacturing (AM) process of metallic alloys for aerospace cheaper and faster, encouraging production of lightweight, energy-efficient aircraft to support net zero targets for aviation.

Katia Harston writes.

Project MEDAL: Machine Learning for Additive Manufacturing Experimental Design is led by Intellegens, a University of Cambridge spin-out specialising in artificial intelligence, the University of Sheffield AMRC North West, and global aerospace giant Boeing. It aims to accelerate the product development lifecycle of aerospace components by using a machine learning model to optimise additive manufacturing (AM) processing parameters for new metal alloys at a lower cost and faster rate.

AM is a group of technologies that create 3D objects from computer aided design (CAD) data. AM techniques reduce material waste and energy usage; allow easy prototyping, optimising and improvement of components; and enable the manufacture of components with superior engineering performance over their lifecycle. The global AM market is worth £12bn and that is expected to triple in size over the next five years. Project MEDAL's research will concentrate on metal laser powder bed fusion - the most widely used AM approach in industry - focussing on key parameter variables required to manufacture high density, high strength parts.

Ben Pellegrini, CEO of Intellegens.

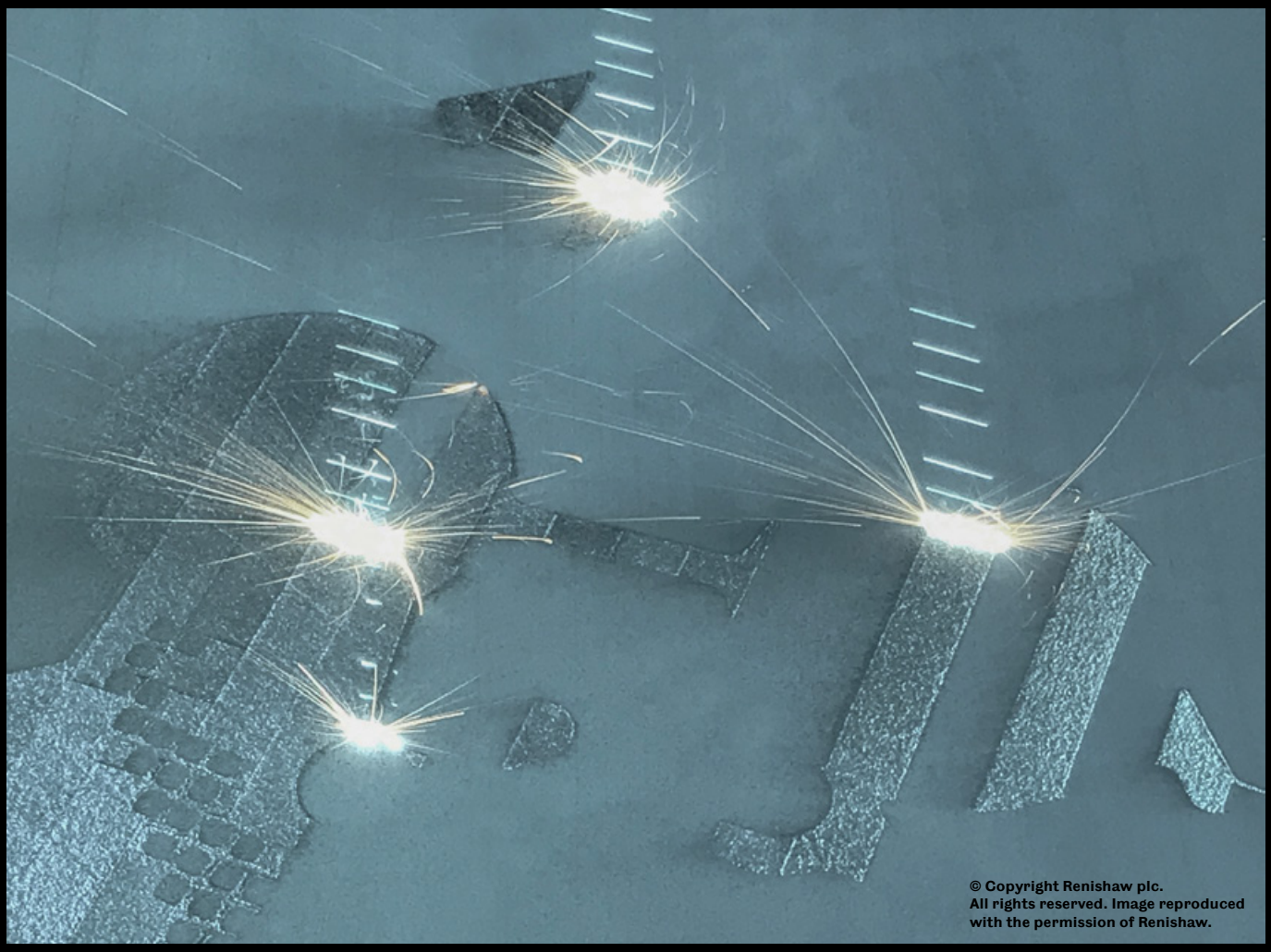
The project is part of the National Aerospace Technology Exploitation Programme (NATEP), a £10 million initiative for UK SMEs to develop innovative aerospace technologies funded by the Department for Business, Energy and Industrial Strategy and delivered in partnership with the Aerospace Technology Institute (ATI) and Innovate UK. Intellegens was a start-up in the first group of companies to complete the ATI Boeing Accelerator last year.

Ben Pellegrini, CEO of Intellegens, said: "We are very excited to be launching this project in conjunction with the AMRC. The intersection of machine learning, design of experiments and additive manufacturing holds enormous potential to rapidly develop and deploy custom parts not only in aerospace, as proven by the involvement of Boeing, but in medical, transport and consumer product applications."

James Hughes, Research Director for University of Sheffield AMRC North West, said the project will build the AMRC's knowledge and expertise in alloy development so it can help other UK manufacturers.

"At the AMRC, we have experienced first-hand, and through our partner network, how onerous it is to develop a robust set of process parameters for AM. It relies on a multi-disciplinary team of engineers and scientists and comes at great expense in both time and capital equipment," said Hughes. "It is our intention to develop a robust, end-to-end methodology for process parameter development that encompasses how we operate our machinery right through to how we generate response variables quickly and efficiently. Intellegens' AI-embedded platform Alchemite will be at the heart of all of this.

"There are many barriers to the adoption of metallic AM but by providing users, and maybe more importantly new users, with the tools they need



Renishaw RenAM500Q multi laser system melting metal powder.

to process a required material should not be one of them. With the AMRC's knowledge in AM, and Intellegens' AI tools, all the required experience and expertise is in place in order to deliver a rapid, data-driven software toolset for developing parameters for metallic AM processes to make them cheaper and faster."

Sir Martin Donnelly, president of Boeing Europe and managing director of Boeing in the UK and Ireland, said the project shows how industry can successfully partner with government and academia to spur UK innovation.

"We are proud to see this project move forward because of what it promises aviation and manufacturing, and because of what it represents for the UK's innovation ecosystem," Donnelly said. "We helped found the AMRC two decades ago. Intellegens was one of the companies we invested in as part of the ATI Boeing Accelerator and we have longstanding research partnerships with Cambridge University and the University of Sheffield. We are excited to see what comes from this continued collaboration and how we might replicate this formula in other ways within the UK and beyond."

Aerospace components have to withstand certain loads and temperature resistances, and some materials are limited in what they can offer. There is also simultaneous push for lower weight and higher temperature resistance for better fuel efficiency, bringing new or previously impractical-to-machine metals into the aerospace material mix.

One of the main drawbacks of AM is the limited material selection currently available and the design of new materials, particularly in the aerospace industry, requires expensive and extensive testing and certification cycles which can take longer than a year to complete and cost as much as £1 million to undertake. Project MEDAL aims to accelerate this process, using machine learning (ML) to rapidly optimise AM processing parameters for new metal alloys, making the development process more time and cost efficient.

Pellegrini said experimental design techniques are extremely important to develop new products and processes in a cost-effective and confident manner. The most common approach is Design of Experiments (DOE), a statistical method that builds a mathematical model of a system by simultaneously investigating the effects of various factors.

"DOE is a more efficient, systematic way of choosing and carrying out experiments compared to the Change One Separate variable at a Time (COST) approach. However, the high number of experiments required to obtain a reliable covering of the search space means that DOE can still be a lengthy and costly process, which can be improved," explained Pellegrini.

"The machine learning solution in this project can significantly reduce the need for many experimental cycles by around 80 per cent. The software platform will be able to suggest the most important experiments needed to optimise AM processing parameters, in order to manufacture parts that meet specific target properties. The platform will make the development process for AM metal alloys more time and cost efficient. This will in turn accelerate the production of more lightweight and integrated aerospace components, leading to more efficient aircrafts and improved environmental impact."

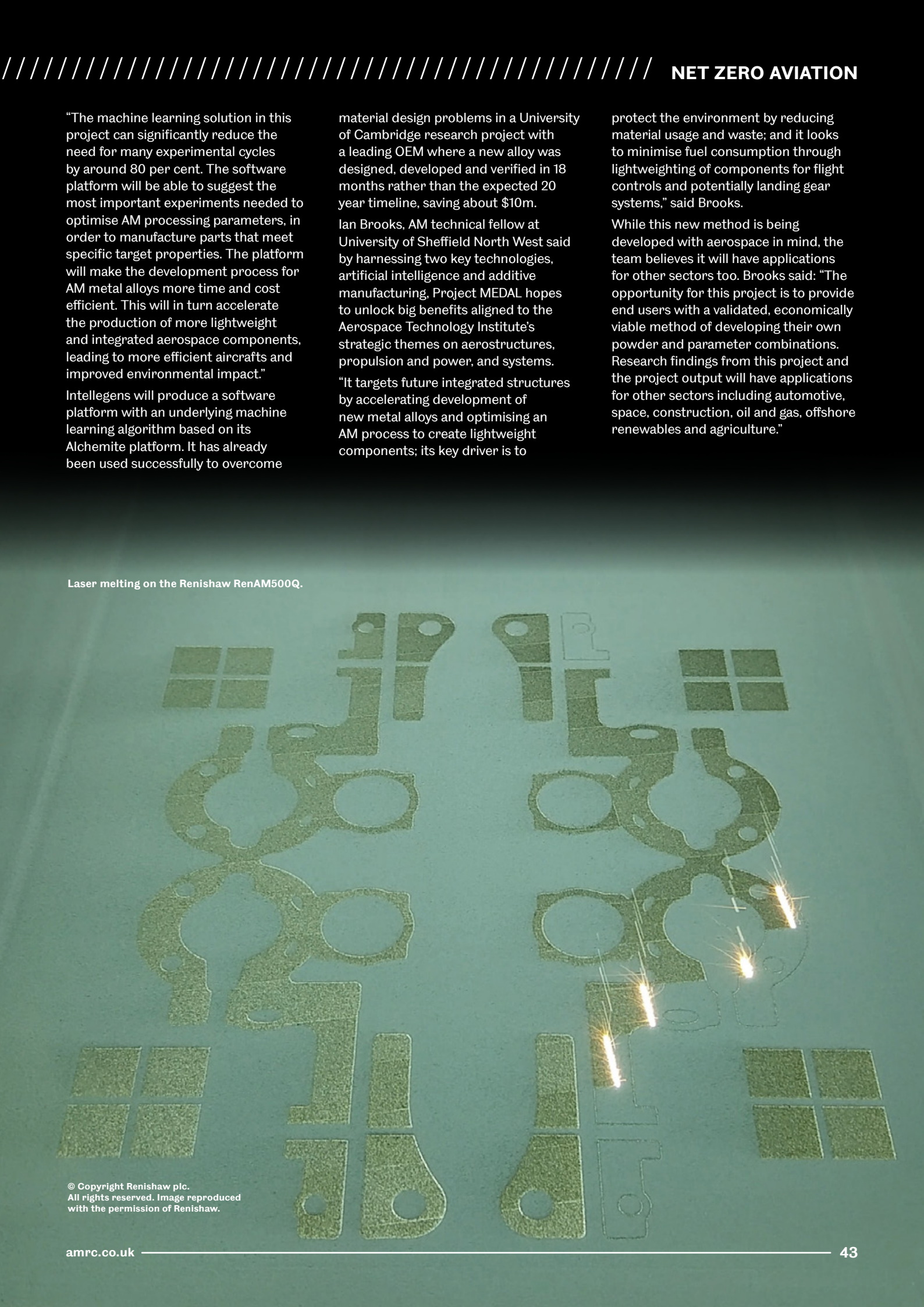
Intellegens will produce a software platform with an underlying machine learning algorithm based on its Alchemite platform. It has already been used successfully to overcome material design problems in a University of Cambridge research project with a leading OEM where a new alloy was designed, developed and verified in 18 months rather than the expected 20 year timeline, saving about $10m.

Ian Brooks, AM technical fellow at University of Sheffield North West said by harnessing two key technologies, artificial intelligence and additive manufacturing, Project MEDAL hopes to unlock big benefits aligned to the Aerospace Technology Institute's strategic themes on aerostructures, propulsion and power, and systems.

"It targets future integrated structures by accelerating development of new metal alloys and optimising an AM process to create lightweight components; its key driver is to protect the environment by reducing material usage and waste; and it looks to minimise fuel consumption through lightweighting of components for flight controls and potentially landing gear systems," said Brooks.

While this new method is being developed with aerospace in mind, the team believes it will have applications for other sectors too. Brooks said: "The opportunity for this project is to provide end users with a validated, economically viable method of developing their own powder and parameter combinations. Research findings from this project and the project output will have applications for other sectors including automotive, space, construction, oil and gas, offshore renewables and agriculture."

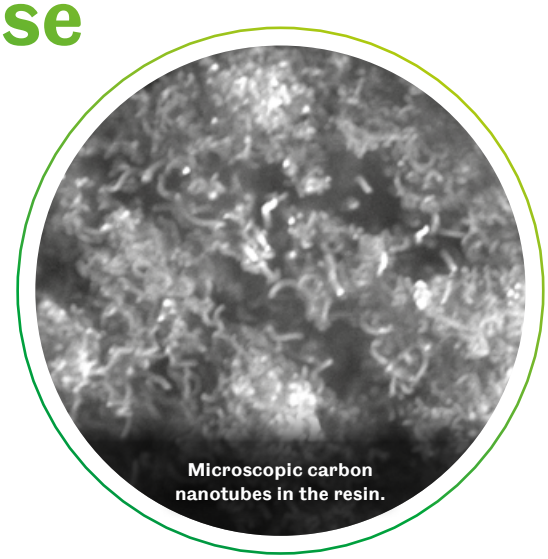
Laser melting on the Renishaw RenAM500Q.



Nanoscale materials hold cure for manufacturing and aviation greenhouse gas emissions

By James Crossling

Composite researchers at the AMRC are at the heart of a European-wide project to develop self-responsive aerospace composites that will significantly reduce greenhouse gas emissions and production costs in the aviation sector as it works toward the goal of net zero by 2050.



Microscopic carbon nanotubes in the resin.

The University of Sheffield Advanced Manufacturing Research Centre (AMRC) is partnering with 16 industrial partners on the MASTRO project, which is tasked with developing intelligent bulk materials for a smart transport sector as part of Horizon 2020, the biggest EU Research and Innovation programme ever with nearly €80 billion of funding available over seven years (2014 to 2020).

"There are three sections within MASTRO: automotive, infrastructure and aerospace; and the AMRC is leading the aerospace section of the project alongside Embraer. We're developing three main technologies: self-cure, self-anti-icing and self-sensing," said Matthew Collinson, Research Engineer in the AMRC Composite Centre.

The AMRC team are developing materials through the integration of carbon nanotubes – measured in billionths of a metre – which can be turned into smart products, and are now in a position to demonstrate the advances they have made.

"For the first year-and-a-half we've been working on developing the materials and so the next stage is developing the smart demonstrators. Now we've reached a point where we can build a section of a composite leading-edge wing – to show off the self-cure, self-anti-icing and self-sensing we have developed," added Matthew.

The development of all three technologies centres on the electrically conductive nature of the composite structure, which is vital as the industry moves to more electrified aircraft, with the ultimate aim of one day being fully electric.

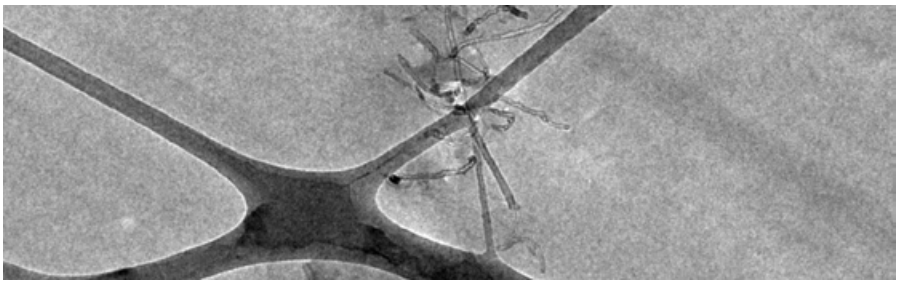
"Firstly, self-curing is a new manufacturing technique for these composites. Currently, they are manufactured in an autoclave but they can be slow and expensive to run. Running electrical current through the

fibres of the composite to act as the heating element to cure the component can be cheaper, quicker and uses much less energy. It also complements our work on anti-icing," said Matthew.

Another disadvantage of using autoclaves to heat composite structures, says Dr Betime Nuhiji, Technical Lead at the AMRC Composite Centre, is that engineers are limited by its size: "An autoclave produces high quality parts but it takes a lot of energy, a lot of time and you can only create a part that is as big as the autoclave.

"The Boeing 787 is manufactured in the biggest autoclave in the world, but it is expensive, not sustainable and not practical to build these huge autoclaves. The team has developed a heating system where a power supply is directly connected to the composite structure and a current is run through it; so it heats up, just like a heating element.

"There are so many benefits, but the main ones are low energy output and low equipment costs. There is also the close control of heating, because when you turn an oven off it is still hot, so you are still effectively heating the part; when you turn off the electrical system no more power is going through it."



The AMRC is developing materials through the integration of carbon nanotubes which are measured in billionths of a metre.

Matthew said similar technology is used to investigate self-anti-icing: "Currently, aircraft remove surface ice by drawing hot air from the engine to melt the ice, but this takes power away from the engine and is less efficient, so we have been developing an electrical anti-icing system that doesn't require separate heating elements in the component.

"Linked to both these technologies is self-sensing, monitoring the electrical resistance of the part to detect damage. When you get barely visible impact damage (BVID), the resistance changes so you can monitor that and detect where the damage is. BVID is something the aerospace industry is very interested in because it is very difficult to detect through visual inspection, which they currently do, on composite structures."

Matthew said to enable these smart functionalities, it has required some development of the resin: "Within a composite, the fibres are extremely electrically conductive but the resin is electrically insulating. Part of the project to develop these bulk materials is to make the component more conductive by mixing carbon nanotubes into the resin, so that the whole part is conductive, not just the fibres.

"Doing that should enhance every

Research Engineer Matthew Collinson with a section of a composite leading-edge wing manufactured in the AMRC Composite Centre.

Tests will be conducted on the self-curing, self-anti-icing and self-sensing leading-edge.

aspect of the MASTRO project. The self-curing and the anti-icing will perform better because the heat is distributed more evenly. And then we will also get increased response in damage detection because, again, the whole composite is conductive rather than just the fibres."

Betime said the challenge now is creating panels that replicate how they would need to be used in a real-world environment, on the leading-edge of an aeroplane wing.

"At the start of the project, we conducted lots of trials on smaller panels to optimise how to detect damage and cure effectively. Now we need to upscale as the final demonstrator we want to show is the leading-edge, which is two metres long," said Betime.

Matthew said the Covid-19 pandemic has meant work on the MASTRO project has had to slow down briefly over the summer, but a physical demonstration of the ground-breaking work they have been conducting is imminent.

"We started the latest work package at the start of 2020, which was making the two demonstrators – which have slightly different properties, then finishing the design and starting to manufacture.

"We have been delayed but we have now manufactured our first self-curing, self-anti-icing and self-sensing part and can start testing very soon."

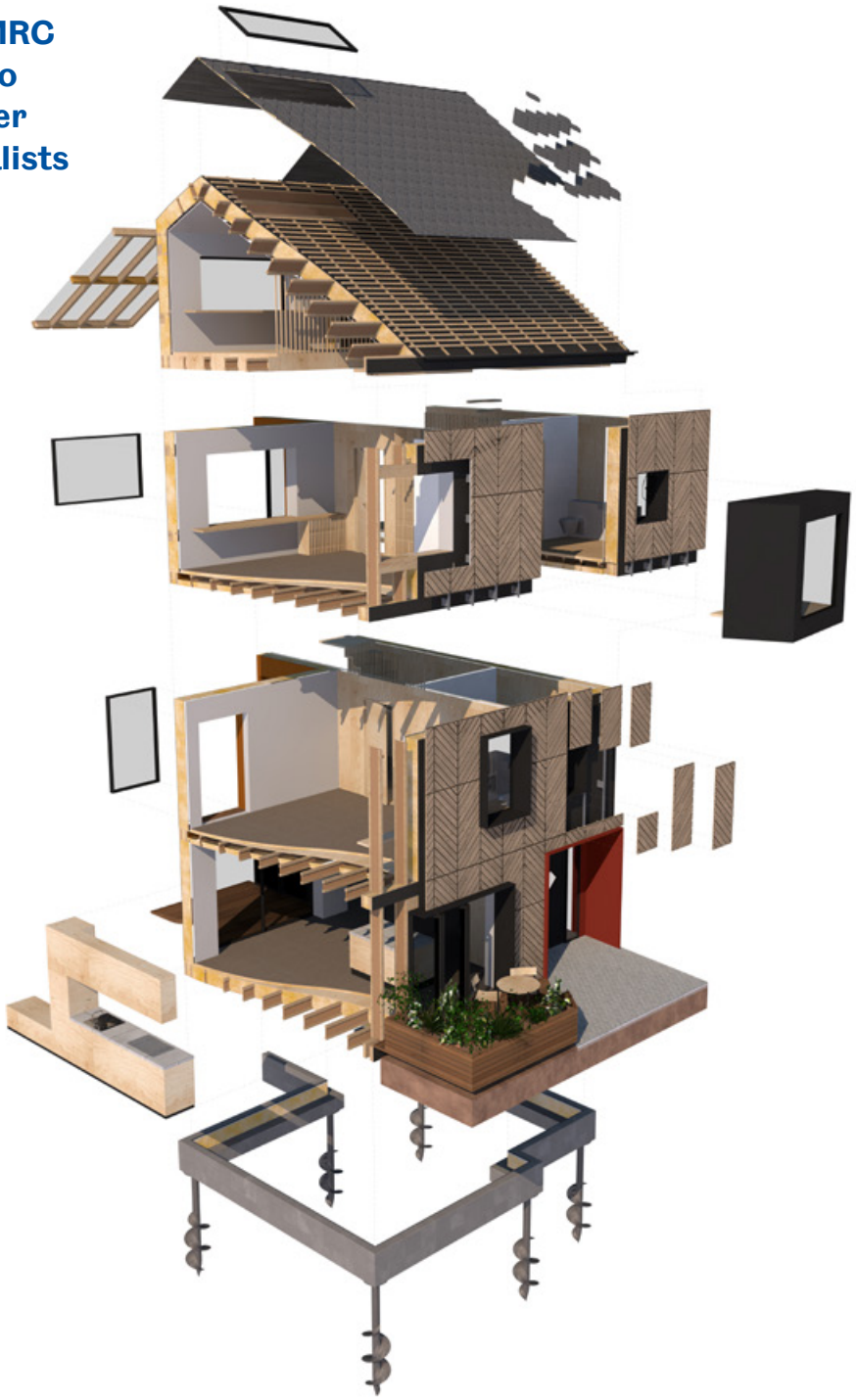
The overall objective of the MASTRO project is to develop intelligent bulk materials, incorporating self-responsive properties that increase consumer safety, component life-span and performance while reducing maintenance and manufacturing costs, and through-life greenhouse gas emissions.

The EU 2020 Strategy states that Europe needs to turn into a smart, sustainable and inclusive economy, based on knowledge and innovation. Horizon 2020 is the financial instrument of the Innovation Union, a Europe 2020 flagship initiative aimed at securing Europe's global competitiveness, driving economic growth and creating jobs.

This project was funded by the European Union's Horizon 2020 research programme under grant agreement No 760940, under the project titled MASTRO.

Smart, sustainable homes for the future

The University of Sheffield AMRC will support HLM Architects to develop its sustainable 'Forever Home' concept, one of six finalists in the prestigious Home of 2030 Design competition, working with the partners in the Homes England Development Framework.

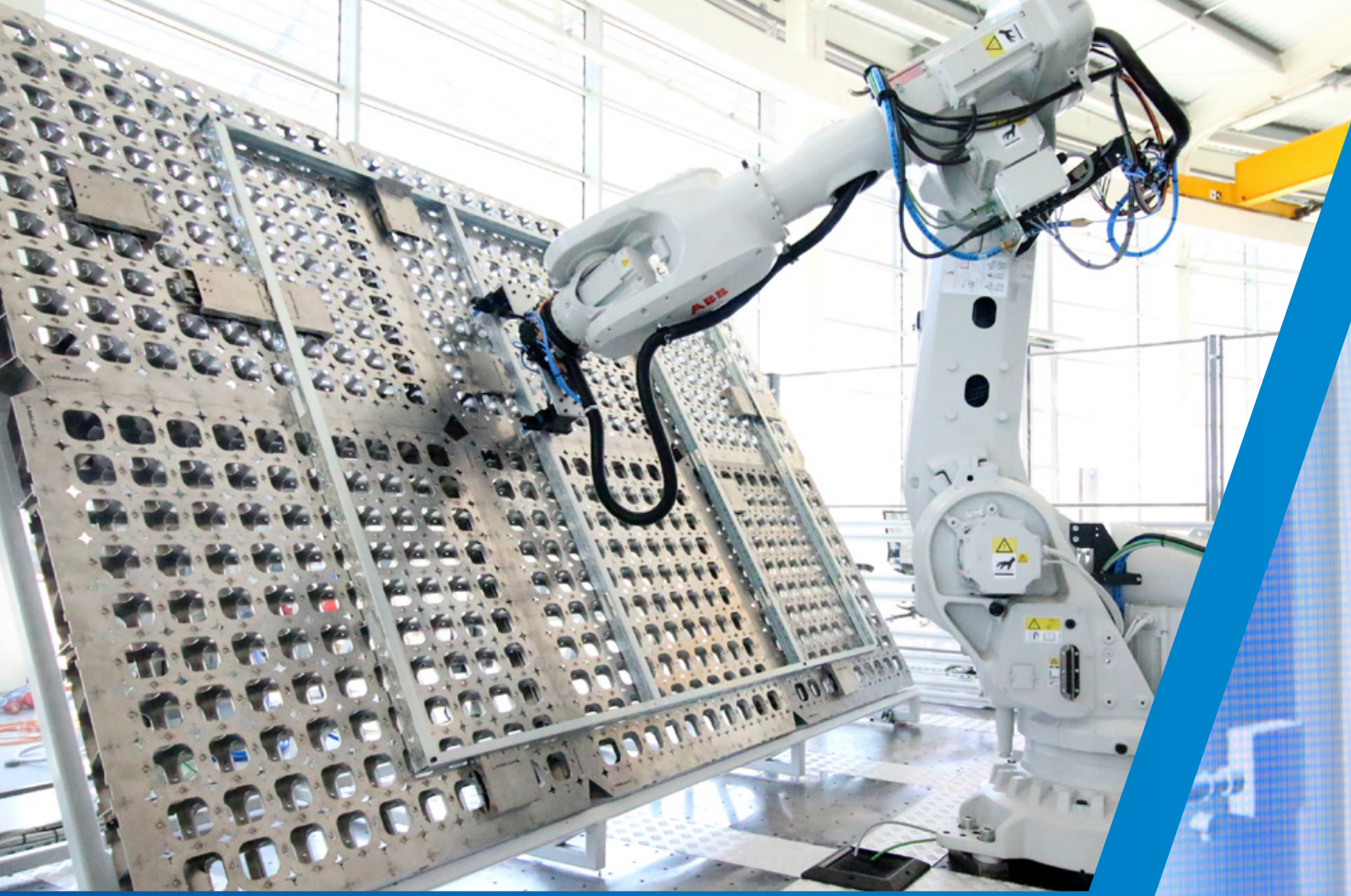


HLM Architects' concept - which will see robotics, vision inspection and augmented reality technologies harnessed to the latest innovations in construction - is to be introduced to the Homes England Development Framework to explore the possibility of developing bids for a series of homes on land owned by Homes England.

It follows the conclusion of the landmark Home of 2030 contest to find homes that are age friendly and have low environmental impact, support healthy living and can be delivered at a large scale to solve our housing shortage.

HLM Architects' 'Forever Home' exploits a universal manufacturing platform to enable flexible, affordable, and sustainable 'forever' homes that are delivered using a circular economy approach. These homes are able to grow and shrink to suit their owners' needs over their lifetime, meaning people can invest in their homes rather than in the cost of having to move, allowing them to put down strong roots that support stable communities.

It was developed with technical expertise from the University of Sheffield Advanced Manufacturing Research Centre (AMRC) on design for manufacture and assembly (DfMA) and Design for Disassembly and Adaptability (DfD/A) approaches. The ambition is to solve



the issues of capacity and compatibility within the offsite manufacturing sector by developing a design standard that enables any off site manufactured system to deliver the same high quality, sustainable design while using interchangeable parts.

The concept is particularly beneficial to housebuilders and developers as it enables them to select contractors and suppliers from a much wider pool. As well as making the tendering more competitive, it also serves to safeguard the supply chain 'ecosystem' by ensuring there is also a back-up manufacturer or supplier should one become incapable. HLM Architects also created a people-centric masterplan that had the community at its heart – with large communal spaces, as well as wild landscaping and ponds – yet was also financially viable for developers.

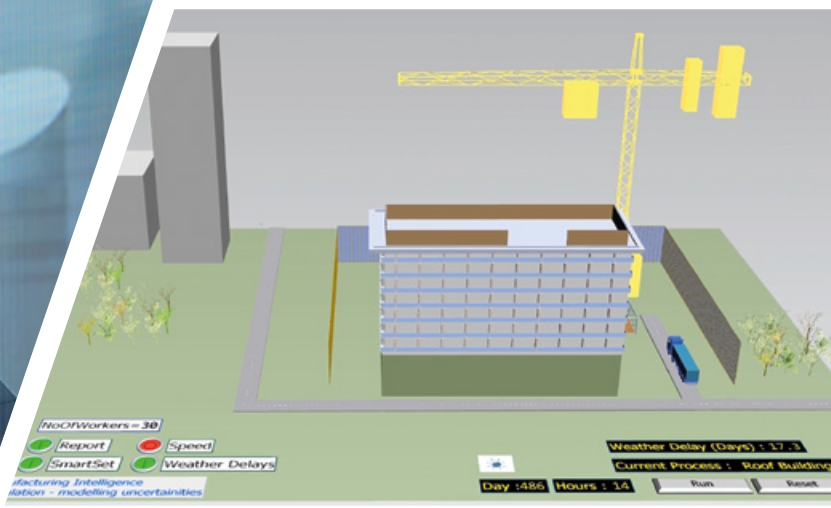
The competition, announced by Housing Minister Christopher Pincher, was based on four themes, which included: age-friendly and inclusive living, low environmental impact, healthy living, and deliverable and scalable. It attracted more than 200 entries from the best and brightest talents of the housing industry and HLM Architects was shortlisted to become one of six companies to make it to the final leg of the competition.

During the final phase of the contest, HLM Architects and the University of Sheffield AMRC joined up with contractor Mid Group, Hydrock, and Greenbuild to develop a platform that provides interchangeability with a varied ecosystem of components and suppliers.

HLM Director and Head of Design, Philip Watson said: "We are greatly looking forward to working with Homes England to develop this new 'Forever Home' concept, which we feel could make a huge impact in our future. Across the UK, there is a strong social imperative to build more homes wherever they

"We will be harnessing digital technologies like robotics, augmented reality and vision inspection to the latest innovations in construction to support HLM in creating this revolutionary new model for sustainable, affordable homes."

James Illingworth, Head of Construction at the AMRC



are needed and not just in areas where land values are high. Our design focus is shifting as we saw the need to address the quality of these new low-rise homes to improve environmental sustainability and placemaking, while helping to build stronger, more resilient communities."

James Illingworth, Head of Construction at the AMRC, added: "We're excited to be working with HLM Architects to develop the 'Forever' home concept, supporting the design for manufacture and assembly (DfMA) approach. We'll be drawing on our experience of translating and developing technology from aerospace and high-value manufacturing to help evolve the innovative technical aspects of the concept, harnessing digital technologies like robotics, augmented reality and vision inspection to the latest innovations in construction to support HLM in creating this revolutionary new model for sustainable, affordable homes."

Housing Minister, Rt Hon Christopher Pincher MP, said the competition had demonstrated the best of British design. He announced the joint winners (Igloo with PlusHome and Openstudio with Connector Housing) in a speech made at the Homes UK Conference, acknowledging each of the six finalist teams for their 'ingenuity and perseverance'.

He said: "A panel of judges made up of industry experts, led by Peter Freeman, the new chair of Homes England, selected six outstanding finalists and they have been hard at work developing their initial design concepts into detailed proposals.

"I know that assembling their teams, engaging with cutting-edge ideas and applying their concepts to a real-world site hasn't been easy. I would like to acknowledge the teams from HLM Architects, Igloo, Outpost, Openstudio, Positive Collective and Studio OPEN for their ingenuity and perseverance.

"The Prime Minister has set out his Ten Point Plan on Climate Change, ensuring that when it comes to cutting carbon emissions, our country remains a trailblazer for other countries to follow.

"Our Home of 2030 competition supports us in realising that vision for a cleaner, greener Britain – changing the way we heat our homes, improving insulation and adopting new technologies."

HLM Architects, whose portfolio includes a number of major schemes in Sheffield, says the biggest challenge facing housing both presently and beyond 2030 is a lack of capacity to build to meet the demand of a growing population, with the current shortfall estimated to be at least 100,000 homes per year.

Watson says this situation is further exacerbated by an accelerating skills shortage due to an ageing workforce and low entry of young people into the manual labour side of the construction industry. In tandem, the overarching climate emergency demands that we

build with less waste in construction and reduced energy demands in occupation. Furthermore, the economic situation of the past decade has meant that many young people have been unable to afford to leave the parental home.

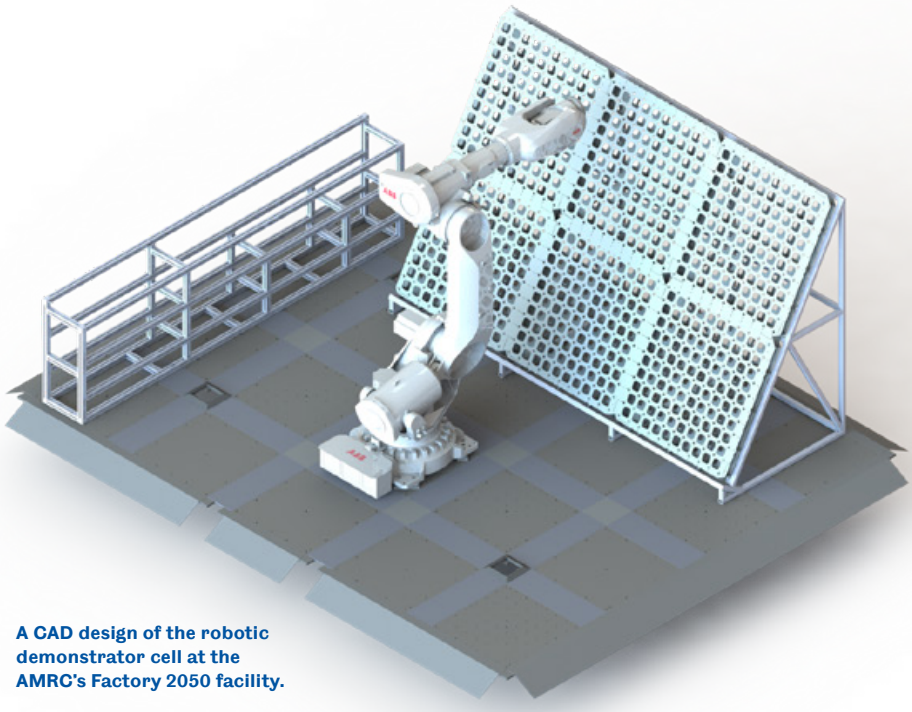
"A new model of affordable housing is required," said Watson. "We believe that to address these challenges head-on we need to make better use of MMC and the benefits it brings, including: improving speed of build; reducing cost; reducing material waste; improving finished quality; improving environmental performance in use; and maximising the social value in that it brings by creating skilled and semi-skilled jobs in manufacturing in controlled and safe environments."

The 'Forever' home system would facilitate a circular economy by using finite resources in a more sustainable way and by allowing manufacturers to refurbish and resell components, increasing their possible revenue streams.

Watson added: "'HLM Architects were looking for a collaborative partner to help develop our concept of a platform agnostic modular home. We have a longstanding relationship with the University of Sheffield and approached the AMRC who were very open to exploring this idea.

"Working with James Illingworth and the team at AMRC was crucial to evolving innovative technical aspects of the concept for the 'ForEva Home'. I am delighted that we continue our collaboration to the second phase of this competition."

Illingworth said supporting the 'Forever' home design concept had been 'an exciting opportunity' for the University of Sheffield AMRC.



A CAD design of the robotic demonstrator cell at the AMRC's Factory 2050 facility.

"The Forever home concept is an agnostic Modern Methods of Construction (MMC) approach, which should enable greater uptake and resilience for both manufacturer and client through putting the customer first to produce an adaptable, sustainable and affordable home," said Illingworth.

"Our role was to explore what the manufacturing process might look like for each stage of the home's lifecycle and I was involved with the brainstorming for the construction methodology.

"The opportunity to develop a concept design standard from the ground up considering the manufacturing approach is fantastic and ensures assembly challenges can be avoided in the future. The AMRC has been able to consider future manufacturing methods that incorporate advanced technologies to ensure a quality-first, productive approach.

"The flexibility of the concept enables offsite manufacturing and distributed construction to be exploited through the home's life cycle, enabling a home for life that can expand and contract according to the owner's needs. Much of the technology required to achieve this can be adapted and applied from other industry sectors such as automotive and aerospace."

Building back better with UK construction

By Katia Harston

National framework provider Pagabo has joined forces with the University of Sheffield Advanced Manufacturing Research Centre (AMRC) for a groundbreaking research agreement that will embrace new ways of working and use learnings from the advanced manufacturing sector to drive transformational advancements within the construction industry.

Together, the two organisations aim to challenge current methods in the construction sector, pioneering fresh ideas and innovations which embrace new technology and advanced manufacturing methods.

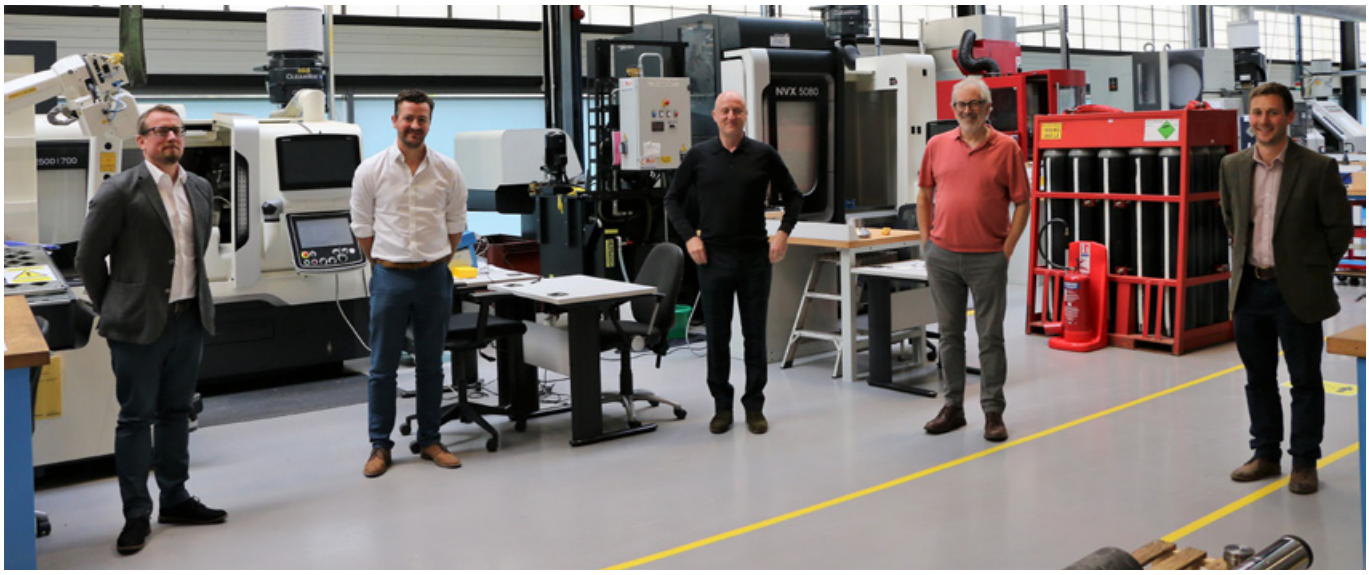
Gerard Toplass, executive chairman of Pagabo, said: "Everyone agrees that construction is a sector that has been left behind in terms of new ways of working and innovation. Many methods in construction have been used for decades.

"What we want to do as a group is to totally shake up the construction sector – and create real change to drive economic growth and establish the UK as a global innovator."

He said that Hull-based Pagabo was so committed to the use of new methods that it had created The Future of Construction (TFOC) initiative to drive industry-wide collaboration to shape the sector's future.

"It's vital that we think about the industry as a whole and how we can promote new technologies to improve how we do things," he explained. "The construction sector needs a revolutionary moment – similar to the aerospace industry when it created the 'black box'.

"This new collaboration between Pagabo and the AMRC will bring the sector together, unify common objectives and drive forward real change. We will be



Steve Foxley, CEO University of Sheffield AMRC; Charley Wainwright and Gerard Toplass, Pagabo; Lord Kerslake; James Illingworth, head of construction research, AMRC.

building an enterprise that seeks to leverage new techniques, innovation and automation.

"We intend to build on the government's agenda for value, procuring for value and its 'build, build, build' initiative. But we also want to foster a new way of doing this that future-proofs the construction sector, secures jobs and builds sustainably – with economic, social and environmental processes in mind."

Steve Foxley, CEO of the University of Sheffield AMRC, said: "We see construction as a wildly exciting and opportunity-filled industry to benefit from our learnings over the past 20 years.

"We want to work closely with Pagabo to create a real catalyst for change. Pagabo has a unique and important role within the industry as a framework provider and has influence across a wider portion of the industry via its ecosystem of contractors and supply chain partners.

"We will be learning from the automotive and aerospace industries and seeing where we can adapt methods and innovations that would work in the construction sector.

"We want to look at areas like enterprise architecture, the future of buildings in a digital world, and how standards and interfaces will enable the digital world in construction."

Joining them in the venture are C4DI - the Hull-based incubator company that promotes growth in tech businesses - specialist data centre company Yondr and industry leader Lord Bob Kerslake.

Just a few weeks into the new relationship, vital research into harnessing technology to streamline health and safety methods on construction sites is already well under way.

Lord Kerslake, the former head of the civil service, is also a non-executive chairman of Pagabo who helped forge its relationship with the AMRC, seeing an opportunity to transform the construction sector through the sharing of expertise and collaboration.

"Research and development are low in construction," he said. "And there is very little collaboration on this among key players in the industry. Combined, we

want to make a real and transformational difference in construction within the next ten years."

He said one of the biggest objectives was to feed into the government's levelling up agenda to create a more level economic playing field across the UK.

"This is a project which sees innovation and development and research in the construction sector happening up north, in Sheffield and in Hull, with a huge focus and drive for economic growth. This new collaboration between Pagabo and the AMRC is hugely powerful."

John Connolly, managing director of C4Di, said the research agreement is powerful because of the way it will accelerate new ways of partnering on innovation.

He said: "There are interesting models of innovation happening around the country, but the AMRC is the exemplar of how to bring large industry bodies together. Their experience harnessing the mental horsepower of large academic institutions and collaborating with industry to drive change is incredibly exciting.

"This new research agreement benefits everyone. Leveraging learning and experience from the AMRC, and Pagabo's connections within construction is a formidable force. The AMRC brought large industry players together to solve their challenges and Pagabo, with its TFOC model, builds on that; this is an exciting next step to extend the work of both organisations through collaboration."

Dave Newitt, CEO of Yondr, the specialist data centre operator, is involved with Pagabo and its TFOC initiative. He said: "We believe that construction has a great deal to learn from manufacturing. We want to look at modularisation and taking works off-site – so, building off site rather than on site. It's how the manufacturing world operates, and we want to emulate that to improve productivity."

Professor Rab Scott, head of digital at the University of Sheffield AMRC, said that in just four weeks, the new collaboration had already created change.

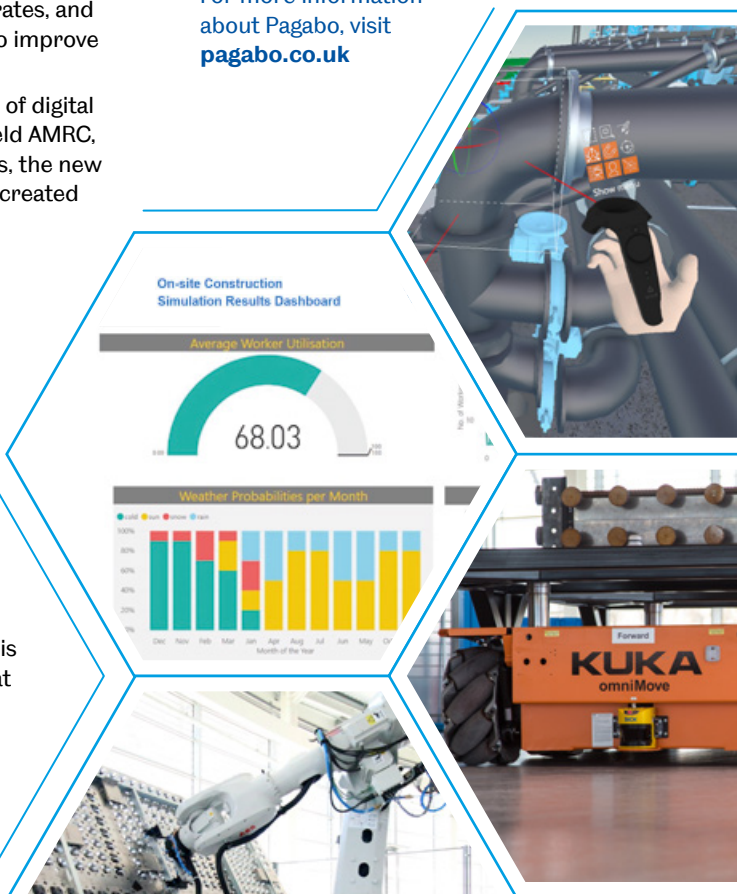
"We have already started working with Pagabo on health and safety on site and are looking at ways of using digital technologies to streamline processes. In terms of results, if we can prevent one accident or one hour's lost time, it has an immediate benefit, and our work is immediately scalable.

"The diversity in the team is one of the great things that makes me get up in the morning. We are proud of what we are doing and what we are going to do.

It is about meaningful relationships, and this is just the start of the journey."

The collaborating team is to meet throughout the year to monitor progress. It will announce further steps soon and is planning a conference in Hull this year.

For more information about Pagabo, visit **pagabo.co.uk**



Small cost, big improvement

By James Crossling

Specialist precision engineering sub-contractor CBE+ use a WNT tool in their machining.

Image: Ceratizit Group.

A precision engineering SME has been shown how an investment of just £20 could bring about a huge improvement in its manufacturing process and unlock significant savings, following a free R&D intervention by the University of Sheffield Advanced Manufacturing Research Centre (AMRC).

"We were able to show the management at CBE+ that with a new tool holder, which would cost £60 rather than the £40 one they currently use, they could get a 10 to 15 per cent improvement on their tool life," said Tom McCready, Technical Fellow in the AMRC's Machining Group.

The AMRC is part of the High Value Manufacturing (HVM) Catapult and the five-day assist project with Chesterfield-based specialist precision engineering sub-contractor CBE+ was paid for using funds from the HVM Catapult as part of a commitment to working with small and medium-sized manufacturers.

AMRC engineers met with CBE+ at the AMRC's very first SME engagement workshop, designed to show manufacturers what capabilities the AMRC has to offer and explain the funding available.

Dave Allen, senior CNC machinist at CBE+, said: "The AMRC offered to fund an improvement project of our choice, working alongside our team to improve an aspect of our efficiency and we decided our machining division would be best suited to the AMRC's work.

"We had been using replaceable insert cutters as the milling tool on certain jobs, however this was a lengthy process and caused problematic vibrations on the machine."

Engineers at both CBE+ and the AMRC investigated what changes could be made to decrease the time it took to machine products. CBE+'s solution was to change the tool to a trochoidal tool, which offered full depth when machining. This simple change cut 14 minutes off the total time of each part machined, bringing the production cost per part dramatically down and giving

CBE+ more capacity.

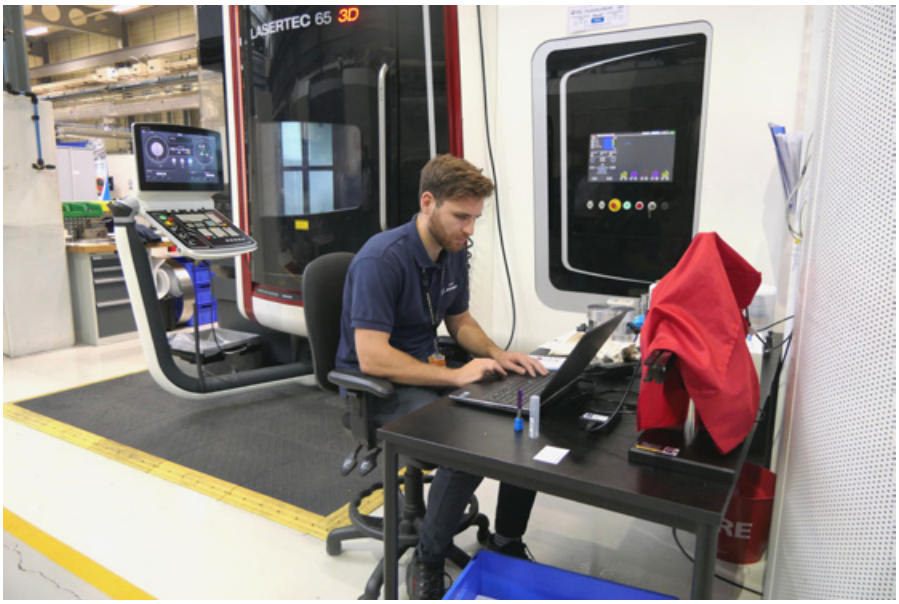
Tom said the AMRC was able to find potentially significant improvements in another area: "Based on their process of making some stainless steel brackets which needed to be in different sizes, I was struck by the potential efficiencies we could find with the tool holder, rather than the tool itself."

CBE+ use a WNT tool in their machining and, through WNT's parent company Ceratizit's Tier One membership of the AMRC, the Machining Group was able to take two of the same tools on consignment to conduct test cuts with a series of different tool holders.

"We brought these tool holders to CBE+'s site in Chesterfield, TAP tested them all in their spindle and gave them conclusive data that a new tool holder would get an improvement in their tool life of approximately 10 to 15 per cent. CBE+ have now bought that tool holder and we're going to do some test cuts with them to prove that hypothesis," said Tom.

"It won't just apply to this component though; it will apply to any material. We have said to initially test the new tool holder on stainless steel, make sure they are happy with it and then apply it to all their components.

"Hopefully, they will get exactly the same benefits, so we have basically opened the gate to a large improvement in their business which would far outweigh the investment."



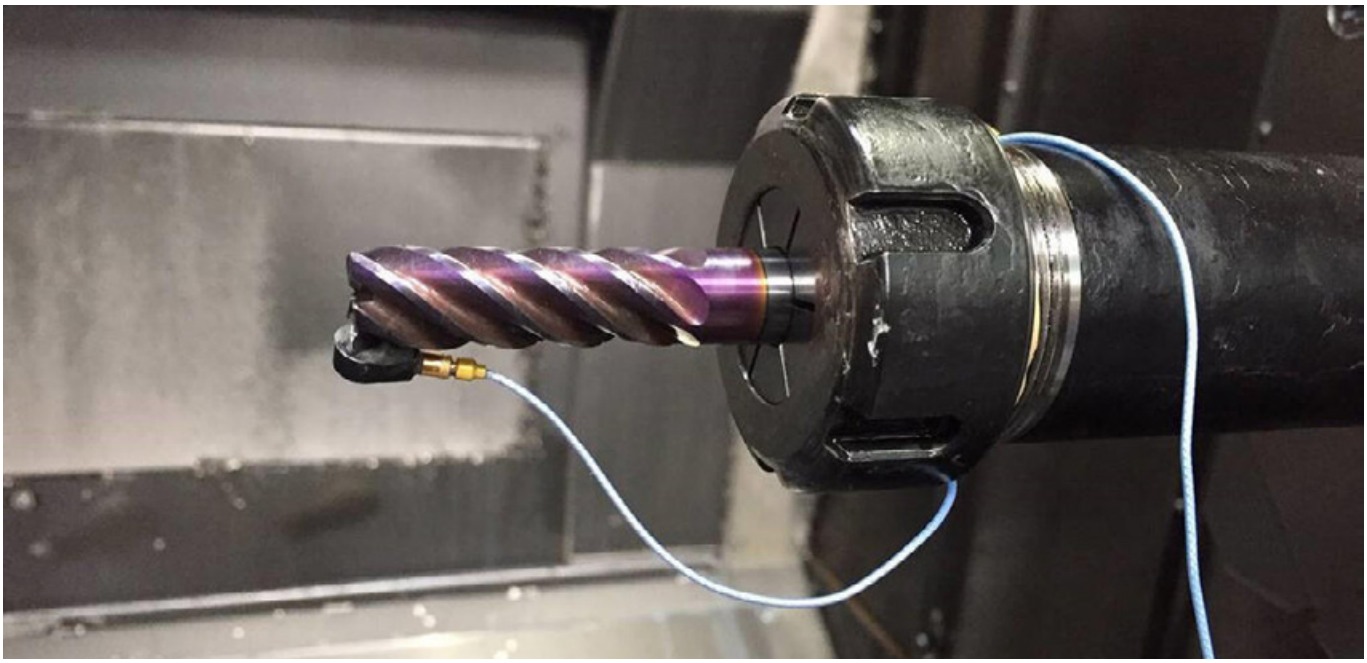
Project Engineer Joe Clulow studies the data from the test cuts conducted at CBE+ on the shop floor at the AMRC's Factory of the Future.

Dave said: "It was great to work with the AMRC on this project. We learnt a lot in the time we spent working with them and I hope to team up on future projects. It was also great to confirm our team is working to the best of their ability, it gives us a real sense of pride."

Tom said the project is the epitome of what the AMRC can do for businesses of all sizes, de-risking innovation to help them make step-changes in their manufacturing processes.

"Because we had access to the tool holders through WNT, we were able to take them to CBE+, put them in their spindle and give them scientific evidence through our diagnostic software from which CBE+ can then make an informed decision," said Tom.

"That data, to back up what we were saying, was crucial; without it CBE+ would have spent a lot longer on machine through trial and error experimentation. It is a perfect example of what the HVM Catapult five-day assist projects can offer SMEs."



The milling tool used by CBE+ was TAP tested by AMRC engineers during the five-day assist project.

The Leica Absolute Tracker was used by the AMRC to measure the frame extensions being stored in the East Lancashire Railway works in Bury.

A hole lot of trouble for loco rebuild fixed

A steam train not seen since the 1960s is being rebuilt by a group of engineering enthusiasts with the help of industrial laser scanning experts at the University of Sheffield AMRC, who got the measure of a mysterious discrepancy between the original drawings and the actual locomotive.

Katia Harston climbs aboard to find out more.

Tim Gears from Hexagon Manufacturing Intelligence putting the Leica Laser Tracker through its paces.

The Standard Steam Locomotive Company group has set itself the ambitious challenge to recreate, operate and maintain a lost class of British steam train - a British Railways' Standard Class 6 'Clan' - using the original 1950s design drawings and 21st century engineering; incorporating modern design and manufacturing techniques and technologies into the build.

The University of Sheffield Advanced Manufacturing Research Centre (AMRC) was involved in a major frame alignment measuring exercise for the project, after a review of the build inventory showed critical gaps in documentation for some of the key parts relating to the locomotive's frames.

Dr Phil Yates is a chartered engineer at the AMRC working on regional and SME development within Factory 2050, and a member of the volunteer group whose headquarters are located at specialist engineering firm CTL Seal Ltd in Sheffield, which has generously allocated an area of its shop floor to give the volunteer team a dedicated space in which to assemble the lost locomotive.

Dr Yates said critical gaps in documentation for some of the parts are thought to be due to the fact that, 80 years ago, there was no direct link between the drawing office and shop floor, as the locomotive was designed and constructed in separate locations some 50 miles apart.

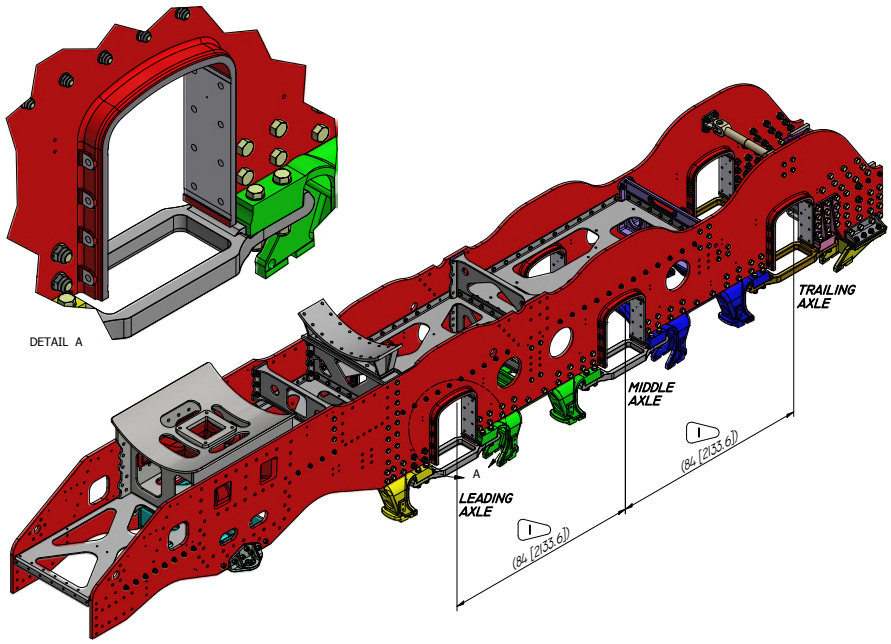
"The Standard Class was designed at the drawing office of the Derby Works while the locomotives were constructed at British Railways' Crewe Works between 1951 and 1954. So the drawing office was nowhere near where they made the locomotive and back then people made stuff based on what they knew rather than what was in the drawing. You have to bear in mind the drawing does not show how a part is manufactured.

"In some ways the drawings were a wish of intent. By the time they got to the shop floor - some 50 miles away in Crewe - if there was a mistake, they would correct it and make a note of it in a little black book which more often than not, never made it back to the drawing office for the error to be corrected in the original drawings.

"That's what these errors are - they show the disconnect between the drawing office and the shop floor. In those days, people just had their little black books of how to make stuff. It was all the tacit knowledge on the shop floor that actually made it work. So when people left, how to make these bits just went with them."

Further doubts on the functionality of the parts were raised when the original 1950s British Rail drawings were converted and turned into CAD (computer-aided design) models, as Dr Yates explains.

"One of the main components that caused serious concern were the frame extensions; the CAD had been produced after the part had been previously manufactured prior to the manufacture of the mainframe plates. The way the fastener hole patterns had



been datumed on the frame and the frame extensions was not identical, so when the parts were aligned in CAD, the fastener holes did not align. The maximum error on the CAD components was 1.6mm.

"The error was because the two original drawings didn't match. The person who did the drawing of the frame and the person who did the drawing of the frame extensions - one of them got something wrong or different - so they didn't align."

Poor draughtsmanship and not understanding manufacturing methods can lead to misinterpretation of drawings; a problem then as it is in today's world. Understanding manufacturing methods is essential in dimensioning drawings with clarity.

As both the frames and their extensions had been laser profiled by separate companies to the original drawing, it was assumed that these errors existed in the parts. To ascertain the size of the error, the frames and frame extensions, which were stored in separate locations, had to be measured.

To measure the frame extensions, which were being stored at East Lancashire Railway works, Dr Yates and Factory 2050's theme lead for inspection and AI, Tom Hodgson, used a Leica Absolute Tracker AT402 laser scanner combined with a Leica B-Probe. The portable coordinate measuring machine, manufactured by AMRC tier one research partner Hexagon Manufacturing Intelligence, enables extreme accuracy over large distances - ideal for the 13ft long frame extensions of a steam locomotive.

When Yates and Hodgson came to measure the 106 holes in the frame extensions, they found themselves working in the shadow of the Flying Scotsman, the world's first high speed train – built in Doncaster – which was in the Bury workshop at the same time.

Yates said: "The frame extensions were over at the East Lancashire Railway works and the Flying Scotsman was there at the time so it was nice to admire the world's most famous passenger locomotive.

"Tom Hodgson and I did the measurement work on the frame extensions. They were being stored in a freezing cold shed and that was something we had to consider because temperature can affect measurement work.

"Materials can shrink and grow with changes in temperature. To account for that involves some tricky maths and we've compensated for it best we can by gauging how much the material would move by a ten degrees difference in temperature."

Geoff Turner, the group's engineering director, said access to University of Sheffield AMRC's expertise and Hexagon Manufacturing Intelligence's advanced equipment allowed for fast, accurate data to be collected and for the errors to be remedied quickly.

He said: "The Leica AT402 was ideal for measuring the frame extensions in situ in the engine shed, negating the need to find a dedicated inspection room and giving us accurate data in the three planes identifying the errors which we were able to correct."

Yates added: "Because we knew this before assembly, we could work out a strategy for re-doing the holes and make slightly oversized fasteners for where the holes were wrong."

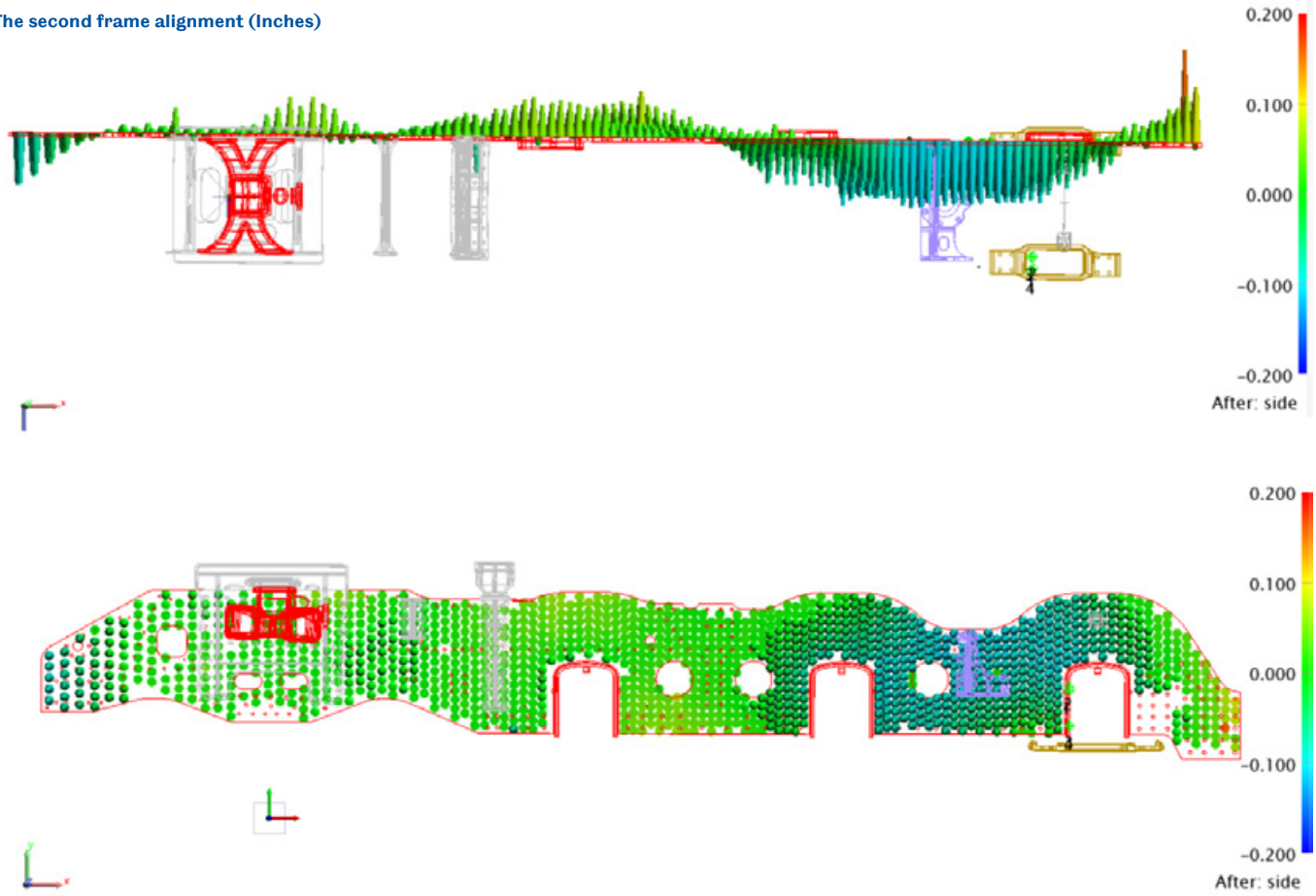
Assembly for the locomotive is being done at specialist Sheffield engineering firm CTL Seal Ltd, which also doubles as the volunteer group's headquarters.

Its frame comprises of main frame plates held apart by fabricated steel frame stretchers, cast steel frame stretchers and pressed steel horizontal frame stretchers. All of these components were manufactured by different suppliers so to ensure the different

"I have measured many things, from an Airbus A380 to a Eurofighter, but never a steam locomotive. Seeing first-hand the versatility of our Leica ATS600, and the flexibility that reflectorless scanning gave us made it perfect as the measurement tool of choice."

Tim Gears, Business Development Manager at Hexagon Manufacturing Intelligence

The second frame alignment (Inches)



components were all manufactured to the same dimensional accuracy, the project team needed confirmation of the frame assembly dimensions.

To do this, Yates and the Standard Steam volunteer group enlisted further help from AMRC partner Hexagon Manufacturing Intelligence, this time trialling a new type of targetless scanning tracker - the Leica Laser Tracker ATS600.

Its scanning ability was ideally suited to the task, says Yates, and Hexagon Manufacturing Intelligence loaned one to the project along with the expertise of its application engineers, Tim Gears and Barry Dimelow.

Tim said: "Hexagon has been supporting AMRC through our tier one partnership since 2013. We have been involved in many projects, but not one as interesting as scanning a 1950s steam locomotive.

"I have measured many things, from an Airbus A380 to a Eurofighter, but never a steam locomotive. Seeing first-hand the versatility of our Leica ATS600, and the flexibility that reflectorless scanning gave us, made it perfect as the measurement tool of choice."

The Leica Absolute Tracker ATS600 is a metrology-grade large volume scanner, combining scanning with tactile measurements seamlessly. It has a scanning range from one to 60 metres, and a reflector range of one to 80 metres; a scanning rate up to 1 kHz and a scanning speed of up to ten10 sec/m2.

It didn't fail to impress. Measurements from the first scan, which consisted of 2,788 points, took just two minutes and showed the frame had a significant bow in it. Further investigation revealed the bow had been caused by a packing piece being left in situ, which had been fitted to allow the removal and replacement of one of the frame stretchers for machining.

By using the combined scan and probing data, the rotational relationship of the frames could be determined.

Yates added: "This showed that the frames were rotating around a point between the second and third driving wheel. The point at the exhaust steam spider was 0.119 inches (3.02mm) high. The manufacturing engineers were shown graphically the relationship between the two frames.

"With the frames loosened and then re-aligned, a second scan was completed and that showed that the frames were aligned and they could progress to final bolting. The position and relationship between the horn guides and the cylinder mounting points was also recorded so that in the final machining procedure, a probing and datuming section could be completed thus saving time on the machine."

Engineering director for the group, Geoff Turner, said the laser scanning survey proved to be another huge help to the project: "It saved so much time compared with using traditional measuring equipment and crucially, it meant that real time adjustments could be made as the survey was in progress."

Rapid response prototyping

keeps COVID clinicians safe

By Katia Harston

Additive manufacturing experts at the University of Sheffield Advanced Manufacturing Research Centre (AMRC) made crucial parts for a protective respirator prototype within a week to help a small design company develop novel PPE to keep clinicians safe while working in Covid-19 intensive care units.

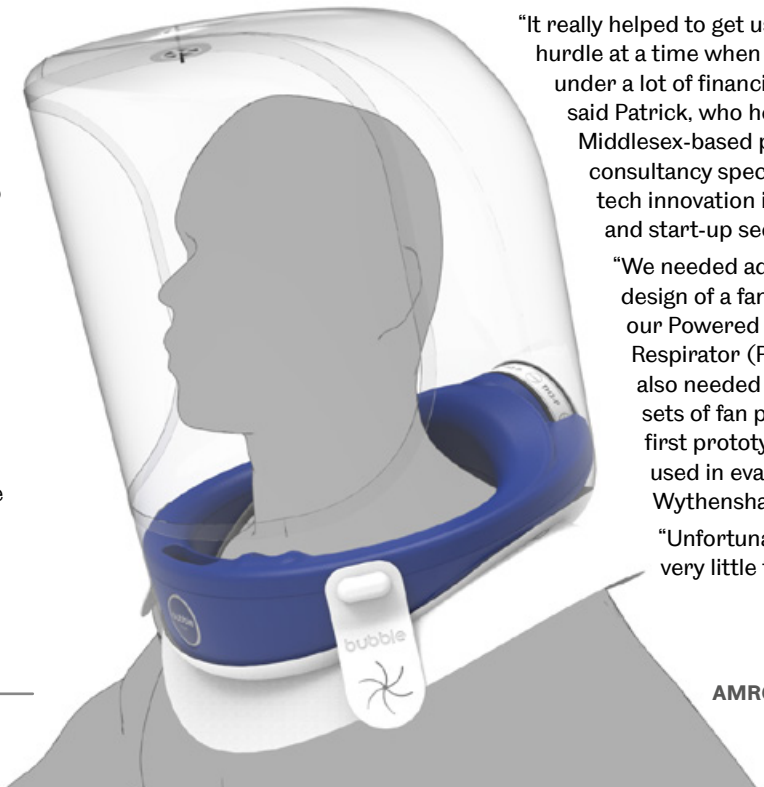
The Bubble PAPR is a low-cost Powered Air-Purifying Respirator developed by Designing Science, a med-tech design consultancy, working with clinicians at Wythenshawe Hospital, part of Manchester University NHS Foundation Trust (MFT), and specialists at Manchester University, to protect frontline healthcare staff during the Covid-19 pandemic.

The simple low-cost device consists of a reusable collar that sits around the neck and a single-use plastic hood that can be easily recycled. The collar contains a fan to draw in air through a virus filter and delivers a cooling airflow around the face. It is designed to be compatible with stringent infection control practices but be comfortable to wear for the duration of a shift in ICU, or other high-risk areas. The wearer's face is also clearly visible to improve communication between staff and patients.

Rapid polymer prototypes for critical components including the Bubble PAPR's ventilation system, impeller and fan housing, were created by Mark Cocking, the AMRC's polymer additive technical lead at the Design and Prototyping Group using funding from the High Value Manufacturing (HVM) Catapult to get the job done even quicker.

Mark said: "Designing Science approached us for assistance with Additive Manufacture (AM) design, material, and process selection. As the request was in relation to development for advanced Covid-19 PPE, it was essential to provide functional components in a reduced time frame.

"To do this we implemented a custom support solution using the FormLabs SLA platform with resin suited to the required mechanical properties. Because of the urgency of the request, we used a bank of printers to speed up the production.



"We were able to deliver an optimised AM print strategy enabling challenging, first-time print components to be delivered for testing by the customer within the week."

Patrick Hall, managing director of Designing Science, said the AMRC's expertise and rapid response allowed them to complete the design successfully. The project is one of hundreds that the AMRC and the HMV Catapult fund as part of their commitment to smaller and medium sized UK businesses.

"It really helped to get us over a financial hurdle at a time when the project was under a lot of financial pressure," said Patrick, who heads up the Middlesex-based product design consultancy specialising in med-tech innovation in the university and start-up sector.

"We needed advice on the design of a fan for use in our Powered Air Purifying Respirator (PAPR) but we also needed to create five sets of fan parts for our first prototypes to be used in evaluations at Wythenshawe Hospital.

"Unfortunately, we had very little funding. We

Image: Manchester University NHS Foundation Trust.

The 'Bubble PAPR' could be a breakthrough to protect staff during the pandemic.

approached the AMRC for help and the engineers there reviewed our fan design and offered advice; they also offered to 3D build the parts for us at zero cost.

"It meant we were able to complete the design successfully; the AMRC delivered the parts and we were able to assemble them into our prototypes and successfully carry out the testing and launch the product.

"The AMRC team was really helpful and professional. Their breadth of experience and resources was of great help for us at a time when the project was under strain."

The Bubble PAPR is a collaboration between MFT, Designing Science and the University of Manchester to identify unmet clinical needs and work collaboratively to develop new solutions.

Patrick, who has more than 30 years' experience in product design and medical innovation, said: "Most current PAPRs are repurposed industrial devices not designed for clinical use and are expensive. We have taken a user-centred design approach to engineer and develop the Bubble PAPR to be as simple as possible while meeting key functional and ergonomic requirements.

"This means it can be easily and cheaply manufactured in large volumes so it can be made available right across the healthcare system, wherever clinical and support staff are interacting with patients who have confirmed or suspected Covid-19 or other serious infections."

Patrick explained how the PPE concept came to be. "Early on in the Covid-19 crisis we asked our long-time collaborator Dr Brendan McGrath, an Intensive Care Consultant at Wythenshawe Hospital, whether there was anything Designing Science could do to help. The answer came back swiftly: 'design a better PAPR'.

"We began a crash program to develop something better, and we quickly focused on the concept of a simple, head-worn device which minimised the exposure of re-usable parts to Covid-19 bearing aerosols by containing, nearly everything, within a disposable hood.

"Weeks of intensive iterative design and prototyping followed where we refined the concept, developing a custom impeller which could be driven by a 5V DC motor and capable of generating the flows we needed to keep the hood inflated and the wearer cool and ventilated.

"Donning and doffing PPE in Covid-19 wards is an exacting and intricate process which must be carried out with discipline. Lockdown restricted our user research to video-conferencing, but we were able to understand user and environmental needs and design a solution which supported good practice."

The team had to overcome many design challenges to create a working design, says Patrick, such as regulations dictating the need for a low-flow indicator, but their intention to avoid electronics meant developing a mechanical solution. That led to the creation of the mechanical low-flow sensor, consisting of a handful of mechanical parts, which is sensitive enough to respond to reductions in airflow and alerts the wearer when flow drops below a threshold.

Dr Brendan McGrath, Intensive Care Consultant at Wythenshawe Hospital, has been the clinical lead through the development and testing process. He said: "We have tested Bubble PAPR and we know it performs its primary function, which is to protect staff against inhalation of airborne viruses. We have also now tested it in the simulated clinical environment. The reaction from staff has been overwhelmingly positive: they saw something that was not restrictive on their face, that allowed them to communicate with their colleagues, that was pleasant to wear and will allow them to interact with their patients."

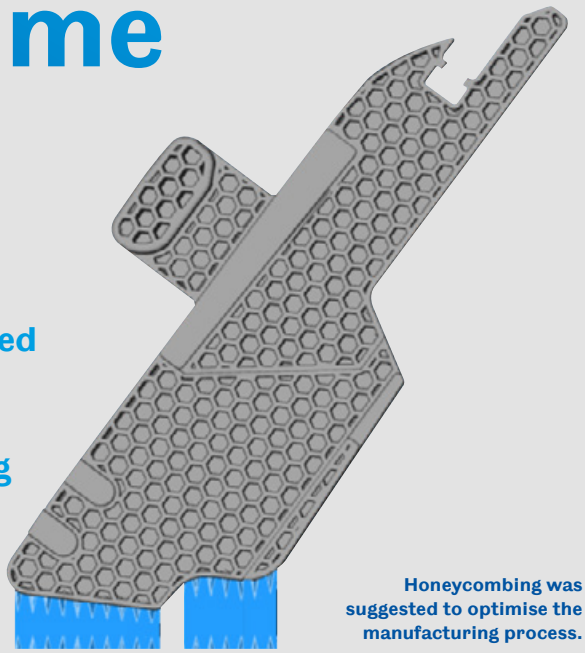
Dr Glen Cooper, Program Director for Mechanical Engineering Design, School of Engineering, The University of Manchester, said: "The Bubble PAPR is both ergonomically and mechanically the right product to meet the need to protect NHS staff during the Covid crisis and beyond."

The Safety Knife Company's ReAkta Knife.

Cutting wasted product development time for knife maker

By James Crossling

Engineers at the University of Sheffield Advanced Manufacturing Research Centre (AMRC) have saved a knife manufacturer valuable time and wasted energy by simulating the manufacturing process and estimating the production costs of introducing additive manufacturing (AM) in its production process.



Honeycombing was suggested to optimise the manufacturing process.

"We were given a definitive answer," said David Harris, General Manager of Gloucester-based The Safety Knife Company. "The answer may have been that unit price was going to be prohibitive and that we needed to look in a different direction, but it stopped us wasting our own time and money testing it out ourselves.

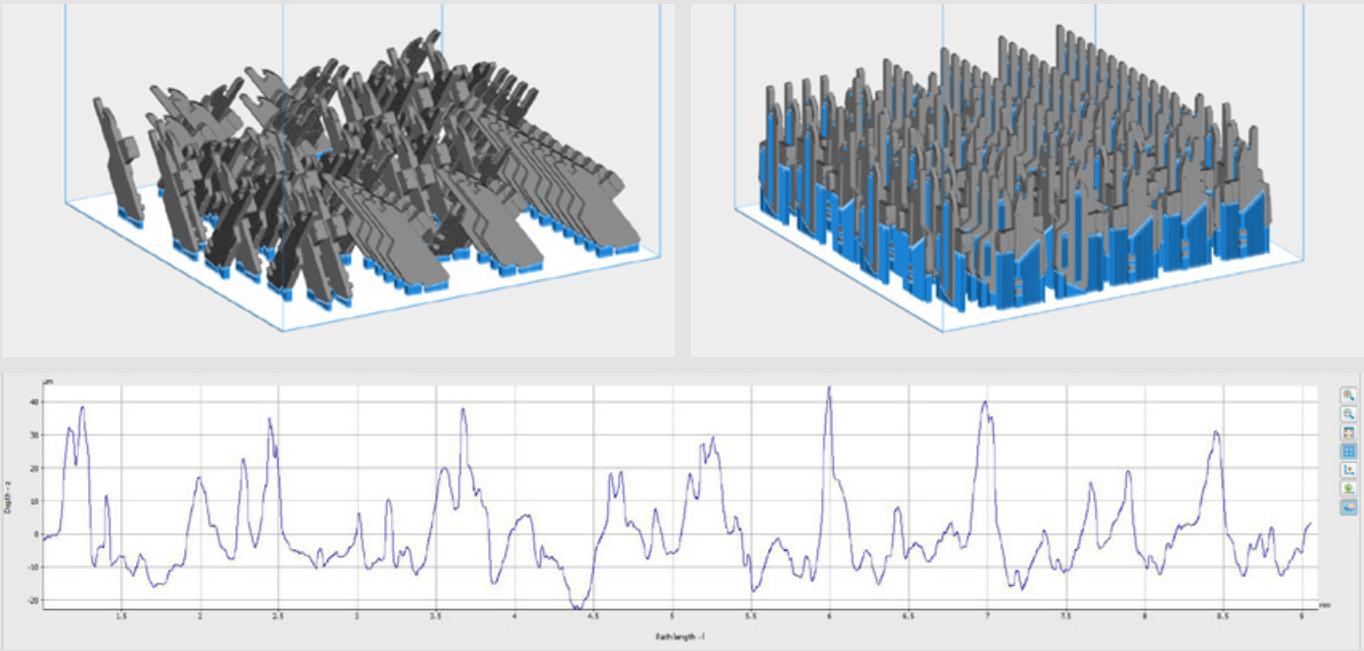
"We never would have got to that conclusive answer on our own without using the expertise of the AMRC."

The Safety Knife Company was formed in 1993 with a license from Bill Ireland who invented his pioneering Fish Safety Knife after a chance encounter with a farmer who had lost an eye when cutting a hay bale string.

Bill, 84, was working as an engineer at Dowty Group at the time and prototyped a knife with a fish-shaped handle which curves around the blade making it safer to use without compromising functionality. Originally marketed as a gardening product, now The Safety Knife Company products are a staple of warehouses around the world and in 2015, Bill was awarded an MBE in the Queen's Birthday Honours for services to innovation.

"The product we needed help with is called the ReAkta Knife which has a retractable blade. It was patented around 10 years ago, but we are yet to find a viable way of manufacturing the blade carrier," said David.

"Originally, we had the part machined and more recently we have had them cast in aluminium; but both have meant



AMRC engineers simulated a Laser Powder Bed Fusion (L-PBF) manufacturing process for the knife's aluminium alloy components.

an awful lot of quality problems and the components need to be fettled manually to achieve the required fit. What we wanted from the AMRC was to research how viable it would be to use additive manufacturing 3D printing to make this blade carrier part."

A team at the AMRC's National Metals Technology Centre (NAMTEC) conducted a feasibility study to determine whether Laser Powder Bed Fusion (L-PBF) is a suitable manufacturing process for the aluminium alloy components required for the blade carrier.

The AMRC is part of the High Value Manufacturing (HVM) Catapult and the project was paid for using funds from the HVM Catapult as part of a commitment to working with small and medium-sized manufacturers.

Project engineer at NAMTEC, James Cantle, said: "The Safety Knife Company wanted a new manufacturing process that would reduce manual fettling during the assembly stage of production. We were able to review component design in line with AM considerations, establish manufacturing process times based on the L-PBF process and use process modelling to identify production levels and the associated cost of manufacture."

James said they were also able to demonstrate how design principle changes and component modification could open the door to integrating additively manufactured parts:

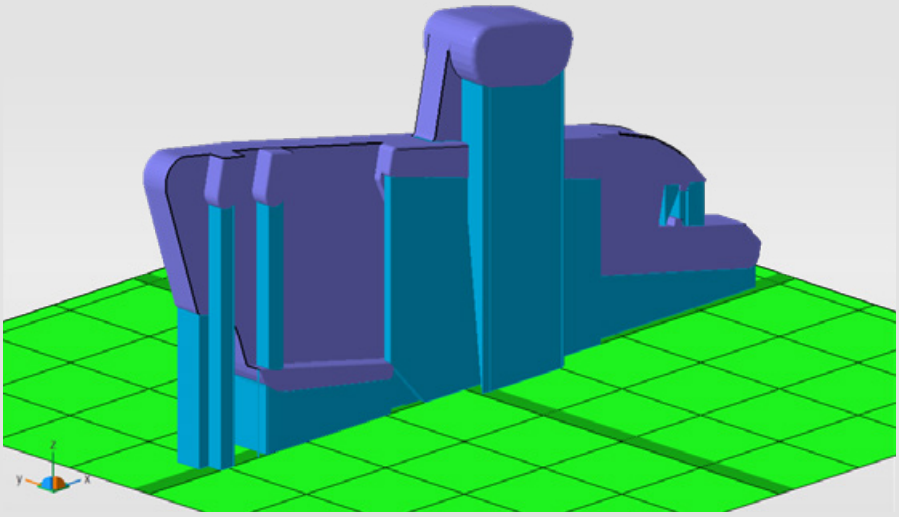
"We suggested some component modification to optimise the manufacturing process. Using honeycombing on the component saved a significant amount of weight and vastly reduced the material required."

David said: "The project was certainly extremely useful. We already knew the component could be 3D printed incredibly accurately, but we lacked the ability to determine if it was financially viable for us and it was invaluable to be able to put that task in the hands of people who knew how to find that out.

"Even though the conclusion was that it wasn't viable, at least we got to a point where we knew it wasn't an option and it has pushed us down the route of machining the component again."

David said the project has also opened his eyes to the potential of 3D printing: "Additive manufacturing is certainly in our minds. It is an option for us to consider as we go forward with other projects.

"Who knows what we are going to be doing, when we get back set up, in terms of product development. We know that any type of manufacturing issue that we might have in the future, we always have the option of approaching the AMRC to utilise their expertise and potentially help us again."



The Safety Knife Company were presented with a feasibility study including simulation data and images.

‘Apprentice of the Year’

Bethany gears up for bright future

A ‘proven high-flier’ displaying ‘ambition and academic excellence’ is how Bethany Cousins was described by Stanley Black & Decker boss Sir George Buckley when he announced her as overall winner of the AMRC Training Centre Apprentice of the Year Awards.

Bethany, a Manufacturing Technology degree apprentice who works as a project engineer at the University of Sheffield Advanced Manufacturing Research Centre (AMRC), was crowned the 2020 champion by Sir George at an online celebration held in December. She was also named ‘degree apprentice of the year’, making it a double win for the talented 25-year-old.

Bethany, whose work for the AMRC Gear Centre team focuses on developing novel gear cutting techniques for gear manufacturing, was ‘shocked and beyond grateful’ to have been recognised for both awards.

“It honestly means the absolute world to me and is the perfect positive ending to this year in particular,” she said. “This has definitely been the highlight and best way I could have ever wanted to end my apprenticeship journey.

“I can’t thank all of the staff and trainers at the AMRC Training Centre enough. I can honestly say I wouldn’t be the engineer I am today without each of them and the AMRC has been a support network beyond anything I could have asked for in an employer.”

Sir George, whose company Stanley Black & Decker was headline sponsor for this year’s awards, left school with no qualifications and began his extraordinary career as an apprentice electrician at Stanley, going on to become the first non-American to be made head of 3M and the only British CEO of a Fortune 500 company.

24 hour social media takeover

A celebration event had been scheduled to take place earlier this year in Sheffield but the Covid-19 pandemic meant the ceremony had to move to the virtual world with a '24-hour social media takeover' to mark the occasion.

He was part of the panel that chose the winners and described Bethany as a 'committed and impressive apprentice', praising her abilities as an engineer and skills ambassador for the region.

"Bethany displayed great ambition and academic excellence and is regarded as absolutely outstanding by the AMRC Training Centre, having impressed with her academic achievements," said Sir George. "She scored the top mark at the end of her degree apprenticeship second year and has gone on to achieve a clear first-class honours degree.

"There's no doubt in the judges' minds that Bethany is a genuine and proven high-flier. She has shown determination second-to-none, which has helped her excel in her studies and play a pivotal role in her position within the AMRC.

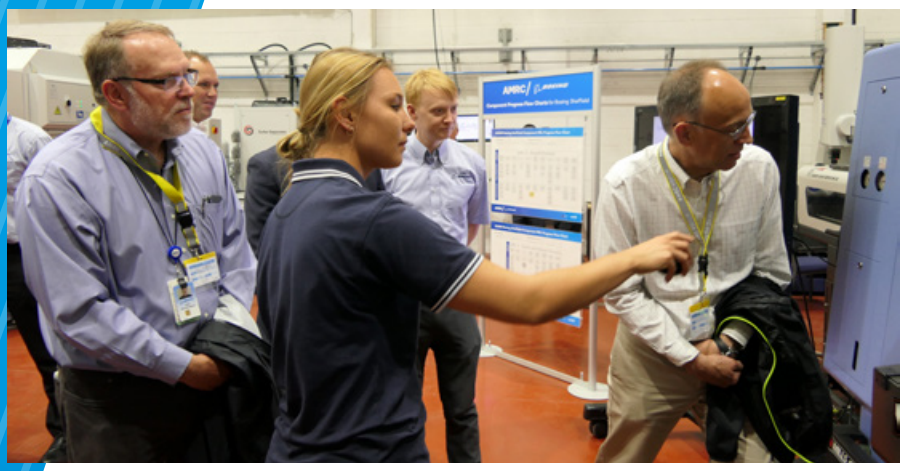
"We were very impressed with Bethany's ambassadorial qualities - she genuinely champions the principles of apprenticeships and is an inspirational role model to all young engineers."

A celebration event had been scheduled to take place earlier this year at Firth Court in Sheffield but the Covid-19 pandemic meant the ceremony had to move to the virtual world with the University of Sheffield AMRC Training Centre holding a '24-hour social media takeover' to mark the occasion.

Nominations for the awards were made by employers and trainers to recognise the achievement or contribution apprentices have made to industry and were judged by a panel of AMRC Training Centre staff and award sponsors.

As part of her prize for winning the overall Apprentice of the Year 2020 title, Bethany will be rewarded with a visit to Stanley Black & Decker's Global Tools & Storage headquarters in Towson, Maryland, USA - when safe to do so - and will have the opportunity of additional training that includes best practice in advanced, innovative subjects such as

Bethany meeting Gladys Berejiklian, New South Wales Premier, in 2019.



Bethany demonstrating a machining process for the then General Manager of Boeing Portland Dave Hyem and his team who came to see the research and development work that supported operations at Boeing Sheffield ahead of its opening in 2018.

automation, robotics, additive design and manufacturing.

Bethany, of Sheffield, is excited for what the future holds.

"I can't even get my head around the prize at this stage. For me this is a once in a lifetime opportunity I am so unbelievably excited about," she said. "I'm hoping for onwards and upwards in the future, continuing to develop my skills and capabilities as an engineer and striving for the best opportunities and achievements that I can reach."

Ben Cook, Technical Fellow at the AMRC who leads the Gear Centre research team, said Bethany's appetite and enthusiasm for engineering is boundless and she is an asset to the AMRC.

He said: "As soon as she joined us as a machinist, she quickly learned how to get the most out of our new machine tools and was soon suggesting methods of enhancing the quality and productivity of the components she was making for us.

"Now, as a project engineer, she undertakes a much broader role including design of experiments, programming, analysis of data and reporting of results to customers and academia.

"Bethany is accomplished in each area and developing further at pace, which shows the great benefit of her apprenticeship background which has given her such a solid foundation in manufacturing science and application.

"She is an enormous asset to the Gear Centre team, the wider AMRC and the clients she is undertaking research for and is a highly worthy winner of the Apprentice of the Year award."

Other winners at this year's annual awards were:

Fabrication and Welding: Rhys Jordan Lowe of Dearneside Fabrications, sponsored by C&S Fabrications;

Maintenance: Joshua Keyworth of Pryor Marking Technology, sponsored by Hexagon Manufacturing Intelligence;

Machining: Dalton Philip Brodie of AESSEAL, sponsored by Sandvik Coromant;

Technical Support: Will Smith of Radius Aerospace, sponsored by the MTA;

First Year: Kirbi Leigh Taylor of NIKKEN, sponsored by Hallam FM;

HNC Achiever of the Year: Jordan Clayton of Polypipe, sponsored by NIKKEN;

Degree Apprentice: Bethany Cousins of University of Sheffield AMRC, sponsored by Close Brothers;

Special Recognition Award: Dalton Philip Brodie of AESSEAL, sponsored by Boeing.

Outstanding contribution awards, sponsored by the University of Sheffield AMRC, were given to university teacher Kathryn Jackson for her 'unrivalled attention to detail, tenacity and determination' and the integral part she played in developing the centre's degree programme. Also recognised was programme administrator Linda White for the care and help given to students, who described her as being 'worth her weight in gold'.

Director of the AMRC Training Centre, Nikki Jones, is proud of 'each and every one' of the apprentices; not only for how they have coped with the challenges brought about by the Covid pandemic during 2020 but for their dedication and commitment to achieving their apprenticeship ambitions.

"This ceremony has always been about embracing the future and that feels more relevant now than ever as we look to the talents of our smart apprentices to help manufacturing and engineering on the road to recovery and towards a smart, sustainable resilient future.

"It's been a tough year for all of us but I can't help but be filled with pride when I think of how our apprentices have risen to the challenges brought about by the pandemic; they have proven themselves with a determined passion and tenacity to succeed."

Steve Foxley, CEO of the University of Sheffield AMRC, congratulated the apprentices and said they should serve as an inspiration to us all.

"We're hugely proud of our apprentices. Seeing their impressive achievements fills me with hope for the future" he said. "They are part of the pipeline of talent that draws manufacturers large and small to invest in the Sheffield City Region.

"It's why we are committed to supporting the quality education needed to fuel the manufacturing and engineering sectors both regionally and nationally, equipping them with the highly-skilled workforces they need to innovate, grow and succeed.

"Apprentices are not only the lifeblood for the region's businesses, they are leading the transformation towards a green, sustainable and a resilient economy. That's why credit must go to the AMRC Training Centre - a critical part of the wider AMRC family whose tremendous positive impact on the region makes it a true engine of social change."

University of Sheffield Vice Chancellor, Prof Koen Lamberts, praised the apprentices for the resilience they have shown throughout the pandemic and the impact they continue to have on their companies.

In a video message for the ceremony, he told them: "You make a real difference, and I know you will continue to do so in the months and years ahead. The stories we have heard show why apprentices like you and the excellent training you receive here are so important."

World's biggest tool company

sponsors engineering apprentice awards

Sir George Buckley, Chairman of Stanley Black & Decker.

Iconic toolmaker Stanley Black & Decker was headline sponsor for the sixth annual AMRC Training Centre Apprentice of the Year Awards.

The world's largest manufacturer of tools, founded 177 years ago by Frederick Stanley, put its full support behind the 2020 awards, sharing the AMRC Training Centre's vision for creating the skilled and thriving workforce that industry needs to innovate and grow.

It builds on Stanley Black & Decker's long-standing relationship with the training centre in fostering a culture of continuous learning and investment in the next generation of engineering talent. The company already sponsors the training centre's internal 'Spotlight Awards', providing toolbox kit prizes to apprentices who excelled in their first year of training.

Sir George Buckley, the Chairman of Stanley Black & Decker, said: "I'm absolutely delighted that Stanley Black & Decker was able to support these important awards. It was my distinct pleasure to be part of the judging panels that decided the eventual winner. The quality of the submissions was superb, and the competition was fierce."

The Apprentice of the Year Awards is a highlight in the AMRC Training Centre calendar and recognises the achievement, innovation, fresh thinking and contribution apprentices and their employers make to industry.

The ceremony is usually held at the stunning Firth Hall at the University of Sheffield's Firth Court campus but it was not possible this time due to the coronavirus pandemic. Instead, to ensure apprentices did not miss out, the awards were presented to winners in the virtual world. The top apprentice was awarded with a visit to Stanley Black & Decker's Global Tools & Storage headquarters in Towson, Maryland, USA.

Stanley Black & Decker is known to households and workshops the world over: homes and cars are repaired with their tools, cars and phones are secured with their fasteners, and their security systems protect things people value the most. But at the heart of the global-industrial company is people and a commitment to innovation, performance and social responsibility; an ethos that began with innovator and social entrepreneur Stanley in 1843 and continues to this day.

Sir George Buckley, who has been Stanley Black & Decker chairman since 2017 and previously held the post of chairman, president and CEO of 3M, said: "We rightly understand the need for advanced technology in manufacturing. But there's nothing that happens in an organisation except through its people. They are the key thing that separates the best from the rest.

"The foundation stones of a corporation's technical capability are its apprenticeships, and they form a vital piece of a country's industrial capability. I began my career as an apprentice electrician at Stanley and I was blessed to work for a company where they fostered a culture of continuous learning, investing in apprenticeships and the next generation of skills. People are the most important assets which a company has and if we invest in those, we invest in the future."

Here are the AMRC Training Centre Apprentice of the Year 2020 winners!

Fabrication and Welding:
Rhys Jordan Lowe
of Dearneside Fabrications, sponsored by C&S Fabrications.

Maintenance:
Joshua Keyworth
of Pryor Marking Technology, sponsored by Hexagon Manufacturing Intelligence.

Machining:
Dalton Philip Brodie
of AESSEAL, sponsored by Sandvik Coromant. Also winner of **Special Recognition Award,** sponsored by Boeing.

Technical Support:
Will Smith
of Radius Aerospace, sponsored by the MTA.

First Year:
Kirbi Leigh Taylor
of NIKKEN, sponsored by Hallam FM.

HNC Achiever of the Year:
Jordan Clayton
of Polypipe, sponsored by NIKKEN.

Degree Apprentice:
Bethany Cousins
of University of Sheffield AMRC, sponsored by Close Brothers.

Outstanding contribution award
Kathryn Jackson
university teacher, sponsored by the University of Sheffield AMRC.

Outstanding contribution award
Linda White
programme administrator, sponsored by the University of Sheffield AMRC.

Nifty apprentice commended at national awards

By Katia Harston.

A talented University of Sheffield AMRC Training Centre apprentice who led a project that will potentially save her company Niftylift Limited up to £30k a month was highly commended at the finals of the National Apprenticeship Awards.

Emma Sisman earned her place at the national final after being crowned Advanced Apprentice of the Year at the regional ceremony for Yorkshire and Humber. She is the third AMRC Training Centre apprentice in three years to reach the national final, following in the footsteps of Oliver Marsh in 2018 and Rebecca Wright in 2019.

"I never thought this would happen, the fact it has still hasn't sunk in. I'm so proud," said Emma. "It means so much because it shows the hard work I have put in over the past three years of my apprenticeship has paid off and other people recognise that. I think the judges saw the amount of hard work and determination I have put into my work throughout my apprenticeship."

The 22-year-old is employed and sponsored by Niftylift Limited, one of the world's leading designers and manufacturers of mobile elevated work platforms, based in Milton Keynes, with the Barnsley site where Emma works being the facility that provides fabricated chassis assemblies. When Emma joined

> Apprenticeships are an invaluable investment and absolute necessity to assist in strongly developing our team of people, who are our asset.

the company two years ago she had 'little to no experience or knowledge' of engineering and manufacturing. She's now become a highly skilled member of the core Quality Assurance team.

"That shows the power the apprenticeship programme has in developing and progressing individuals," said Emma, who completed a three-year technical support apprenticeship and is now in her first year of a manufacturing technology degree apprenticeship. "My greatest achievement to date, during my apprenticeship, has been heading up a project where we demonstrated a potential to achieve a reduction in lost-in-production parts costs by up to 80 per cent, which could save the company, on average, £29,000 per month."

It is one of several projects she has been involved with that have made an impact on the bottom line of the business. Her next goal is to manage and drive resolution to internal and customer non-conformance issues. At the start of the year, these were taking in excess of 20 days for resolution. However, due to improved management, the Quality team at Barnsley, where Emma has demonstrated strong leadership skills, has reduced this to under five working days.

> The third AMRC Training Centre apprentice in three years to reach the national final.

It is the blend of practical skills and knowledge gained during her University of Sheffield AMRC Training Centre apprenticeship, coupled with a progressive company like Niftylift that values its human capital, which saw Emma triumph at the regional heat of the National Apprenticeship Awards.

Niftylift's Steve Beckwith, Operations Director, and Dave Tuckwood, Operations Manager, are 'absolutely delighted' that Emma's hard work and motivation has led to her being named Advanced Apprentice of the Year for the region and highly commended at the national ceremony.

"Niftylift has been fully committed and supportive of apprenticeships programs since the business was started over 35 years ago," they said. "Apprenticeships are an invaluable investment and absolute necessity to assist in strongly developing our team of people, who are our asset. We are committed to enhancing the diversity within our Engineering Support Teams and actively encourage individuals from all backgrounds into Engineering careers.

"The continued success, development and growth of our business is greatly enhanced by the skills, knowledge and abilities of our apprenticeship programs."

Nikki Jones, Director of the AMRC Training Centre, says Emma is a credit to Niftylift and very deserving of the recognition. She said: "She is a perfect example of how industry can harness the fresh-thinking, skills and new ideas apprentices bring into company and use those to help them innovate, drive productivity, become resilient, recover and regrow.

"We're so proud of Emma for what she has achieved; it's testament to her remarkable abilities as an engineer."

The National Apprenticeship Awards, now in its 17th year, celebrates apprenticeships and the benefits they bring to individuals, businesses and local communities. The 2020 event attracted more than 1,100 entries from apprentice employers, apprentices and apprenticeship champions from all industries.

New partners at the AMRC

Heraeus

Heraeus Noblelight counts itself among the market and technology leaders worldwide for special lamps with wavelengths from ultraviolet to infrared for industrial, scientific, and medical applications. Heraeus' Xenon Flash System solutions offer high performance heating in automated carbon composite processes.

CPD courses at the AMRC Training Centre

To book your place for any of the courses please send us an email to **cpd@amrctraining.co.uk** or call us **0114 222 9958**

18-19 February 2021
Principles of Heat Treatment
Online course
See course details

03 March 2021
Metallurgical Failure Analysis and Prevention
Online course
See course details

18-19 March 2021
Metallurgical Failure Analysis and Prevention
Online course
See course details

25-26 February 2021
Carbon and Alloy Steel Metallurgy
Online course
See course details

11-12 March 2021
Fundamentals of Metallurgy
Online course
See course details

25-26 March 2021
Non-Ferrous Alloys
Online course
See course details

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