The University Of Sheffield. /AMRC Journal Issue 14

Mixed reality lands at Royal Air Force

Fuelling a green future:
Hydrogen electric propulsion testbed set up to accelerate decarbonisation of transport sector

The electrification gold rush:
Prof Geraint Jewell explains how global net zero ambitions has created a boom time for electrical machines

Data-driven manufacturing:
£3.5m investment to deliver digital innovations to connect supply chains and boost productivity

CATAPULT High Value Manufacturing
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Welcome to the

AMRC Journal

2022: We're on it

We're in the calm after the storm: the strangely tranquil period that comes after the busy festive break as we hide away the chocolates, shake off the Christmas lull and look to another new year with optimism and fresh ambitions. But tranquility is not the mood to describe activity at the AMRC over recent months and even less so as we step in 2022. The outlook here is one of energy, busyness and bustling excitement for what the year will bring.

While the headlines of the Make UK Manufacturing Outlook 2021 Q4 forecast showed that output growth slowed a little compared with previous quarters and confidence fell slightly - order balances remained strong, employment was holding steady and manufacturers remained optimistic about the future. Yes, there are serious challenges around supply chains, labour shortages, access to skills and inflation increasing the cost of doing business - but industry is bouncing back and on the road to recovery.

That positivity is matched by ambition for the future position of manufacturing. The High Value Manufacturing Catapult has set bold plans to grow the manufacturing sector in the UK over the next decade. Government is equally bold with strategies on hydrogen, innovation, net zero and the promised piece on levelling up, all leaning in on the importance of manufacturing as a key to unlocking challenges both nationally and in our local places.

Moving from the headlines to the detail, the AMRC will be playing a critical role on a number of these agendas. Our strategy sets our focus on digital manufacturing, sustainability and future propulsion; the key technology challenges that will pave the way for a more productive economy, support growth and skills ambitions and enable us to drive and thrive in a low-carbon economy.

You'll find some of our work in these crucial arenas as you turn the pages here; whether it be our growing footprint in the regions with the opening of the £20m AMRC North West facility in Lancashire; our hydrogen electric propulsion systems testbed at AMRC Cymru to accelerate the decarbonisation of aerospace, automotive and rail; creating a sustainable future for UK steel; developing native 5G sensors to unlock the productivity potential of 5G in manufacturing; or creating an open-access digital architecture with our Factory+ to show how manufacturers of any size can build and reap the rewards of scalable fully-connected smart factories. We have the people, the places, the technology and the track record to deliver on the innovation and impact needed to make things better for manufacturing.

As our CEO Steve Foxley says in his foreword, we're starting 2022 in strong and fine form and our strategic themes of digital manufacturing, future propulsion and supply chain resilience are going to be the sweet spots of our future focus - for 2022 and beyond.

Now, talking of sweet spots, where did I put those chocolates...

Katia Harston
Editor

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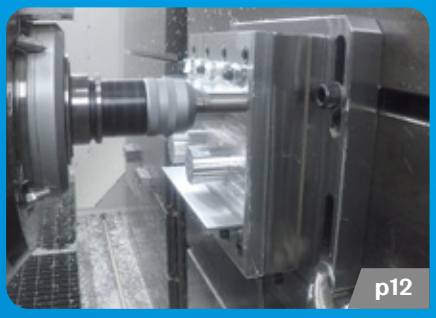
Unlocking the potential of 5G p31



Cover image: The Microsoft HoloLens 2 headset overlays 3D CAD assets for an RAF engineer carrying out maintenance on a Hawk T Mk 1.

Hitting the sweet spots for 2022 and beyond

By Steve Foxley, CEO, University of Sheffield AMRC.

When I came to write this, my second article for the AMRC Journal, I couldn't believe that it's been two years since I started this incredible job. It has flown by; due not only to the tremendous pace of change in the world over the past 24 months but also the fact that the challenges we're all facing in the manufacturing sector have been unmatched in my 26-year career.

Yet during these past two years, the team at the University of Sheffield AMRC has remained rock steady. I'm not going to repeat all of our achievements in this past year, save to say that open relationships, courage, agility, entrepreneurship and leadership across the entire business helped the AMRC come through the pandemic in a stronger position.

It was particularly special to end the year with the chance to properly celebrate the AMRC's 20th anniversary face-to-face with our partners, stakeholders, staff and those that have helped the business succeed.

Everyone at the AMRC is very proud of where we've come from and all that's been achieved. And those achievements will always be available to us to draw inspiration and energy from. But in the same way that January marks the start of a new year and the start of a fresh page, there's been a strong feeling from the team that celebrating the 20th anniversary is an opportunity to draw a line in the sand. We will always be proud of our past but let's look fully forwards, turn up our narrative on the future and where we are heading.

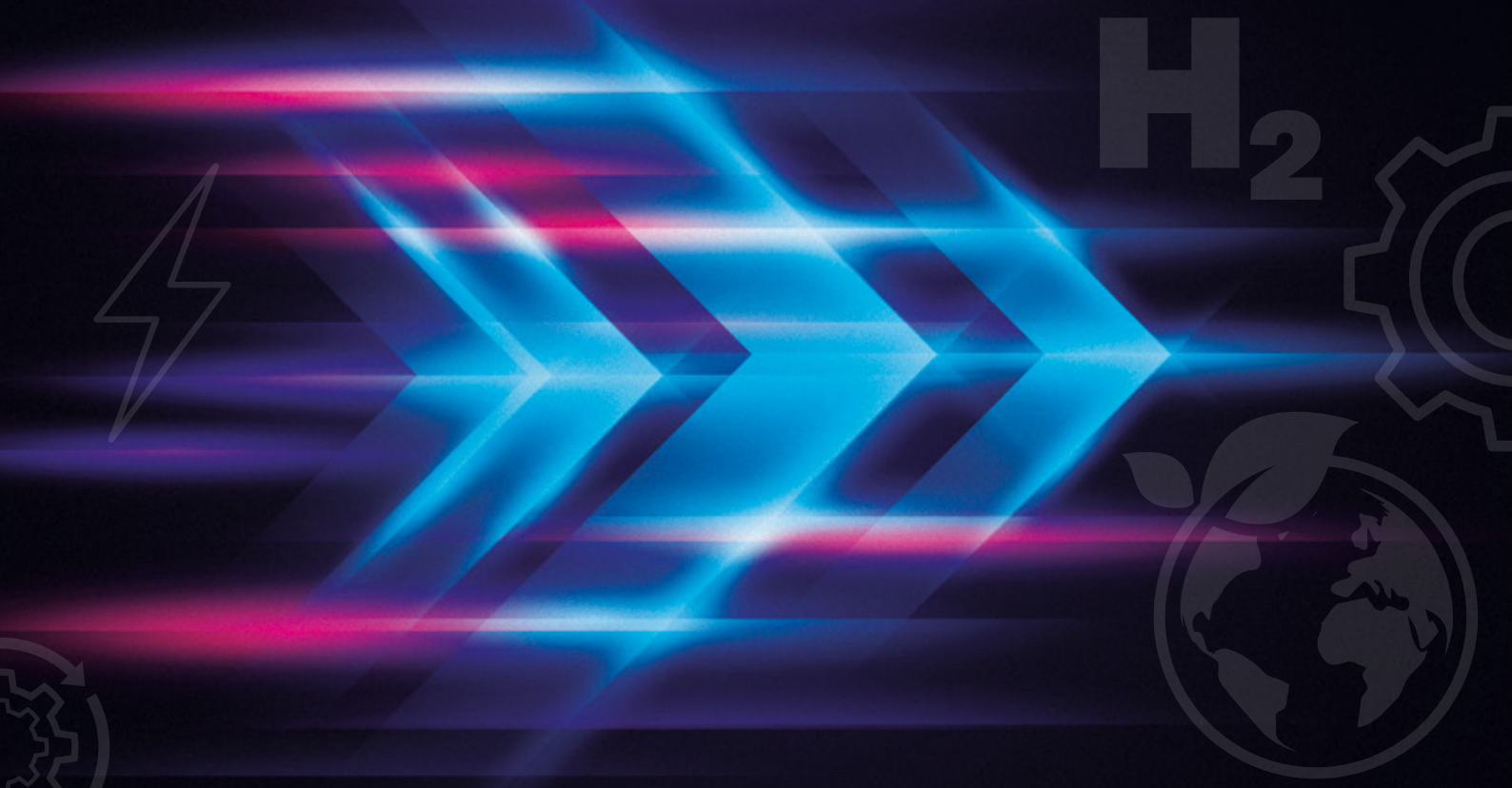
With that in mind, I'm very optimistic about the path we are on and the outlook for 2022. We've had a positive start to the year; a good barometer being that several AMRC groups are already looking to increase forecasts with our opportunity pipeline building nicely.

We start the year with a pipeline of opportunities that demonstrate our core capabilities are alive and kicking; helping manufacturers to embed new products and processes, to improve productivity, to learn and invest in new skills and to invest in new technology. We come off the back of a year where we've worked with 485 large manufacturers, supported 420 small to medium-sized enterprises, and have 45 new companies looking to join the AMRC as partners.

The recent Comprehensive Spending Review from the government also points to a promising future. Yes, as part of the manufacturing research sector we were hoping to see a commitment to the £22bn research and development target, but the pledge of £20bn by 2024-2025 still signposts good innovation funding opportunities via levelling up and the High Value Manufacturing (HVM) Catapult network.

Our strategic themes of digital manufacturing, sustainability, future propulsion and supply chain resilience are becoming an important part of our business. These are going to be the sweet spots of our future focus over the next decade.

Net zero is going to be the driving machine. New relationships have been established with organisations like



ITM Power and Hybrid Air Vehicles; partnerships formed with consortiums like Zero Carbon Humber and all underpinned by existing relationships with companies like Rolls-Royce in areas such as nuclear small modular reactors. We've already been massively supporting the transition to a low-carbon economy through our impacts on productivity; we will improve translating these impacts into tonnes of CO2e (carbon dioxide equivalent) saved.

I want us to go big on this topic. Not only by getting our own AMRC house in order and tackling our own carbon footprint - our Scope 1 emissions are 313 tonnes of CO2e, which is equivalent to the annual emissions of 68 petrol cars, and Scope 2 and 3 emissions of 7,517 tonnes of CO2e - but also, to understand and guide our partners on the impact of every piece of innovation that leaves the AMRC in helping the transition to a low-carbon world.

We're doing this through our work with Mike Berners-Lee, a leading expert in carbon footprinting and author of *There is No Planet B*, and his team at Small World Consulting. They are helping to help assess the choices for the AMRC using a framework they have been developing to answer two questions: one, to what extent is this organisation pushing for the low carbon transition that we need to see and two, to what extent is this organisation well-positioned to thrive under such a transition.

I'm so excited by the digital opportunities in front of us. Our Factory+ blueprint continues to develop and grow within the manufacturing community, providing an open framework to standardise and simplify the way that data is extracted, transported, stored, processed, consumed and protected across an organisation.

We are exploring first-hand the opportunities with 5G infrastructure and the recent announcement with Digital Meet Manufacturing and WANdisco is truly groundbreaking. There's a lot of excitement around the AMRC Data Cloud and the potential it has for rapid development of machine learning and AI as well as a tool for research and education. Becoming part of the EyUp infrastructure, a Yorkshire venture on a mission to teach more people tech skills, will also be a unique capability in the region to help close the massive gap we have in digital skills across the country.

We also start the new year with the new £20m purpose built AMRC North West facility up and running in Lancashire which, alongside our AMRC Cymru centre in North Wales, is bringing impact to the regions through advanced manufacturing. The teams are massively ambitious and excited about helping their local network of manufacturers, and keen to exploit the levelling up opportunities to create high value manufacturing jobs.

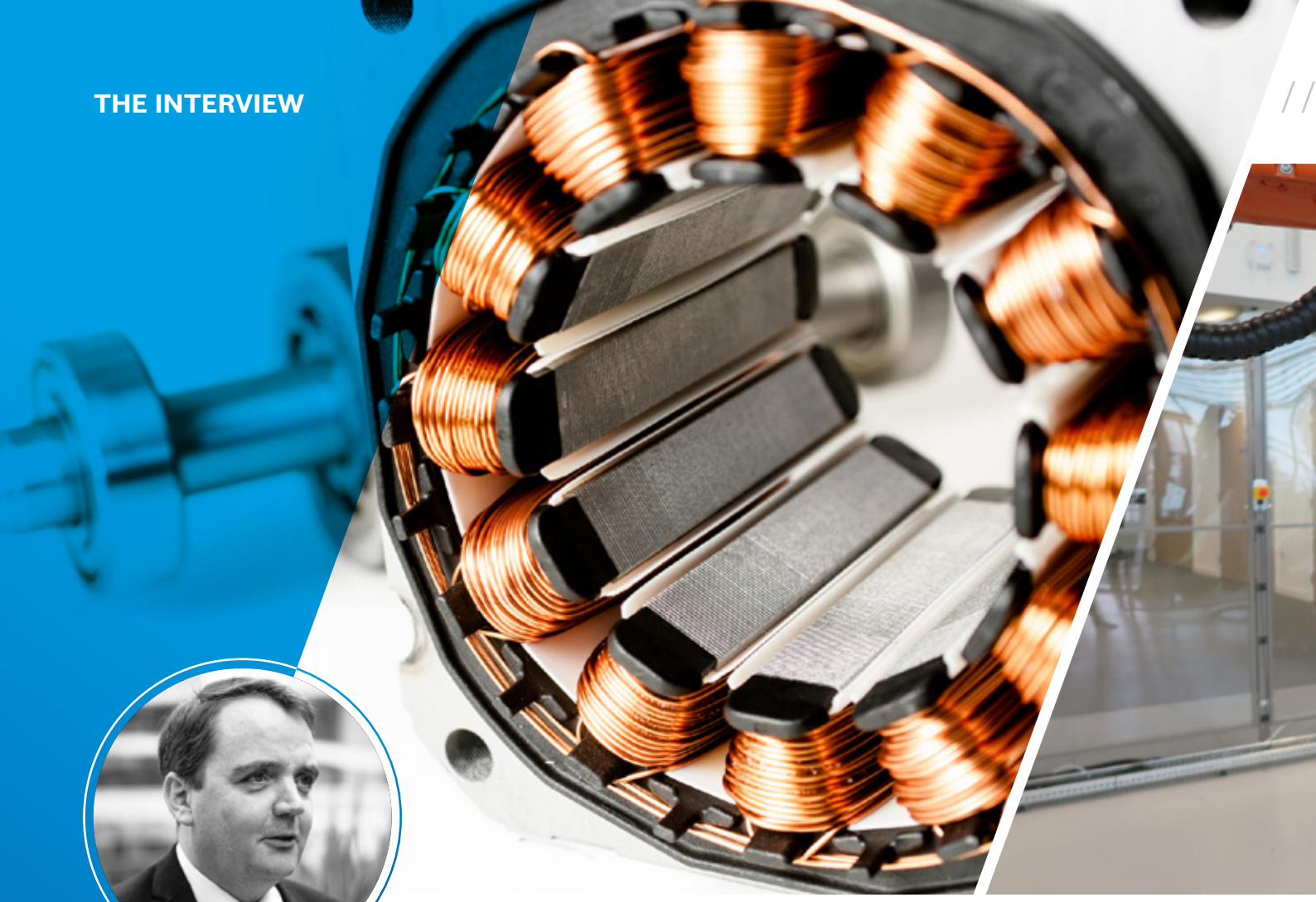
All of this is brought together with a more open, collaborative fabric running between the national network of HVM Catapult centres, united behind a common strategy for manufacturing.

As always, the start of a new year is a chance for some resolutions and new behaviours.

Collectively, we need to shake off the Covid pandemic coat that has inevitably focussed talk on 'short-term' needs and instead re-orientate towards more long-term solutions that will support manufacturing over the next decade.

Personally, my key resolution for 2022 is to speak up more on the promise of a 'skills revolution'. Labour market shortages continue to hold back manufacturers and levelling up opportunities in the regions where we work. We have a wonderful blueprint from our AMRC Training Centre showing how an industry-led curriculum can support businesses of all sizes as well as exploring sharper training courses such as digital skills boot camps through our collaboration with EyUp.

The outlook for 2022 is exciting. As part of an amazing team at the AMRC, I'm looking forward to getting stuck in.

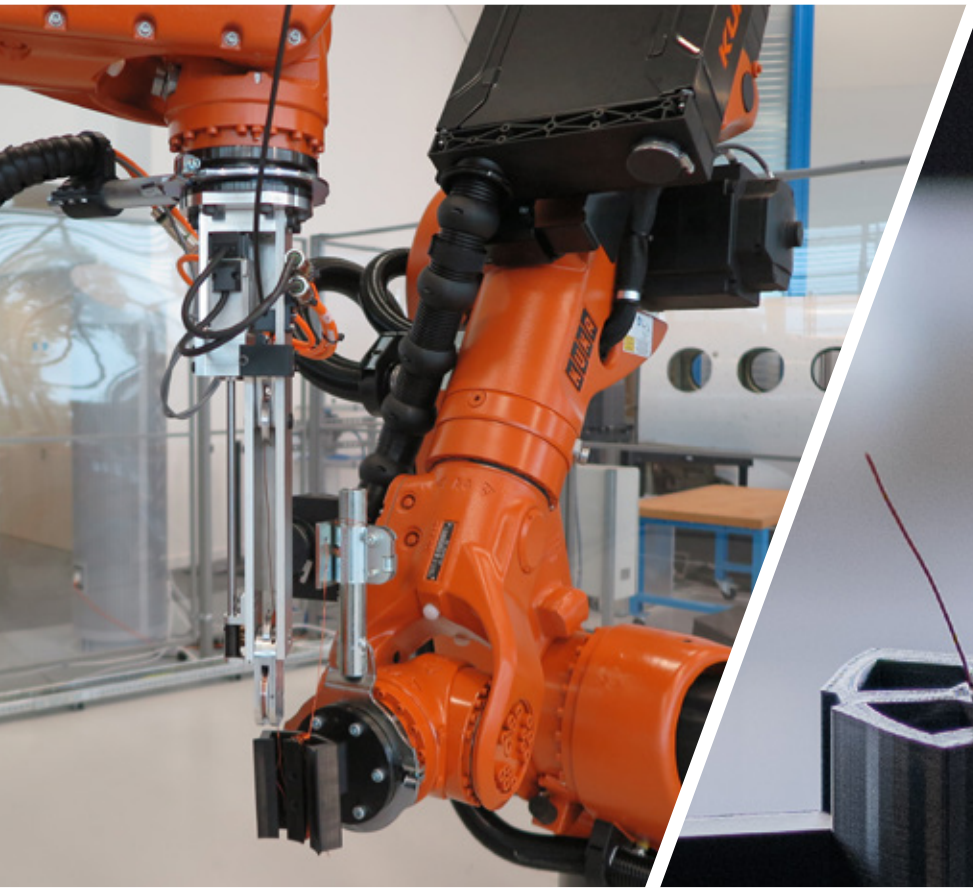


The electrification gold rush

Professor Geraint Jewell, a leading expert on electrical machines, tells **James Crossling** about the vast opportunities for electrification at the AMRC and why his two-year secondment from the University of Sheffield should set a precedent for other academics.

"Electrical machines are in a boom time right now. With the global net zero agenda and a huge push from industry, it's like the gold rush."

If anyone knows about the potential of electrical machines then it should be Professor Geraint Jewell. With a CV that would be the envy of many academics, he is director of both the Future Electrical Machines Manufacturing (FEMM) Hub and the Rolls-Royce University Technology Centre (UTC) in Advanced Electrical Machines and Drives; academic in the Department of Electronic and Electrical Engineering



since 1994; and now on secondment at Factory 2050 to drive forward the University of Sheffield Advanced Manufacturing Research Centre's (AMRC) goals to support zero emission flight.

"Researchers are almost plateauing in what they can do with classical research on electrical machines. The biggest opportunities in the UK research landscape now are around their manufacture rather than squeezing out another one per cent of efficiency, or developing a new model, because that is kind of levelling out now," said Geraint.

"There is huge potential in this area and some large opportunities to grasp that can carve out a position for the AMRC that complements both the outstanding work being done at the University of Sheffield and the capabilities of other High Value Manufacturing (HVM) Catapult centres. That is what has brought me to the AMRC."

Geraint has a 36-year association with the University of Sheffield which started as an undergraduate in the Department of Electronic and Electrical Engineering in 1985 and progressed onto the academic staff in 1994. Alongside mainstream academic roles within the department and the directorships at FEMM Hub and the Rolls-Royce UTC, he has served as the Faculty of Engineering's first faculty director of research and innovation, from 2008 to 2011, and as head of the department, from 2013 to 2019. That's not to mention a two-year Royal Society secondment at Rolls-Royce where he contributed to the early development and growth of its electrical team.

The majority of Geraint's research has been directed towards aero-engine applications in collaboration with industry leader Rolls-Royce. This research has included high temperature devices and several demonstrator starter-generators for aero-engines. Geraint says the UK has a very strong international standing in electrical machines research.

"The UK is very strong internationally in research into electrical machines and Sheffield, in terms of permanent magnet machines, is amongst the best known groups in the world."

South Yorkshire's pedigree in engineering and in electrical machines is now bearing tangible fruit through the work of the Rolls-Royce UTC and two successful spin outs from the university's Electrical Machines and Drives (EMD) group. Rotherham-based drives systems manufacturer, Magtec, is targeting sales of £30m in 2022; while Sheffield-based Magnomatics' revolutionary magnetic gears are used in all manner of sectors, from marine propulsion to renewable wind energy.

While those spin outs are examples of the outstanding

Continues...

The AMRC is hosting the majority of FEMM Hub's capital investment at Factory 2050 in Sheffield.

track record for innovation and successful commercialisation of the EMD group from the Department of Electronic and Electrical Engineering, pioneering research into electromagnetics, Geraint says it has become clear in recent years that electric machines need to be approached from a manufacturing perspective as well.

Enter, the Future Electrical Machines Manufacturing Hub.

The £28m, seven-year programme, which began in 2019 and is core-funded by the Engineering and Physical Sciences Research Council (EPSRC) with supporting contributions from a range of industry partners, is developing new manufacturing techniques and technologies to improve the reliability and performance of high value electrical machines. Researchers are working closely with an industry advisory board and scientific advisory board to address key manufacturing challenges in the production of electrical machines to put UK manufacturing at the forefront of the electrical revolution.

The hub is a consortium of five research groups from three institutions: the University of Sheffield's AMRC, EMD group from the Department of Electronic and Electrical Engineering; and the Department of Automatic Control and Systems Engineering (ACSE); the Electrical Power group at Newcastle University; and the University of Strathclyde's Advanced Forming Research Centre (AFRC), part of the National Manufacturing Institute Scotland.

Geraint says when the consortium wrote the bid for FEMM Hub, there was little coordinated or sustained activity in electrical machine manufacture of any note in the UK and, indeed, it was not recognised as a discipline in its own right.

"Three of the five partners have a manufacturing background and two have backgrounds in electrical machines. They had not previously worked together and it was deliberately pitched to the EPSRC in that way," said Geraint. "Each part of the consortium is very strong at what it does, but never had a mechanism to work together. That was the central message of the bid."

The AMRC is hosting the majority of FEMM Hub's capital investment at Factory 2050 in Sheffield. Two winding robots and a remote laser cutting facility have now been established.

Geraint said: "Currently, 5 kW/kg is a very good continuous power density for an electrical machine, but if the UK is to truly make electric flight a reality in the next 15 years, that needs to get up to 15 or even 20kW/kg.

"When producing an electrical machine there are two distinct aspects: the magnets, coils and cores where the 'magic' happens, and the structural elements which play a key role in mechanical integration thermal management. A key focus of the FEMM Hub is research into advanced materials and advanced manufacturing to reduce weight in the structural parts of a machine – the casing, the shafts and hubs. These have as big a role to play in increasing power density as advances in the active regions of the machine.

"If you look at the materials in a state-of-the-art high performance electrical machine: the stator core material tends to be a Cobalt-Iron alloys, which in essence is an incremental development on permendur, which was discovered in 1932; the magnets are samarium cobalt, which has been around since the late 1960s; and the wire is drawn copper wire, which Theophilus the Monk was documenting in the 12th Century. An electrical machine designer's palette of materials is very static, so the idea that

The AMRC's technical fellow in electrical machines, Lloyd Tinkler, explains the FEMM Hub's work to business secretary, Kwasi Kwarteng, at Factory 2050.

the magnetic aspects of a machine is going to get us that doubling of power density over the next 15 years is for the birds – we'll do it through developing the structural elements and in particular thermal management. Longer-term, more usable superconducting material may provide the step change in active materials within a machine but even then, they will remain a niche option if any form of cryo-cooling is required."

The nature of the FEMM Hub consortium, bringing together academics and engineers with disparate backgrounds, means a skills programme has slowly developed, largely through necessity.

"It started because half of our team were manufacturing engineers and the other half electromagnetic engineers, so we needed to teach one half what the other did," said Geraint.

"The first course I did was for about 40 people across the hub and our industry partners. That has evolved now to half a dozen training courses a year, attracting over 100 people with 80 per cent of those coming from industry.

"FEMM Hub doesn't have a specific remit to address talent and skills in this area, but we have a vibrant skills activity which has grown due to the demand from our industry partners. There is a massive thirst for courses in this area and even though we are EPSRC-funded, we have to keep our industry partners engaged and convinced there is good value in continuing to work with us."

Now, alongside that work with FEMM Hub, Geraint has begun a two-year secondment from the University of Sheffield's Department of Electronic and Electrical Engineering to the AMRC, bringing with him a wealth of experience and unparalleled familiarity with electrification.

"Electrical machine manufacture, certainly in the UK, is a low profile and small-scale subject academically," said Geraint. "But, as we're seeing with FEMM Hub, there are massive opportunities to lightweight the structural aspects of electrical machines. Working closely with the AMRC's CEO Steve Foxley, research director Ben Morgan and technical fellow in electrical machines Lloyd Tinkler, I want to build up the AMRC's electrification capability and really push onto the next stage.

"Electrification doesn't have its own pillar in the AMRC's ten-year strategy, but it is central to the theme of Future Propulsion. Drawing on my experience in electrical machines, one of the first things I am doing at the AMRC is writing a plan of action in this area from which we can pull elements for proposals.

"There are some big decisions to be made soon about what the scope of capital investment is going to be and what the AMRC's role in this space is going to be. My background is largely working with Rolls-Royce, so there is a lot of potential with aerospace, but we also need to investigate electric machines for other sectors that require high-power and high added-value electrical machines such as off-highway vehicles, rail, marine and renewables."

Geraint says he will benefit hugely from spending half his time at Factory 2050 and working much closer with the AMRC's engineers.

He said: "I've had links with the AMRC since it started in 2001 and have always felt at home here. There is the ambition at the AMRC that doesn't always exist elsewhere which allows us to go out and bid on a large scale for big investment.

"The AMRC directors will hopefully benefit from my input to build a strategy for electrification and the Department of Electronic and Electrical Engineering should profit from having a direct link into the AMRC. Really, this secondment should benefit every part of the Faculty of Engineering."

For Geraint, there is the additional value of setting a precedent he hopes other academics at the University of Sheffield will follow.

He said: "I'm hoping to demonstrate to my colleagues more widely, not just with the AMRC, the value of not just meeting up once every six months saying 'we should work together' but putting someone on the ground, making it real - that's a formalism you need to be able to do this properly.

"It's something I would like to see more of, but only when it has got a prospect of being good for the individual, good for the home department and in this instance good for the AMRC.

"I might be the first one, but I don't want to be the last."

FUTURE
Electrical Machines
Manufacturing Hub
EPSRC Future
Manufacturing Hub

New chapter for AMRC North West

A first glimpse inside AMRC North West reveals the £20m research centre set to make Lancashire a leader in manufacturing innovation and act as an engine room for the region's sustainable economic growth. Katia Harston reports.

The flagship AMRC North West sits at the heart of the Samlesbury Aerospace Enterprise Zone in Preston. It is run by the University of Sheffield Advanced Manufacturing Research Centre (AMRC) and has been built using a £20m grant from the Lancashire Enterprise Partnership (LEP) Growth Deal.

Construction on the 4,500 sqm research and innovation facility began in late 2020 and completed last October. Work in the months that followed has focussed on installing a raft of cutting-edge machines and equipment, and getting the building ready for staff to move in ahead of the ceremonial opening in 2022.

Final preparations are being made to mark the official opening of AMRC North West which Melissa Conlon, commercial director at the AMRC North West, says will keep Lancashire at the forefront of advanced manufacturing and technologies, and support the region's regeneration and economic growth.

"Our new building will enable us to scale-up our work with regional stakeholders to help manufacturers in the North West improve processes, speed up product development and stay competitive by benefitting from new technologies," she said.

"Our strengths lie in demystifying and de-risking the process of adopting Industry 4.0 technologies through research, collaboration and knowledge. By having this fantastic facility rooted in Lancashire, the region's manufacturers will be able to take advantage of world-class pioneering academic research and translate it into innovative industry-transforming solutions that make a real difference to their businesses.

"Not only will our new home in Samlesbury be a manufacturing research centre but it will also be an open-access technology demonstrator, a 5G testbed, and set the standard for low-carbon smart factories to drive inward investment to the region."

The state-of-the-art applied research centre combines sleek, modern office workspace with a flexible high-tech workshop and a triple-height atrium forms a hub where staff can interact and exchange ideas. A 'social heart' space overlooks the workshop area where innovation-led R&D will focus on digital and additive manufacturing, vehicle electrification, battery assembly and lightweighting technologies.

Research director James Hughes is delighted to see the staff settling into the new building, and says its size

Slick new images give a first look inside the £20m AMRC North West facility which sits at the heart of the Samlesbury Aerospace Enterprise Zone in Lancashire.

and scale matches that of the ambitions of the AMRC North West team.

"The journey from concept to reality has been a challenge, however we're looking forward to a new chapter in the AMRC North West story," he said. "The new building will allow us to fully showcase the breadth and depth of our research and development technology portfolio in a way that just wasn't possible previously.

"The team and I are hugely excited that we have the opportunity to show the region exactly what we can do to help manufacturers meet their future challenges."

AMRC North West has been operating from an interim facility provided by the University of Central Lancashire (UCLan) in the centre of Preston since forming in 2018. The AMRC North West team's new home is now a gateway development on the Samlesbury Aerospace Enterprise Zone, which is part of the wider Lancashire Advanced Manufacturing and Energy Cluster.

Iain Martin, senior engagement manager at AMRC North West, said: "Completion of the facility brings to a close a long and challenging development period, during which time we have been able to establish our Lancashire presence thanks to the generosity of the University of Central Lancashire playing host to us on their Preston campus.

"Having this base in Preston has enabled us to support more than 200 of Lancashire's manufacturing SMEs through our diverse range of fully-funded support programmes.

"We are now incredibly excited to move into our facility which represents the next step in our journey and a real step-change for manufacturing support in the region."

Helping our partners to to thrive and drive innovation

A UK-first for automatic digital twin control of machining tools, flame retardant battery boxes, and the 3D weaving of a composite blade were some of the technology highlights from the Technical Fellows conference hosted by the University of Sheffield AMRC.

By Chloe West

More than 70 industry leaders gathered to hear from the AMRC's highly skilled teams of engineers about the work they are doing to help businesses thrive, highlighting the progress they have made in the past 12 months, helping to find solutions to some of manufacturing's biggest challenges and outlining future project plans.

Jody Turner, technical lead for composites at the AMRC, gave a passionate presentation on 3D weaving capabilities – bringing a composite blade for all to see and to show what can be achieved with advanced manufacturing technologies.

She explained how the Composite Centre's work has investigated different fabric architectures and how it can influence thickness and compaction – with future work expected to look at automating further processes within the field.

Rob Ward, research engineer for the integrated project team at the AMRC, discussed automatic control of a machine tool by a digital twin.

In his presentation, Rob displayed the research which went into looking at model-based simulations, allowing online feedback and closed loop control of intelligent machining applications – as well as demonstrating the feasibility of digital twin control applications for a roadmap to a fully autonomous, self-optimising machine tool.

He added that the project is a UK-first because nothing like it has been done before - and cutting force prediction is something the AMRC excels in - with the past ten years being spent on continuing relevant research. Digital twins still remain to be a developing technology.

After what has been a testing 18-months for many key industry sectors due to the coronavirus pandemic, and following last year's virtual event, speakers at the two-day conference all echoed their joy that face-to-face networking had returned.

In his opening address to industrial partners, Matt Farnsworth, commercial director at the University of Sheffield Advanced Manufacturing Research Centre (AMRC), shared his delight about seeing a room full of industry leaders networking and sharing ideas in person.

"I was reflecting on my first Technical Fellows in 2003 and we had our industrial partners come over to where we were based, with just three or four small milling machines out, on what was then

Matt Farnsworth, commercial director at the University of Sheffield Advanced Manufacturing Research Centre (AMRC), gave the opening address.

> "It's an exciting time to be part of the translational research space...."
>
> **Matt Farnsworth,** commercial director, AMRC

Jody Turner, technical lead for composites at the AMRC, spoke about her 3D weaving project and its capabilities, which looked to produce a composite blade.

An example of a 3D geometry constant cross-section section, created by 3D weaving.

Mark Laycock, senior composite technician, holding a demonstrator fan blade.

The roughing operation under the closed loop digital twin control on the Starrag Ecospeed machining centre.

Rob Ward, research engineer for the Integrated Project Team at the AMRC.

the Sheffield Airport Business Park," said Matt. "It was there we had Boeing, Technicut, Nikken and it's fantastic for the continuity of the AMRC that all of those companies are still with us today, as well as many new partners."

He added: "It's an exciting time being part of the translational research space – with the budget outcome on the face of it looking quite favourable towards innovation. And there's still a real drive towards the government's aspiration for 2.4 per cent of Gross Domestic Product (GDP) being spent on research and development activity by 2027."

Ben Morgan, AMRC research director, thanked everyone for attending the event which was also an opportunity to celebrate the AMRC's 20th anniversary with a special dinner held at the Kelham Island Museum in Sheffield.

Ben said: "Work at the AMRC has continued despite a difficult 18 months of Covid – but the shop floors have still kept humming away with plenty of progress being made."

Jamie McGourlay, Tech Board chair at the AMRC, added: "It's been pleasing to see participants back around tables to hear some of the very varied, good quality work seen at the AMRC - and this year's event saw some fantastic, in-depth presentations."

Twenty years of the AMRC 20 in 21

celebrated with 'courageous' partners

"Places like the AMRC start with a fantastic idea, but they don't become successful by accident – the success is down to a combination of difficult choices and sacrifices made by many people over many years." That was the message from University of Sheffield AMRC leader Steve Foxley to guests gathered for the organisation's 20th anniversary dinner. **Chloe West writes.**

Kelham Island Museum was the perfect setting for toasting two successful decades of the University of Sheffield Advanced Manufacturing Research Centre - coupling together a venue which encompasses Sheffield's rich industrial and steelmaking heritage, with a room full of expert industry insiders who are building on these life-changing historical benchmarks as they strive to deliver problem-solving research, innovation and commercial success.

The celebratory dinner was an opportunity to look back at how the AMRC began in 2001 as a brainwave of Prof Keith Ridgway and local businessman Adrian Allen, who, with the backing of the University of Sheffield, went on to secure landmark support from aerospace giant Boeing to apply Sheffield's traditional expertise in metal working and create new innovations with a focus on machining research. Over the years, businesses both big and small have believed in that vision and joined the AMRC in its mission to support the advancement of manufacturing technologies.

Twenty years on, the AMRC is still here, bigger and better than ever; a world-leading research centre working across the aerospace, automotive and transport, construction, energy and medical sectors. Looking ahead, the future brings many new challenges: electrification, net zero, jet zeo, sustainability and climate change – but the AMRC is ready for the challenge to

bring further change and will continue to make a mark for future generations to be proud of.

The anniversary dinner not only celebrated the AMRC's industry partners, who received several rousing rounds of applause, but it also gave thanks to the AMRC's founders, critical friends and staff for making the AMRC what it is today.

AMRC CEO Steve Foxley gave a speech at the dinner. He thanked everyone in the room, and those who couldn't make it, for the courage they showed in taking a leap of faith in creating the AMRC.

"We have people in the room tonight who started on day one and have helped to shape the AMRC over the past 20 years," Steve added. "Others in the room showed courage, fought for what they believed in, saw something developing that others couldn't see, a seed of opportunity growing in the region. Others helped us to invest, helped us grow, focussed their energy and willpower on building something new – not defending the old.

"People in this room have been courageous and given their blood, sweat and tears everyday to make the AMRC the success it is today. These sacrifices can't easily be seen in what everyone sees today as the shiny assets and buildings at the AMRC.

"The truth is, without these moments, sacrifices and difficult choices, the AMRC would not be what it is now and that is what I want to celebrate. On behalf of the AMRC, thank you to each of you for your courageous moment.

"As we look to the future, we are looking at challenges, global warming, levelling up, post pandemic working – we need to arm the future generations with new technologies and opportunities they need to thrive; to give future generations jobs, careers and choices locally so that success doesn't end up being a postcode lottery."

Koen Lamberts, president and vice-chancellor of the University of Sheffield, spoke of the fantastic relationship the AMRC has with hundreds of businesses, which are 'helping to create something that is really making a difference'.

"We don't have to look much further at what levelling up is all about than the AMRC," he said. "The AMRC has attracted some of the best industrial partners, and convinced them to set up a base in Sheffield, it is a tremendous success story. In addition we have helped other regions set up what we have here, such as our other bases at AMRC North West and AMRC Cymru.

"We also have the AMRC Training Centre, which gives more people an opportunity and is another form of levelling up in action.

"Local, regional and national governments are also helping us to deliver real innovation, and this is what the AMRC is all about; driving innovation and solving productivity problems across the country."

As key leaders acknowledged the continued support of dedicated partners, a series of anniversary videos played throughout the event, cementing the work the AMRC has put in for them.

Partners including Rolls-Royce, Boeing and Siemens spoke out about the 'important relationship' they have with the AMRC, describing the organisation as providing opportunities to work with the latest generation technology, delivering solutions at scale and on pace to industry and supply chains, as well as being able to achieve things companies on their own can't, with a greater level of depth, alongside saving time and costs and de-risking and accelerating innovation in the UK.

Industrial board chair of the AMRC, Pete Hoffman, shared his honour of speaking at the celebratory dinner and expressed his excitement about seeing a room full of people face-to-face.

"The AMRC is all about the fastest and greatest equipment and has made a big difference right from the start and up to the present day. They have brought about an ability for large and small companies to get together and form relationships, which is unique from an industry perspective. We are sharing the financial burden and solving big, difficult problems together.

"For me, it's about the pride of being something bigger than yourself and it's a pleasure to work with the AMRC and seeing the impact it's had within industry and on the lives of the apprentices that train at the AMRC every day and the differences it has made to their lives.

"It has taken real vision to get to where we are 20 years down the line and I know that as things start to take a different direction, the AMRC has a very bright future ahead."

UK consortium to develop hydrogen storage prototyping hub in drive for net zero

An industrial technology consortium developing innovative hydrogen storage solutions has signed a research agreement to work towards setting up a Hydrogen Storage Prototyping Hub (HSPH).

By Chloe West

The proposed hub brings together the expertise of the University of Sheffield Advanced Manufacturing Research Centre (AMRC), Oxford Advanced Surfaces, Xcience and SET Europe with the aim of developing improved hydrogen storage solutions for the transportation sectors as they journey towards zero emissions.

The research undertaken by the consortium, which has signed a Memorandum of Understanding (MoU) to progress the hub, has been supported by the Advanced Propulsion Centre's Automotive Transformation Fund (ATF).

The Hydrogen Storage Prototyping Hub will be an independent, open-access resource for innovators and industrial end-users to accelerate the design and manufacture of prototype hydrogen storage vessels. It is actively seeking collaboration opportunities and is exploring the development of an industrial steering board comprising companies involved in the wider hydrogen landscape.

Dr Martin Kemp, technical director of Xcience who is spearheading the initiative, said: "We believe that improved mobile storage is a crucial technology area to enable future hydrogen vehicles, and access to a state-of-the-art prototyping service will help bring the latest storage technology to vehicle design."

Stuart Dawson, chief engineer for hydrogen at the University of Sheffield AMRC, welcomed the agreement, adding: "Hydrogen propulsion, whether it's performed via fuel cells or combustion, has an essential role to play in the decarbonisation of transport, particularly for heavier, longer range and higher duty cycle applications.

Stronger together: Chief engineer for hydrogen at the AMRC, Stuart Dawson, is pictured with Xcience's Dr Martin Kemp at the AMRC's Composites Centre.

"The AMRC is delighted to be part of the HSPH consortium where we can contribute our composites manufacturing expertise towards developing safe, lightweight, conformal and affordable hydrogen storage tanks to help accelerate the adoption of hydrogen propulsion systems."

Jon-Paul Griffiths, chief technology officer and founder of Oxford Advanced Surfaces (OAS), said the move to zero-emissions transportation is a key issue facing society on a global scale. He added: "We believe that the ability to prototype hydrogen storage vessels will accelerate the development and adoption of hydrogen fuelled vehicles."

Anselmo Gomes, head of engineering and research and development at SET Europe, added: "The drive to net zero has revolutionised the automotive industry. Thus far, the main focus has been on battery-powered drive systems. However, we believe that hydrogen also has a role, and that this role is yet to be exploited. This being true, we believe that our technology can help develop the solution for storing hydrogen on any future vehicles."

The hub is developing an operational model that will provide an independent, confidential service to meet the needs of industry, and welcomes expressions of interest from original equipment manufacturers (OEMs), the manufacturing supply chain and organisations involved in the wider hydrogen and transportation sectors.

AMRC teams with Hybrid Air Vehicles to deliver zero-emissions flight

Hybrid Air Vehicles (HAV) will harness research expertise and advanced manufacturing technologies at the University of Sheffield Advanced Manufacturing Research Centre (AMRC) to deliver its Airlander 10 production and drive towards zero-emissions flight before 2030.

By Katia Harston

HAV and the AMRC have signed a teaming agreement that will see them working together to identify projects developing research, innovation, and training linked to HAV's Airlander 10 production. As HAV prepares to launch the programme, the AMRC and the wider South Yorkshire region present a unique combination of skills, supply chain, and expertise.

With a shared focus on aerospace manufacturing innovation and decarbonisation, HAV and the AMRC will bring together their expertise to address projects relating to zero-emissions propulsion and its supporting technologies. HAV aims for Airlander 10 to be the first aircraft capable of carrying up to 100 passengers to achieve zero-emissions flight.

The AMRC is a global exemplar of manufacturing innovation, and its flagship Factory 2050 building in Sheffield is a showcase for technologies that HAV can leverage during the build out of the Airlander 10 production facility. This is one of several focus areas for the agreement between the two organisations, creating a green aerospace capability leveraging regional excellence.

"As we move to production of Airlander 10, establishing strong regional relationships is critical," said HAV CEO Tom Grundy. "The skills in South Yorkshire and the AMRC's world-leading innovation and manufacturing expertise will help us deliver Type Certified Airlander 10 aircraft and hundreds of green aerospace jobs from a new British manufacturing facility."

In addition to its expertise in design for manufacture and assembly optimisation, the AMRC also carries out research into novel manufacturing techniques. Steve Foxley, CEO at the University of Sheffield AMRC, said Airlander presents unique opportunities in this area and may consider further research projects with HAV on this theme.

He said: "The goal of zero-emissions flight is one the aerospace sector must reach if the UK is ever to achieve its target of net zero by 2050. To be involved in the production of Airlander 10 which will offer zero-emissions flight before 2030 is a tremendous opportunity.

HAV aims for Airlander 10 to be the first aircraft capable of carrying up to 100 passengers to achieve zero-emissions flight.

"The AMRC and the wider University of Sheffield are driving the development of new types of propulsion systems, whether that is industrialising the production of hydrogen fuel cells or leading the research into sustainable aviation fuels with the University's Sustainable Aviation Fuels Innovation Centre (SAF-IC); our teaming agreement with HAV adds to that growing portfolio."

Delivering a new aircraft to market requires an ecosystem of support through production and into service. HAV and the AMRC also plan to explore projects centred around training and delivering the skills needed to produce and support Airlander 10 throughout its lifecycle.

Fuelling a green future with hydrogen electric

The University of Sheffield Advanced Manufacturing Research Centre (AMRC) is accelerating the decarbonisation of the transport sector and pushing the UK further down the road to net zero by de-risking the assembly and production scale up of hydrogen fuel cells for the aerospace, automotive and rail industries. James Crossling reports.

A £600,000 Hydrogen Electric Propulsion Systems (HEPS) testbed, based at AMRC Cymru in North Wales, will drive the industrialisation of the green technology by harnessing the AMRC's expertise in design for manufacture in a fuel cell assembly testbed where Industry 4.0 technologies and in-process inspection techniques will optimise the assembly process.

"Hydrogen fuel cells can address key challenges of the transport sector as it searches for alternatives to the internal combustion engine," said Lee Wheeler, hydrogen technology lead at AMRC Cymru. "However, the current cost of manufacturing and assembling the fuel cells is incredibly high, which means there's a lack of uptake.

"We want to support businesses who want to make the net zero energy transition to hydrogen electric propulsion systems by giving them a facility where they can use advanced manufacturing techniques to assemble and verify their product and then eventually integrate it in their vehicles."

Like battery electric vehicles (BEV), fuel cell electric vehicles (FCEV) run on a supply of electricity. However, whereas BEVs take hours to recharge to maintain that supply, FCEVs burn hydrogen which can be refuelled in minutes. The bi-product of the chemical reaction is water vapour which means that, in operation, fuel cells are a zero-carbon propulsion system that can produce electricity for as long as fuel is supplied.

The High Value Manufacturing (HVM) Catapult, of which the AMRC is one of seven centres across the UK, has funded the project which is specifically targeting seven industries: aerospace, energy generation, heavy automotive, off highway, public transport and rail.

Work on the HEPS testbed is being guided by an industry steering board which includes large global manufacturers including BAE Systems, GKN, Rolls-Royce and Toyota, alongside

An artist's impression of the HEPS facility on the AMRC Cymru shop floor, containing collaborative robots, in-process verification capability and other Industry 4.0 equipment.

smaller companies such as electric vehicle manufacturers Wave Industries, Hypermotive and Riversimple. The board has been assembled by the AMRC to ensure that work is industry-relevant and addresses real-world manufacturing challenges relating to this technology.

Stuart Dawson, chief engineer for hydrogen at the AMRC, says the technology has enormous potential and is right at the top of the government's agenda following publication of its Hydrogen Strategy in August 2021 which estimated the hydrogen economy could be worth £900m and support more than 9,000 jobs by 2030.

"The government showed real intent by publishing the UK's first ever Hydrogen Strategy, promising to lay the foundations for a low-carbon hydrogen economy in the next decade and to support innovation to massively scale-up the production of low-carbon hydrogen.

"Battery technologies that are well suited to electric cars are not necessarily well suited to use in heavy goods vehicles (HGVs) due to the long vehicle downtime during charging and the weight of batteries required to power large vehicles over long distances. Lightweight hydrogen fuel cells are ideal for the electrification of long-distance vehicles due to their long range and faster refuelling compared to BEVs. At the AMRC we must now enable companies to flexibly and competitively manufacture these hydrogen propulsion systems."

Lee says the current production process for fuel cells is extremely labour intensive and the UK supply chain for this technology is immature.

He said: "Assembling this kind of system involves a lot of manual work and little automation which makes it prohibitively expensive. Internal combustion engines

The government estimates the hydrogen economy could be worth £900m and support more than 9,000 jobs by 2030.

are currently cheaper to manufacture and, as a country, we need to give people an affordable alternative.

"There is a real need for this kind of centre to support small businesses who are looking to explore this technology and utilise an already highly skilled workforce to make the UK a more competitive place to build fuel cells."

The HEPS facility will have a self-contained assembly area on the AMRC Cymru shop floor, containing collaborative robots, in-process verification capability and other Industry 4.0 equipment. The first assembly project is hoping to start in April this year.

The AMRC team will explore how to de-risk, industrialise and scale-up the assembly of hydrogen fuel cells and electrolysers by applying advanced manufacturing processes and the AMRC's capabilities in automation, digital, in-process verification and design for manufacture.

"We are anticipating that some of the assembly operations will not be able to be automated in their current design so that is why our design optimisation skills are key," said Stuart.

"Ultimately we want to drive the industrialisation of this technology, reduce component and assembly costs, and accelerate industry up-take with globally competitive methods of manufacture here in the UK."

Lee says the steering board is directing the work of the HEPS testbed and explaining how the AMRC can position itself to best support them.

He said: "We have gathered some valuable information about the current industry pain points, the overall position of manufacture of these systems in the UK, and the technology and the equipment required. They are helping us adapt the service we offer as we originally wanted to focus on the assembly of the fuel cells, but the steering board has told us that they would like to do both assembly and some performance testing in our centre.

"Manufacturers are also very mindful of the 'whole of life' consideration for components which we must take into account; not only do we need to study the assembly of the fuel cells, but we also need to consider how we can take them apart, remanufacture, reuse and recycle."

AMRC Cymru is a £20m cutting-edge R&D facility that opened in 2019 to provide an open innovation centre for manufacturers in Wales. Backed by the Welsh Government, AMRC Cymru is the first HVM Catapult centre in Wales.

AMRC Cymru research director, Andy Silcox, said: "There is nothing like the HEPS testbed currently available in the HVM Catapult and we see it as a key capability for AMRC Cymru. There is real interest in this technology amongst businesses in Wales and the north of England; we want our facility to be the place to go for research into the assembly of hydrogen fuel cells, so we must invest our funding from HVM Catapult wisely and address real industry challenges.

"By combining the AMRC's expertise in advanced manufacturing technologies with the insight from the industrial steering board, we can establish a springboard for hydrogen electric industrialisation and help to build a sustainable, green transport sector."

Pioneering collaboration

to advance zero-carbon green hydrogen

The University of Sheffield and energy storage and clean fuel company ITM Power have launched a pioneering collaboration to advance the hydrogen sector, including an agreement for a new ITM Gigafactory close to the University of Sheffield Advanced Manufacturing Research Centre (AMRC).

The AMRC sits at the heart of the university's Innovation District where ITM Power will build a new Gigafactory.

ITM Power has reached an agreement on Heads of Terms with the university to acquire a substantial site at its Innovation District for the company's second UK factory, near to the AMRC's flagship Factory 2050 in Sheffield. The Gigafactory, which is expected to be fully operational by the end of 2023, will manufacture electrolysers that split water into molecules of hydrogen and oxygen using renewable power. The resultant zero-carbon green hydrogen can then be used to decarbonise industrial processes, transport and heating, and will play a major role in achieving net zero.

The partnership between ITM Power and the university will also include the development of a new National Hydrogen Research, Innovation and Skills Centre, which will lead to the creation of new jobs at all levels of the hydrogen sector as well as training and career development, and the promotion of hydrogen domestically and internationally.

Stuart Dawson, chief engineer for hydrogen at the University of Sheffield AMRC, said: "The energy transition is also an industrial transition and this incredibly important announcement gives both the University of Sheffield and the AMRC a leading role in South Yorkshire's future hydrogen economy.

"ITM's investment in an additional 1.5GW of electrolyser production capacity is central to making South Yorkshire a hub for 'green manufacturing' and the AMRC will have a key role helping ITM and its supply chain, scale-up production, boost productivity and reduce costs."

Professor Koen Lamberts, president and vice-chancellor of the University of Sheffield, added: "We are very pleased to be launching this partnership with ITM Power. Hydrogen is one of the most exciting and promising clean energy solutions and ITM is at the forefront of green hydrogen manufacturing. This partnership is a milestone for both partners and the region in leading the way to achieving net zero through technological innovation."

The new factory will also include office space for manufacturing staff and will be a low environmental impact building, using the best of current low-carbon technologies. ITM Power will work closely with a developer, to be appointed once planning permission has been received, to incorporate low-carbon footprint materials and facilities.

Sir Roger Bone, chairman of ITM Power, said: "The opportunity to partner with the University of Sheffield, recognised for its excellence in all aspects of industrial research, will enable both parties to train the next generation of hydrogen engineers and scientists, and continue to grow the company and the economy in the region. I look forward to seeing this relationship develop and prosper in the years ahead"

The National Hydrogen Research, Innovation and Skills Centre, which will also be located at the University of Sheffield Innovation District, neighbouring ITM Power's proposed new site, is expected to include research into the safe and efficient manufacture of hydrogen using renewable energy and/or nuclear power; research into improving hydrogen system manufacturing processes; and research into the use of 'digital twins' (as already in use with ITM Power) to enhance manufacturing of hydrogen equipment.

The University of Sheffield's vice-president for innovation, Professor Dave Petley, said: "The University of Sheffield has world-renowned expertise in energy innovation, and we recently announced a new Sustainable Aviation Fuels Innovation Centre, adjacent to our Translational Energy Research Centre, both housed at the University of Sheffield Innovation District. Our experience in bringing together academic research and industrial expertise is helping to solve the world's biggest problems, and our partnership with ITM Power to advance the hydrogen sector will help make net zero a reality."

Dr Graham Cooley, CEO of ITM Power, said: "I am delighted to be working more closely with the University of Sheffield and that our second UK factory site is in Sheffield. Both initiatives will support the local economy through job creation and supply chain support.

"The planning and construction of our second, 1.5 GW capacity, factory marks the next step on delivering on our strategic plan to create a blueprint for a more automated PEM electrolyser manufacturing facility to be rolled out internationally. Our focus now is on increasing utilisation and throughput at our Bessemer Park Gigafactory as we prepare for the next step change in capacity."

Data-driven manufacturing for Wales

A £3.5 million investment into advanced product verification technologies at AMRC Cymru will deliver digital innovations that connect supply chains, increase productivity, drive sustainability and create high value engineering jobs.

Support from the Aerospace Technology Institute (ATI) has allowed the University of Sheffield Advanced Manufacturing Research Centre (AMRC) Cymru to establish a Manufacturing Data Centre of Excellence in Broughton to develop technologies that will allow Welsh manufacturers of all sizes and across all sectors to leverage the data they generate.

"Every piece of equipment we have bought with the grant has been purchased with data in mind," said Andy Silcox, AMRC Cymru research director. "We want to demonstrate the power of data to improve manufacturing organisations and the kit falls under three categories: data acquisition, data handling and processing, and data visualisation.

"This centre of excellence is investigating how manufacturers can get all the data they need without it being a cost or time burden, to process it efficiently, and then ultimately make data-driven decisions back on the shop floor."

The £3.5 million grant from the ATI programme has been spent on both software and hardware, including: high-accuracy metrology equipment to measure accuracy and update robot paths in real time; projected work zones to show live data; motion tracking haptic gloves; a suite of human behaviour sensors to capture biometric data; and a chroma key room to use with the latest mixed reality headsets.

Andy continued: "You ultimately want to exploit the data you acquire to inform your automated equipment. To do that, you firstly need kit to gather data from the machines; then kit to handle the data, which is the processing equipment; and finally, the kit to effectively utilise that data, to close the loop and improve manufacturing processes.

"We have all that at AMRC Cymru for manufacturers to develop solutions on - from SMEs to OEMs."

Technologies developed at AMRC Cymru through the centre of excellence will support high-profile projects such as BAE Systems' Tempest programme and Airbus' Wing of Tomorrow programme. With Airbus, AMRC Cymru's first major tenant, the new advanced product verification technologies will help digitalise manufacturing processes.

Sophie Lane, chief relationships officer at the ATI, says the centre is targeting a number of innovations that will make a significant impact on how the UK approaches manufacturing.

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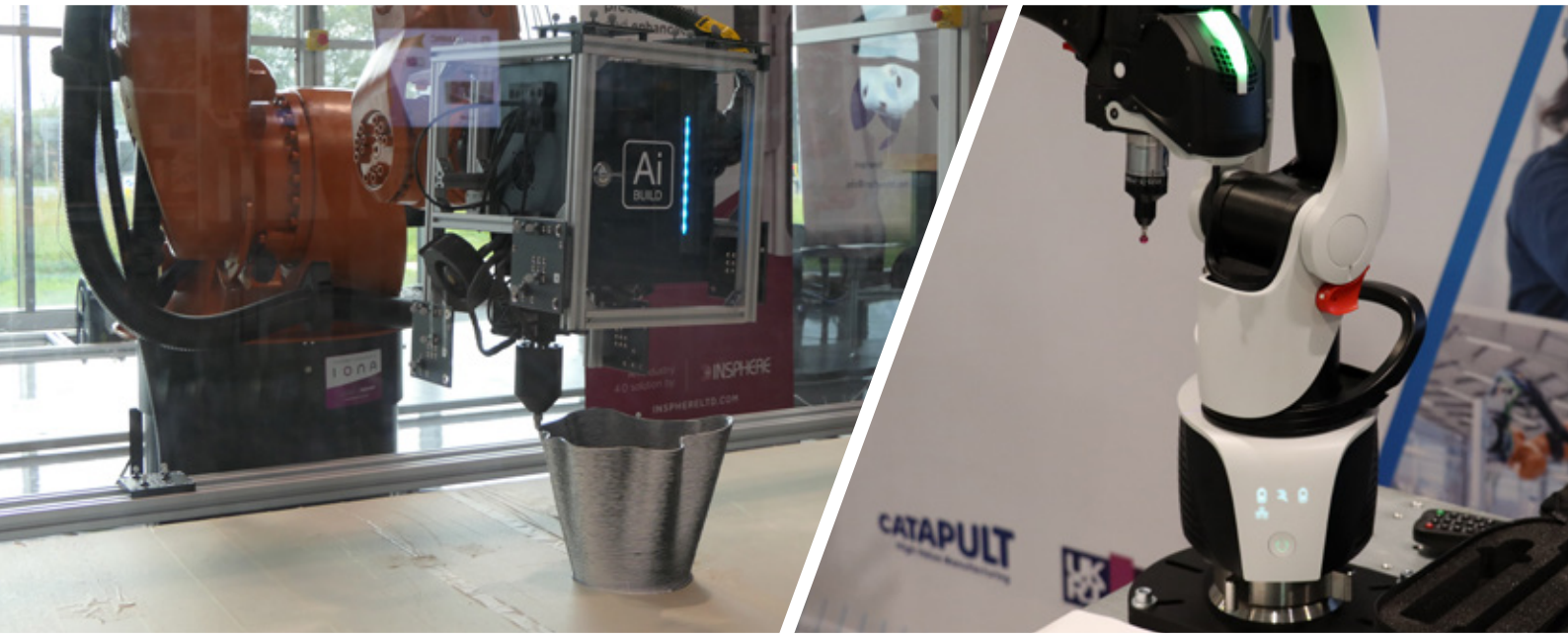


Left: IONA, part of the suite of high-accuracy metrology equipment. Right: The Hexagon Absolute Arm.

She said: “This centre of excellence provides a sandpit environment, independent of any vendor, for industry to develop solutions before they are implemented on the shop floor. Those innovations will lead to a digitally connected supply chain and smart factories that will strengthen the competitiveness of the aerospace sector and wider manufacturing sector in the UK, and lead to the creation of high-value engineering jobs and increased productivity.

“The AMRC’s expertise in aerospace assembly and automotive technology is world class. Those skills added to this investment into advanced product verification technologies will be a vital part of the UK delivering high-quality aerospace products at rate and at competitive cost.”

Andy says key to the meaningful use of data is understanding what data is important and then knowing that it is accurate.

He said: “Right now, businesses want to understand where they are in terms of their carbon footprint. It’s all very well saying you need to be carbon neutral, but if you don’t know where you are now how can you ever reduce it to zero?

“Manufacturers need to measure energy consumption at a really granular level to understand what is going on in their facilities. Looking at utility bills can only take you so far, it doesn’t tell you as an engineer what you can do about it. The information you need, for example, is to be told that the CNC machine that is 25-years-old is drawing three times the current of a new machine, so you can make an informed decision on whether to invest in a new one.

“That’s the kind of information we’re trying to get - and you get that through acquiring, processing and utilising accurate data.”

Left: Artec Leo. Centre: An engineer demonstrates virtual reality technology. Right: Pepper, the world’s first social humanoid robot.

> Designing, manufacturing and assembling aerospace products with the end goal of sustainable aviation must be the focus of the entire UK supply chain.
>
> Sophie Lane, chief relationships officer, ATI.

Sophie says that thread of sustainability is important for manufacturers large and small, regardless of the sector in which they work, but especially so in aerospace.

She added: “It strikes at the heart of the ATI mission. Designing, manufacturing and assembling aerospace products with the end goal of sustainable aviation must be the focus of the entire UK supply chain if we are to meet the target of net zero emissions by 2050.”

AMRC Cymru, which opened in 2019 with £20m from Welsh Government, is assessing its own energy usage by working with digital transformation company Getronics. The work will begin by evaluating the building management system before measuring every individual piece of equipment.

“Our work with Getronics will allow us to make data-driven decisions on energy consumption,” said Andy. “But the value of data and the equipment we have bought for the centre of excellence doesn’t end at sustainability; from it we can confidently make proper decisions and real changes to all parts of our organisation.

“That’s exciting for us, but also for our partners and the companies with which we work.”

Data is used to create a virtual representation of a manufacturing shop floor.

Lightweighting heavy industry with hybrid anti-roll bars

Two South Yorkshire SMEs have joined forces with the University of Sheffield Advanced Manufacturing Research Centre (AMRC) to push the automotive sector further along the road to net zero by designing, manufacturing and testing a high-performance stabiliser bar for trucks and trains that is 30 per cent lighter than those currently on the market.

The AMRC Composite Centre worked with Sheffield-based Tinsley Bridge and Performance Engineered Solutions, in Rotherham, on the Lightweight Metal Composite Hybrid (LiMeCH) project which, with £400,000 in funding from Innovate UK, created a lighter alternative to the tubular steel bar currently used for suspension units.

"Lightweighting is top of the agenda for our customers," said Russell Crow, director of engineering at Tinsley Bridge. "That is even more so when they are looking at alternative propulsion systems, such as electric drive trains and alternative fuels, because every gram they can save offsets the additional mass they have to carry for the batteries or hydrogen fuel tank."

Carbon fibre composites are not yet widely used in the volume automotive sector for functional parts such as suspension systems where the industry standard is a steel tube welded to metallic end fittings. Replacing the steel with lighter materials can improve fuel efficiency, helping operators meet new emissions regulations, and composite materials are less affected by fatigue so their use can deliver increased reliability without compromising performance.

In the two-year LiMeCH project, the consortium aimed to create a suitable joint between a composite tube and a metallic end fitting that together form an anti-roll bar (ARB), a key part of a vehicle's suspension unit.

Russell says as a minimum, the joint needed to be capable of transmitting the same loads as the equivalent part manufactured from steel spring.

He said: "The key was finding a modular system. This project was not about making a very expensive composite part, but about how we could bond together metallics and composites to create high configurability from a low number of stock parts."

Tinsley Bridge had previously worked with the AMRC, part of the High Value Manufacturing (HVM) Catapult, to develop an metallic and carbon fibre reinforced plastic (CFRP) hybrid composite roll bar, joined with an adhesive, on a project called Lightweight Composite Suspension Components (LiCoSuCo).

Craig Atkins, research engineer at the AMRC Composite Centre, says while that project made advances in the areas of volume composite manufacture, metallic arm production and bonding, it created

Continues...

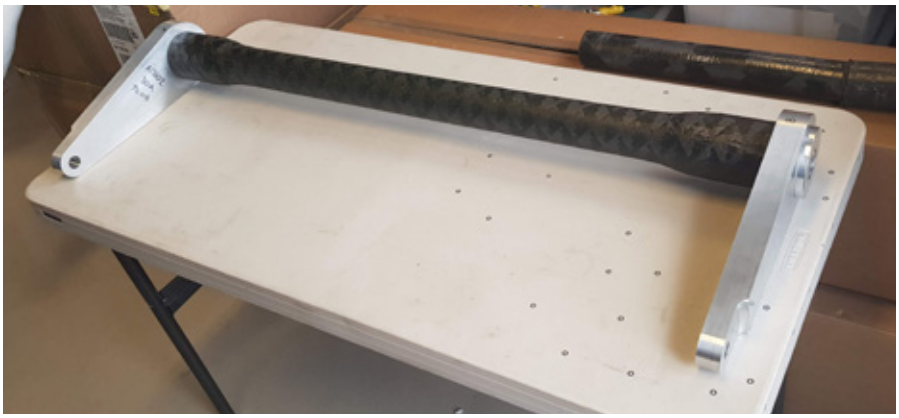
other issues which the team had to develop solutions.

He said "We took outcomes from LiCoSuCo that didn't succeed, in particular with the integrity of the bonded joint between the metallic and carbon fibre. The continued LiMeCH project builds upon the results of the previous project and continues the collaboration and research."

Performance Engineered Solutions used its expertise in composites and lightweight materials to design the ARBs, employing Finite Element Analysis (FEA) to simulate the process prior to manufacture to determine whether the proposed designs could resist the loads an ARB is subjected to.

Stefan Dalberg, senior design engineer at Performance Engineered Solutions, said: "We needed to consider the ease of manufacture as well as the material selection, adhesive selection and how it would perform during non-destructive testing (NDT)."

The AMRC's Composite Centre produced four anti-roll bar prototypes using its MF Tech filament winding system in which filaments of carbon, impregnated with resin, are wound onto a rotating mandrel to form a desired shape. PES penetratively inspected the inside of the bar using CT scanning technology, then used an in-house light scanning system to visually inspect the parts.



One of the prototype anti-roll bars produced on the AMRC's MF Tech filament winding system.

Russell says the prototypes were subjected to rigorous testing.

He said: "Inspection of the composite system was key because these parts have different failure modes to the traditional steel that everyone in the industry knows, understands and is very comfortable with. We researched and developed a whole range of non-destructive testing techniques, both in situ and on a test track, to understand if the part had been damaged, to what extent it had been compromised and whether it was suitable for continual use or not."

Stefan says that non-destructive testing means the consortium can now confidently state that they can bond metallics to composites in a manner that passes the fatigue requirements of industry.

"We have done the NDT, environmental testing and impact testing; so we have effectively looked at everything demanded of this bar under a vehicle and created the safety case," said Stefan.

"Now it is a matter of optimising the design, because we can potentially make it even lighter, and continue to engineer out unit cost."

Craig says the results of this project have applications beyond heavy industry.

"The ARBs we prototyped are designed for trucks, trains and military vehicles, but it can be scaled-down - there is no reason why this technology can't be applied to electric vehicles (EVs) and smaller vans used by courier services," said Craig.

"As the automotive industry moves towards greater electrification and lighter weight parts, there is ever greater focus on moving away from wholly metallic components. Finding a way to bond metallics to composites and reduce a component's weight by almost a third is a significant step along the road to net zero."

Credit: Unsplash.

Molten metal is poured into a ladle - a process used in a blast furnace.

"Collectively, we must find a new way of producing steel that both meets the demands of manufacturers and protects the environment." Steve Foxley, CEO, University of Sheffield AMRC.

A sustainable future for UK steel

The University of Sheffield Advanced Manufacturing Research Centre (AMRC) is part of a major new three-way policy partnership which set out thinking on policies required to develop a sustainable future for UK steel and embed investor support for the decarbonisation of steel production during the COP26 summit in Glasgow.

GFG Alliance (GFG), owner of LIBERTY Steel Group, has announced the partnership with the AMRC, Green Alliance and Bright Blue. It was launched with a Prospectus for GREENSTEEL, in which the three organisations highlight the role that steelmaking and products made from steel can play in the drive to net zero, and with a competitive operating environment and the right policy incentives in place.

GFG Alliance, a lead sponsor of the World Climate Summit, has for over a decade led the debate on the need for transition to GREENSTEEL. LIBERTY Steel UK operates electric arc furnaces at its Rotherham site which recycle steel scrap instead of producing steel from coal and iron ore. Electric arc

Continues...

Electric arc furnaces are operated by LIBERTY Steel UK in Rotherham.

furnaces produce only a tenth of the direct emissions compared with traditional blast furnace operations but are highly electro-intensive. With a rapidly decarbonising energy grid the UK has a significant opportunity to lead the GREENSTEEL transformation by recycling steel with renewable power.

GFG Alliance executive chairman, Sanjeev Gupta, said: "The UK steel sector has been under enormous strain in recent years due to competitiveness issues and a lack of investment, yet the chance to show leadership and innovation in GREENSTEEL is now there to be grasped.

"Steel can be at the heart of our collective transition to a net zero world. To achieve this the industry must change how steel is made. The case for decarbonised technologies – electric arc furnaces and in time hydrogen – is overwhelming.

"Clear thought and commitment from policy-makers and business leaders is needed to unlock investment in decarbonising steel production. Our partnership with Green Alliance, the University of Sheffield Advanced Manufacturing Research Centre and Bright Blue will tap into their environmental, operational and economic expertise to make the case for change until it becomes a reality."

This activity will draw on the expertise of a range of specialists at the AMRC, part of the High Value Manufacturing Catapult network of research centres, and from across the University of Sheffield and its wider academic network. It will be led by AMRC senior research fellow, Dr Peter Osborne.

University of Sheffield AMRC CEO, Steve Foxley, said: "A net zero future for our planet requires a sustainable steel industry and it is essential that innovation is at its heart.

"Collectively, we must find a new way of producing steel that both meets the demands of manufacturers and protects the environment; decarbonising the steel sector is critical to making this a possibility."

Green Alliance is an independent think tank and charity focused on ambitious leadership for the environment. The project will be led by policy director, Dustin Benton, and deputy policy director, Roz Bulleid.

Green Alliance executive director, Shaun Spiers, said: "Early investment in renewables a decade ago turned a profit for investors, cut consumer bills, and turned coal power plants into stranded assets. New technology and policy means the steel sector is in for a similar transition this decade: rapid scaling up of clean steel will secure the jobs of steel workers and undermine the economics of high-carbon laggards. We are delighted to join forces to accelerate the transition."

Bright Blue is an independent think tank for liberal conservatism, which seeks to defend and improve liberal society. The partnership work will be led by senior research fellow, Patrick Hall, and associate fellow, Wilf Lytton..

Wilf Lytton, an associate fellow at Bright Blue, said: "Green steel is an indispensable building block of the net zero future we are heading towards, and the UK's steelmakers can play a leading role in producing it. Bright Blue's vision is for the UK to become home to the world's first zero-emissions steel industry, securing skilled jobs and investment in manufacturing.

"With much at stake and a narrowing window in which to grasp this opportunity, now is the time to set a clear policy direction that will determine the shape of the industry for decades to come and give steelmakers confidence to make long-term investments in their UK operations."

'Green' steel

crucial to net zero ambitions

The COP26 conference in Glasgow saw the eyes of the world focus on global leaders as we looked to them to make the lasting commitments which will help us achieve the goals of the Paris Agreement and the UN Framework Convention on Climate Change.

By Dr Peter Osborne, senior research fellow, University of Sheffield AMRC.

At the University of Sheffield Advanced Manufacturing Research Centre (AMRC) we have set ourselves the mission to 'make things better' so what role should we have in helping to achieve these goals and what should we be doing as an organisation to help solve the challenges which lie ahead?

If we, as a nation, are to accomplish our net zero obligations, we are going to have to make some significant changes to our lifestyles, the products we use and the way we create the raw materials that go into them.

Air travel is often held up as one of the activities that we should curb, but it is important to remember that flying itself is not the issue, emissions are; and therefore the problem that we must solve is how to fly while not creating harmful emissions.

I attended the World Climate Summit, a two-day event hosted alongside COP26 in Glasgow. At the event I argued that if we are to achieve our net zero ambitions, then we must move UK steelmaking away from production using virgin material towards recycled steel made with sustainable power.

Today's industrial processes have largely been designed without resource constraints and with only limited consideration for the impact of emissions on the environment.

Sustainable material production is as much a requirement of our future as battery-powered automotive technology. Whatever powers cars, planes and trains, will need to be made of high-performance specialist materials, and our capacity to participate in a low-carbon supply for those products will be critical to the UK economy's future.

Sheffield and Rotherham, where the AMRC is based, owe much of their history and development to the growth of the steel industry. This growth came about as a direct result of the development of new processes, such as crucible steel and the Bessemer converter, which allowed the manufacture of better-quality steel than had previously been possible. It therefore seems only right that we play a leading role in the next phase of industry's development.

With 'green' steel we have the opportunity to take the lead again and ensure that the steel inputting into these lifetime infrastructure assets is both sustainable and auditable and potentially produced in the UK - particularly if we mandate that steel has to come from green sources.

The phrase *reduce, reuse, recycle* is often used when we talk about how to be more environmentally friendly, how to be greener, how to be ecologically sound and live sustainably.

But what does this mean from a manufacturing perspective? And what are the key problems that we must solve?

One of the most significant challenges we face is how to reduce waste generated through our manufacturing processes. Around a quarter of all finished steel made each year, and about half of all sheet steel, never even makes it into a product but is cut off in manufacturing. The situation in aerospace is even more challenging. In this sector, as little as five per cent of the original material makes it into the final flying component. This occurs because the final user wants components that do not closely match the intermediate products and needs to guarantee the microstructures for performance reasons.

Making Condition of Supply (CoS) parts which are closer to net shape is not without its challenges and we are currently investigating a number of these at the AMRC. Forged parts often include significant residual stresses, which are released during machining and cause the part to distort. Similarly, we must ensure that the final products have the correct microstructure if they are to have the performance characteristics required by the designer. These challenges are solvable, but only if we consider the full manufacturing process early enough in the design process.

It's the solution to these types of problems that the AMRC has built its reputation on over the past 20 years and where we can play our part over the next two decades as we help industry to make things better and solve the climate crisis in which we all find ourselves.

Dr Peter Osborne is leading the University of Sheffield AMRC's involvement in a partnership with GFG Alliance, Green Alliance and Bright Blue which has been launched with a Prospectus for GREENSTEEL. The policy partnership will draw on the expertise of a range of specialists at the AMRC, across the University of Sheffield and its wider academic network.

RAF takes off with mixed reality

Senior commanders in the Royal Air Force (RAF) have been shown by experts at the AMRC how the same Industry 4.0 digital technologies that have drastically changed how NASA astronauts perform duties in orbit could transform how the RAF operates and trains its workforce.
James Crossling visited RAF Cosford to find out more.

University of Sheffield Advanced Manufacturing Research Centre (AMRC) engineers worked with officers at RAF Leeming in North Yorkshire to demonstrate how augmented reality (AR) headsets could revolutionise day-to-day maintenance, repair and overhaul (MRO) by streamlining inspections, providing access to remote expert assistance and rapidly upskilling the workforce.

"This could completely change the way we work," said Squadron Leader Marcus Ramsden, engineer officer (AeroSystems) at RAF Leeming. "Because of its use in gaming, this is technology that new RAF recruits are completely familiar with; we need to grasp it and embody it in our operations."

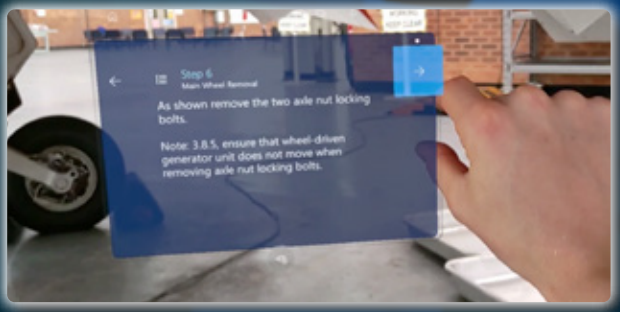
Since 2015, Microsoft HoloLens' have been employed by astronauts on the International Space Station when they need hands-free, remote assistance from NASA scientists on Earth, who are able to see precisely what the astronaut is seeing and advise accordingly.

After identifying mixed reality, specifically the Microsoft HoloLens 2 AR headset, as having the potential to streamline inspections within the RAF, by replacing traditional pen-and-paper checklist work instructions with simple, step-by step holographic instructions displayed in an engineer's field of view, a team from RAF Leeming visited the AMRC's Factory 2050 in Sheffield.

Sqn Ldr Ramsden said: "At Factory 2050 we saw mixed reality devices being used to do MRO on a kit car and it set my mind into overload – if it could work on a car, why couldn't it work on an aircraft?

"The University of Sheffield has a Hawk T Mk 1 on its campus, the AMRC has the expertise, and a relationship with Microsoft was already there. It was all perfectly aligned so we commissioned the AMRC to turn one of our paper-based systems into a mixed reality solution, to see what it could do."

To demonstrate the technology, the AMRC chose to create a mixed reality solution for a wheel change and brake pack assembly on the Hawk T Mk 1, a two-seat training aircraft familiar to many as the aircraft of choice for the RAF's aerobatic team, the Red Arrows. Developing the mixed reality solution involved learning the current manual method for the wheel change and brake pack assembly, reverse engineering



AMRC engineer Stephen Forte demonstrates the augmented reality (AR) technology on one of the RAF's Hawk T Mk 1 aircraft.

the paper-based instructions and then measuring the individual components to create computer-aided design (CAD) assets. Work instructions were created from those assets and generated in AR on the HoloLens 2 headset using the Microsoft Dynamics 365 Guides application.

Mike Lewis, former digital theme lead at the University of Sheffield AMRC, said: "The major element of the solution we demonstrated is the overlaying of the 3D CAD assets onto the aircraft to provide holographic instructions to the operator. On the headset, an engineer can see components superimposed in 3D on the workpiece and, using spatial perception on the HoloLens 2, be told exactly where they need to be working.

"An AR headset can store far more information than a paper instruction document and it reduces the margin for error considerably because there is a 3D representation of the instruction."

Sqn Ldr Ramsden says the AMRC, part of the High Value Manufacturing (HVM) Catapult, has demonstrated how the technology could be integral in three core areas of the RAF's operations: remote assist, understanding data and training.

"Right now, when an aircraft is moved to the front line, a team of engineers with individual expertise and their many 400-page manuals move with it. Those paper-based systems not only use up valuable space and weight, they are susceptible to wear-and-tear and can be very cumbersome in the environments we work," said Sqn Ldr Ramsden.

"Added to that, most of our processes were written down in the 1970s, which means they have been updated inconsistently, can be tough to understand and are hard to translate from the page into the real world.

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An RAF engineer is shown a mixed reality solution for a wheel change and brake pack assembly.

"Mixed reality would completely change the way we work; one engineer can have the entire up-to-date dataset right in front of them and can be supervised remotely by subject matter experts potentially located on the other side of the world.

"Then, when we consider training, not only can our engineers learn in a safe environment where maintenance notes are flagged up in front of their eyes, they can be guided through simulations of different tasks before physically performing that process – all entirely hands-free. This technology has the potential to streamline our processes, boost our efficiency and improve our safety."

RAF Leeming is home to RAF eXperimental (RAFX), an innovation hub which experiments 'at the edge', allowing for concepts to fail early, fail safely and learn rapidly to embrace capabilities that will shape the future air force.

Sqn Ldr Ramsden says RAFX, a concept brought over from the USA, is a space to generate ideas but also a sandbox for concepts that can be presented to senior commanders as part of the Astra programme.

Astra, inspired by the forces' motto Per ardua ad astra (Through adversity to the stars), is the campaign plan for building the next generation air force with the core themes of people, support and equipment, training, and infrastructure. Cutting across each of the themes are emphasises on replacing outdated systems, digitalisation and exploiting cutting-edge technologies.

"We pitched the integration of mixed reality, demonstrated by the AMRC, to senior commanders at an Astra Technology Exposure Day," said Sqn Ldr Ramsden. "There was positive feedback from the Chief of the Air Staff, Air Chief Marshal Sir Mike Wigston, and they seem keen to take this technology forward."

Mike says using AR for MRO could be just the start.

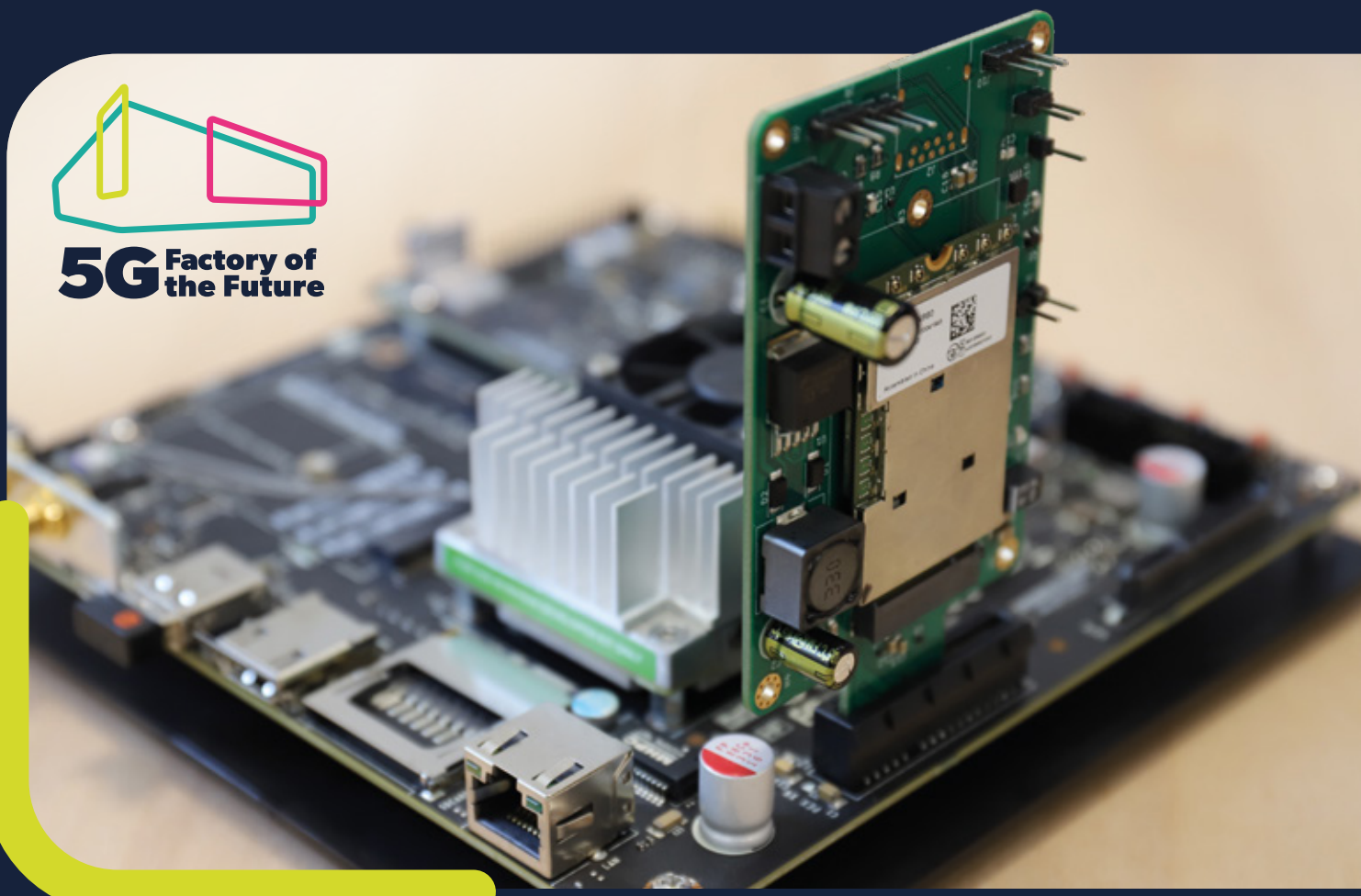
"The example we have chosen is a really quick way to get value from these kinds of devices but once an organisation starts to adopt this kind of technology in a wider sense, you can start to harness so much more power," he said.

"Applying AR to work instructions opens the door to wholesale integration and every data-producing system communicating with each other, which any operator can access. The scope for its application is massive."

Professor Rab Scott, director of industrial digitilisation at the University of Sheffield AMRC, said: "Augmented reality is going to shape the way people work in the 21st Century. It is going to allow us to perform tasks faster, more accurately and with a much richer basis of knowledge from which to work; as importantly, it also has a powerful role to play in the training of staff and the upskilling of workforces.

"This project is at the heart of what the AMRC has been doing for the past 20 years - helping organisations adopt technologies more quickly through proof of concept and applying horizontal innovation by transferring best practice in one sector to another.

"Industrial digitalisation is happening now, it is happening at the AMRC and it's great to see it being embraced by Sqn Ldr Ramsden and his team at RAF Leeming."



Ventus is a native 5G device that connects to equipment and a 5G network directly.

5G sensors making ultra-low latency a reality

Mechatronics and software engineers at the University of Sheffield Advanced Manufacturing Research Centre (AMRC) North West have designed and built a novel, native 5G sensor to unlock the low latency and productivity potential of 5G in manufacturing.

By James Crossling

"There is nothing like this available in the manufacturing sector. This is a fully integrated 5G device that can be connected to anything on the shop floor, from machines, sensors, automation and robots, to building management systems," said Dr Aparajithan Sivanathan, senior software engineer at AMRC North West.

Dr Sivanathan is project lead for the 5G Factory of the Future project, a £9.5m, two-year programme funded by the Department for Digital, Culture, Media and Sport (DCMS) and delivered by a consortium from industry which includes BAE Systems, IBM, aql, MTT, Miralis, Digital Catapult, and is being led by AMRC North West, part of the High Value Manufacturing (HVM) Catapult.

Matt Warman MP, then digital infrastructure manager, welcomed the sensor and saying it can help

Continues...

Dr Aparajithan Sivanathan, senior software engineer at AMRC North West.

manufacturers capitalise on the potential of 5G technology.

He said: "5G can play a massive role driving productivity in production lines up and down the country and I look forward to seeing this new kit in action on the factory floor.

"We have invested £200m in projects across the UK that use 5G in new ways to improve lives and boost the economy and I'm delighted that it has led to yet another innovation in this cutting-edge sensor."

5G Factory of the Future is an open-access industrial testbed that aims to find new and more efficient ways of manufacturing to help lead industry towards a smart, sustainable and resilient future. The programme will transform manufacturing by unlocking the potential of 5G technologies in the sector to accelerate industrial digitalisation. The testbed will be based primarily at AMRC North West's soon-to-be-completed £20m facility on the Samlesbury Aerospace Enterprise Zone in Lancashire.

Dr Sivanathan said a key part of the testbed is connecting every piece of equipment on a factory floor to a 5G network.

He said: "This will bring the physical elements of a factory floor even closer to intelligent, computational units; essentially it will weave an invisible, cyber-physical fabric necessary to achieve the vision of Industry 4.0 and beyond. Eventually, 5G is expected to become the de-facto connectivity standard for the manufacturing industry, enabled by its low latency, bandwidth and fine-grained controllability.

"There is a huge appetite for 5G connectivity in manufacturing, but a major piece missing from the puzzle is the limited availability of 5G devices connecting the machines, robots and sensors.

"5G is promising to deliver ultra-low latency, as low as five milliseconds, but there is currently very limited choice available to connect our industrial equipment to a 5G network. Existing devices are mostly consumer grade, limited to mobile phones, USB dongles or routers, and not suitable for industrial use. Furthermore, multiple devices need to be daisy chained to connect the industrial equipment to a 5G network - every device added to the chain introduces latency and that eventually jeopardises the original purpose."

Zohaib Farhat, embedded systems engineer at AMRC North West, led the development of the native 5G sensor, named Ventus.

He said: "We talk about a 'latency budget', so for each device you bring into your connectivity pipeline you are adding at least a few milliseconds of latency. What we needed in order to achieve this ultra-low latency was our own terminal that could connect to our equipment and the 5G network directly; in effect, a native 5G device.

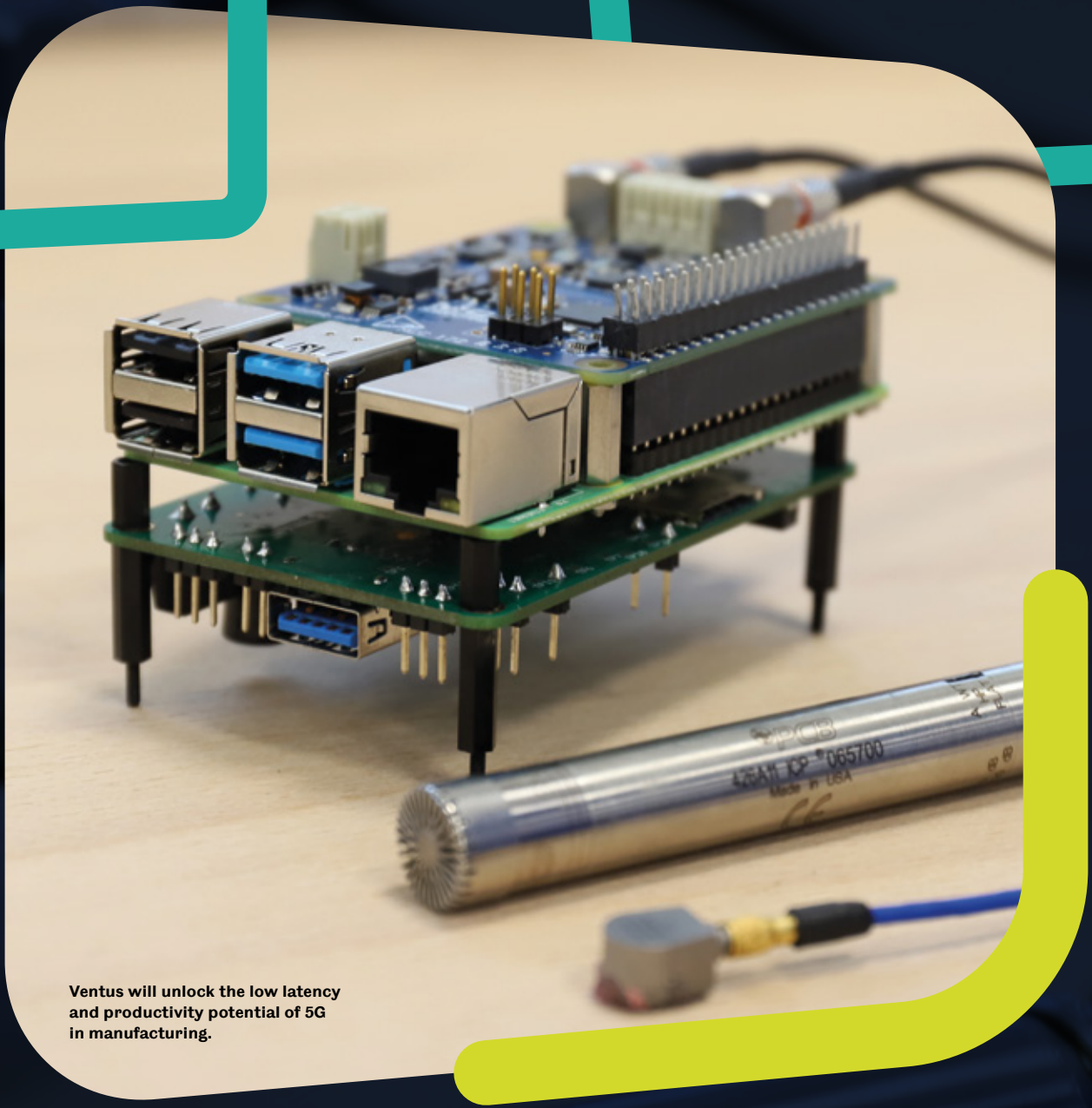
"No one has produced a direct integration between 5G and a device like this. Currently, the way other people are progressing this technology is to have a 5G customer-premises equipment (CPE) wired up to the robots, machines and computers to make a 5G network. Ventus is far more advanced than this because we have built 5G into the sensor, so it doesn't need to be wired to anything else.

"Because Ventus has integrated 5G, we have the ultimate minimum latency, so if the 5G network supports five milliseconds, our testbed will be able to support five milliseconds. We have also added in a considerable amount of built-in compute power - allowing us to do some extremely low-latency processing even before the data hits any 5G radio waves. We can use this, for instance, to compress video streams or run a fast fourier transform (FFT) algorithm on the vibration data.

"Even with the 5G's increased bandwidth capabilities, some of the time-critical data streams can be overwhelming for the network infrastructure, particularly when a large number of sensors are involved. There is also an option to add an additional layer of security by encrypting the data before it gets handed over to the wireless modules, another means of enforcing the zero-trust policy."

The next stage of the project is to conduct testing on the Ventus native 5G sensor at AMRC North West. Dr Sivanathan says every new piece of equipment could be immediately 5G enabled.

He said: "We are building a kind of a reference design so if any new machine comes in, we will be able to immediately integrate it into the 5G network. Ventus is flexible and general purpose, so an industrial computer, a processor, a robotic arm, PLCor a 3D printing machine can all become 5G enabled. "Our design is modular and it includes a plethora of commonly used low-level



Ventus will unlock the low latency and productivity potential of 5G in manufacturing.

industrial interfaces, from analogue to digital converters, charge amplifiers, ethernet, USB and many others."

Professor Rab Scott is the University of Sheffield AMRC's director of industrial digitilisation, one of the testbed spokespeople and sits on the UK5G manufacturing group.

He said: "The work that Dr Sivanathan and his team have been doing on Ventus is a game changer. The removal of milliseconds of latency in the manufacturing process may not sound a lot, but it can be the difference between success and failure, between a perfect part and a scrap part.

"5G communications as a whole have the potential to accelerate huge productivity improvements of the UK's manufacturing sector and to ensure that manufacturing does its part in the UK's drive towards net zero, and Ventus is a trailblazer for the sector."

5G Factory of the Future

AMRC Factory+ Establishing a smart factory architecture

An open-access digital architecture for manufacturing shop floors has simplified the way data can be handled across an organisation, showing how manufacturers of any size can build a scalable, fully connected smart factory. James Crossling reports.

Factory+, designed by digital engineers at the University of Sheffield Advanced Manufacturing Research Centre (AMRC), provides an open framework to standardise and simplify the way valuable data is extracted, transported, stored, processed, consumed and protected across a manufacturing organisation.

Following an initial Literature Review to evaluate the current landscape, engineers at the AMRC's Factory 2050 have now written a Specification, a technical document outlining the high-level concepts and architecture of Factory+, and an Implementation Guide, a step-by-step instruction manual for deploying it.

Together, the documents shape how an organisation could design a smart factory by demonstrating good architecture principles and approaches including openness, efficiency, security and scalability.

Dr Rikki Coles, former theme lead for connectivity and artificial intelligence (AI) at Factory 2050, said Factory+ lays solid foundations from which organisations can build.

"It gets your house in order," says Rikki. "Factory+ is an enabler for Industry 4.0, so the question for a production facility looking at this specification isn't really 'How can Factory+ benefit me?', it is 'How can Industry 4.0 make a more profitable and leaner organisation?'

Alex Godbehere and Arturs Grigals study the Factory+ data.

"With data all standardised and stored in one place that can be accessed in a matter of seconds, rather than hours, businesses can look to exploit it more efficiently and acquire manufacturing insights from their data faster than ever before.

"Manufacturing is starting a journey to the cloud and the Factory+ architecture removes many of the barriers to that migration; hopefully it will accelerate the adoption of cloud technologies within the sector. However, it is also edge-driven so the architecture fully supports on-prem, cloud, or hybrid deployments."

At Factory 2050, the Factory+ architecture has been used to connect the AMRC's smart tools, robots, automated guided vehicles (AGVs) and computer numerical control (CNC) machines. In just four months, six cells transmitted over one billion data points with capacity for much more.

"Factory+ has had two drivers from the beginning – one was operational within the AMRC and the other was a demand

Alex Godbehere reads the Literature Review, Specification and Implementation Guide, written by a team of AMRC engineers.

from industry," said Alex Godbehere, technical fellow for smart factories at the AMRC.

"At Factory 2050, we recognised that organic silos of approaches to how data was collected and stored were developing. Different project teams, working with different partners and using different pieces of equipment might all have their own way of collecting data.

"We saw this vision for a standardised way that devices could be connected on the shop floor, which would mean data could be extracted consistently and stored in the same format. We needed an abstract architecture that was always online, could collect the data, standardise it and store it in a permanent, central database."

Alex says the second motivation was seeing manufacturing organisations attempting to unlock the reduced operational costs, increased agility and improved productivity of Industry 4.0 technology adoption, but becoming stuck because they were using Industry 3.0 architectures that simply weren't scalable.

"A shop floor is often made up of discrete connections to disparate applications with each one requiring a different adaptor or protocol. This works fine in silos, but as an organisation grows their requirements grow and it becomes a spider web of connections," said Alex.

"If a business wants to scale up it becomes messy, difficult to maintain and too expensive to upgrade, so what we see is architectures stagnate and that is where security vulnerabilities start to creep in. Ultimately what happens is the company doesn't scale up because it lacks the solid, scalable foundations. Architectures like Factory+ solve this problem by adopting the concept of connecting devices to infrastructure, rather than to each other."

The Literature Review, Specification and Implementation Guide, written by an AMRC team including Rikki, Alex and Arturs Grigals, technical lead for industrial internet of things (IIoT), live on the publicly accessible Factory+ portal so any manufacturer can study the architecture, implement it and start to benefit.

Factory+ is an implementation of the Sparkplug specification, which provides an open and freely available specification for how devices and applications communicate bi-directionally within a Message Queuing Telemetry Transport (MQTT) infrastructure. The specification aims to define an MQTT topic namespace, MQTT state management, and MQTT payload targeted towards real

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time SCADA/IIoT solutions.

Sparkplug is a project within the Eclipse Foundation which is an independent, not-for-profit organisation, currently host to 400 open source projects and 17 working groups which underpin many of the key digital technologies and initiatives used all over the world.

The University of Sheffield is part of the Eclipse Foundation and both Alex and Rikki are on the Sparkplug working group. Alex says that means the AMRC, part of the High Value Manufacturing (HVM) Catapult, is both adopting the specification and driving it forward.

He said: "We are trying to accelerate the adoption of these technologies and approaches and because this is free and open, organisations can deploy the architecture as a pilot to see if it works.

"That makes it very attractive to SMEs because they can get on the first rung of the ladder without having to pay an integrator thousands of pounds for a proof-of-concept. For smaller companies it is affordable, relatively simple and you can use it tomorrow without spending a penny.

"But this isn't just applicable to SMEs. For larger companies, there is the flexibility of not being locked into one hardware vendor, and Factory+ can scale up and integrate with their existing architecture. It really can be used by two engineers in their shed or global heavyweights."

Arlen Nipper, president and CTO at Cirrus Link and co-inventor of MQTT, has championed Factory+.

"If you are considering starting your digital transformation journey, regardless of the industry you are in, the Factory+ Specification is a fantastic place to start," said Arlen.

"The document presents a concise blueprint for a common-sense approach to applying modern MQTT and Sparkplug technologies to existing infrastructures and equipment. Regardless of where you are in your implementation, this is definitely an excellent framework approach to consider.

"Continuing on from the Specification, the Implementation Guide is a great way to explore specifics and experiment with actual MQTT Sparkplug infrastructure.

Alex Godbehere and Arturs Grigals stand in front of the Factory+ wall in Factory 2050.

It is a great read that I would highly recommend."

Rikki says the Factory+ project is by no means finished with ambitious plans for the next 12 months.

He said: "We have proved Factory+ as a concept and have implemented it in Factory 2050, so the next stage is to roll it out across the entire AMRC to demonstrate that our best principles work on a much larger scale.

"Alongside that expansion, a next step for us is starting to make informed decisions from the data we are collecting and storing, demonstrating how secure Factory+ is from a cyber security point of view to improve trust in the area, and understanding how this can integrate with both brownfield and greenfield installations used by our partners and other UK manufacturers.

"Factory+ is like an organism: sustained by data, supporting an intelligence, hardened by security, and evolving according to operational needs. Thanks to its constituent parts, it is intuitive, flexible, powerful and open. We are now looking for collaborators with whom we can further test and optimise this framework to promote homogeneity and ubiquity within digital manufacturing."

The dark side of Industry 4.0

and its sustainability impact

The evolution of the Smart Factory and the widespread implementation of Industry 4.0 technologies are essential tools which the UK manufacturing sector must employ if it is to stay globally competitive in the 21st Century. That much is clear.

By Ryan Diver, chief engineer for digital transformation, University of Sheffield AMRC.

A recent report by SAP, one of the world's leading software producers, made that connection when highlighting four key benefits those companies who have embraced these advances are now experiencing: radical improvements in productivity and automation; resilience and agility no matter what the market or economy bring; confidence to explore new business models and seize opportunities quickly; and green and sustainable solutions without sacrificing profitability.

Those same benefits are often used to argue that Industry 4.0 leads to green and sustainable manufacturing. But from a sustainability perspective, this only tells half of the story.

It is true that Industry 4.0 and Smart Factory technologies can enable reduced wastage through better control and visibility; better efficiencies leading to energy savings; increased productivity; improved quality through insights from the data collected, and much more. But there is the other half to the story that has a significant impact on the climate emergency.

Productivity is great for companies, but does it help sustainability? I have spent the last ten years devoted to the application of robotics, automation and digital manufacturing technologies to improve productivity usually through

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the application of robotics to improve quality leading to right-first-time manufacturing. However, productivity improvements usually result in cheaper manufacturing costs or larger volumes, better market competitiveness that can lead to more competitive prices that can ultimately lead to higher consumption and thus a higher sustainability impact.

Then there is the carbon footprint of data.

Data is the foundation of Industry 4.0. Within the research team at the AMRC's Factory 2050 we have the Factory+ project, an open framework to standardise and simplify the way that data is extracted, transported, stored, processed, consumed and protected across a manufacturing organisation. This is essentially the network that transports data from all of our industry 4.0 devices to a central location, and where the hidden sustainability impact lies. In a month, billions of data points traverse the network and millions are stored.

Even with the best intentions, the capture and storage of complex manufacturing operations using Industry 4.0 technologies will result in a significant environmental impact. In 2018, data centres worldwide consumed around 200 TWh, equal to one per cent of global energy use [1], with different companies relying on generating (or buying to offset) renewable energy to lessen the burden on the world.

And what is the impact of translating paper-based recording systems to a digital passport, or even just an identical digital copy? What would the storage impact be?

Recently, while helping my parents move home – sadly, there were no robots on hand to help with the heavy lifting – my mum gave me a box of photos and asked me to upload them to her tablet. For her, it was a simple task of digitising something analogue, but as a researcher of advanced manufacturing smart factories and a student of sustainable manufacturing, it highlighted a significant sustainability impact of Industry 4.0 and the Smart Factory manufacturing mindset.

From a sustainability perspective, there was an energy cost from taking and printing the images, but that energy cost hasn't increased in the past 15 years since my parents last moved house. But what will happen now is, I will digitise these images into around 500Mb of image data that will be stored on Google's Photo servers. While it would be very difficult to understand the energy cost of my photos on Google's servers, there would be a year-on-year sustainability cost to the storage of these photos within one of Google's Data Centres.

This is just for a few family photos, not a global organisation. In June 2021 alone, Airbus delivered 63 single aisle [2] aircrafts which as you can imagine, even if only basic data is captured on each process, would require significant amounts of storage that would have to be kept for the life of the aircraft plus a number of years.

Even with the best intentions, the capture and storage of complex manufacturing operations using Industry 4.0 technologies will result in a significant environmental impact. In a number of years, I would expect that manufacturing data at a large aircraft or automotive company could be rivalling the quantity of storage of Facebook putting a massive strain on processing systems, data storage servers and clouds, which all need energy to function.

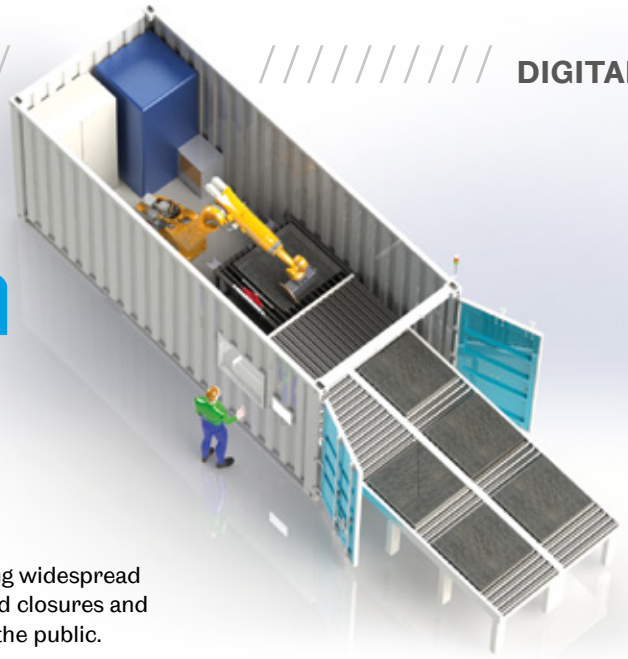
When global leaders met in Glasgow next month for COP26, sustainable manufacturing alongside the UK government's target of net zero by 2050 was inevitably be high on the political agenda. Embracing Industry 4.0 and pushing ahead with the development of the Smart Factory will be part of that conversation but alone they cannot be the shining light for a green manufacturing sector, there are hidden sustainability impacts we must remember.

Industry 4.0 technologies present a bright future, but with that comes a dark side as well.

[1] https://insights.sap.com/what-is-industry-4-0/

[2] https://www.techerati.com/features-hub/opinions/2021-the-year-of-the-sustainable-data-centre/

Paving the way for **construction automation**



By Katia Harston

A groundbreaking robotic paving slab cutting process harnessing innovative digital technologies such as AI and automation is being developed for the construction industry to improve productivity and safety while reducing waste and disruption.

The Distributed Automated Cutting System (DACS) project, led by Eurovia UK in partnership with Loop Technology and the University of Sheffield Advanced Manufacturing Research Centre (AMRC), uses a suite of advanced digital technologies to produce bespoke, made-to-measure slabs in a controlled environment, minimising on-site disruption and helping accelerate Britain's urban regeneration.

The process of developing and testing automated cutting robots can be complicated, with high initial investment and resources needed. The £500,000 DACS project, funded through UK Research and Innovation (UKRI), brings together the partnership's skills and expertise to remove these barriers. It will run until April 2022.

Andrew Tyrer, challenge director at Robots for a Safer World at UKRI, said: "With net zero ambitions underlying industrial plans in every sector, and the chance to rebuild new industries after the pandemic, robotics, artificial intelligence (AI) and automation are vital ingredients going forwards. The UK is a world leader in the field of robotics thanks to projects like DACS and we look forward to seeing the impact this innovation has on the construction sector."

The growing demand for pedestrianisation, to reduce the impact on air quality and climate change, is resulting in local councils undertaking more infrastructure projects that involve laying new paved areas. These can take from several months to a few years, sometimes causing widespread disruption including road closures and noise for residents and the public.

Paving slab cutting, to fit into gaps or around street furniture, is one of the bottlenecks of paving operations. On-site cutting can create safety risks to the workforce and disruption and environmental nuisance to the general public.

Modern Methods of Construction (MMC), incorporating metrology, robotics, AI and off-site processing, will be used within the project to reduce disruption from paving operations, whilst improving productivity, safety and environmental impact.

"This project is literally breaking new ground to bring automation to our public spaces. Cutting paving slabs on site is a messy, noisy and timely process – both for local people and our own workforce," said Phil Reid, Eurovia Contracting's digital construction manager.

"DACS will modernise paving operations to deliver a safer and environmentally friendly process along with a 40 to 50 per cent improvement in productivity. For a typical year-long scheme this could cut disruption by almost a month.

"This partnership is bringing together expertise from the highways and construction sector, artificial intelligence and robotics to design out waste and risk and deliver a new process on the ground that reduces waste, noise, dust and the inconvenience associated with public realm improvements."

A robot cell has been created at the AMRC's Factory 2050 facility. This will be followed by the development of a compact and containerised system to make DACS accessible anywhere.

Ejae Perez, a senior project engineer at the AMRC, said DACS will scan data from areas to be paved and automatically create robot cutting paths. AI will then assess the available slabs and offcuts to choose the optimal piece to maximise material usage and minimise waste.

Perez added: "Our role will be to introduce automation to replace a time-consuming and manual process. We aim to introduce digital manufacturing technologies such as automated cutting optimisation through AI to reduce stone wastage and robotic machining to cut paving stones to the required shape.

"Automating this process will allow cutting of paving stone off-site in the factory, removing any health and safety implications and improving quality and productivity on-site."

The technology developed by the consortium will work in a wide range of applications where paving slabs are cut and showcase the potential of robotics in the construction industry.

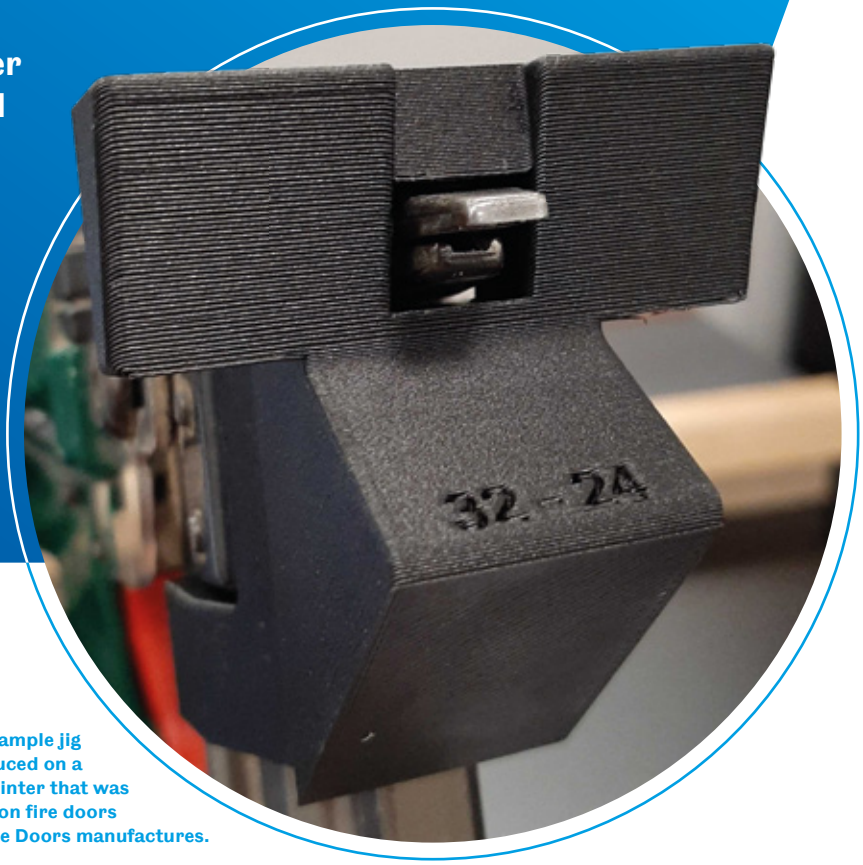
Other key benefits of DACS include:

- Cutting can be moved off-site to eliminate on-site noise, wastewater and carcinogenic silica dust and other hazards;
- Reducing the extent of road and footway closures where cutting would normally occur with ad-hoc fencing around a large safety radius;
- Improving worker safety by removing manual site cutting operations and exposure to noise and vibration;
- Reduced waste paving from ten per cent to three per cent by optimising cutting patterns. For a typical contract this would save about around 16 articulated lorry-loads worth of waste;
- Making best use of a limited pool of specialist, skilled paving teams.

AMRC the key to better accuracy for life-saving fire doors

A Lancashire door manufacturer has invested in a 3D printer and is seeing 'massive productivity gains' after engineers from AMRC North West showed the company how additive manufacturing technology could support production of its specialist fire doors.

By Chloe West



An example jig produced on a 3D printer that was used on fire doors Pendle Doors manufactures.

Pendle Doors Ltd is a family-run business established in Burnley in the 1950s and relocated to a 30,000 sq ft manufacturing facility in Blackburn in 2007. It makes a range of doors for use across the healthcare, residential, leisure and education sectors.

The project with the University of Sheffield Advanced Manufacturing Research Centre North West, focused on its specialist fire doors and explored how additive manufacturing (3D printing) could be used to create a bespoke jig to improve the accuracy and repeatability of its manufacturing process.

Dominic Haigh, project engineer at AMRC North West, which is part of the High Value Manufacturing Catapult, said: "For obvious reasons, fire doors have to be manufactured to precise safety specifications and standards. The project with Pendle Doors was about ensuring the beading around the window panels in the fire doors were holding the glass inserts securely in position.

"Pendle Doors uses an air gun to insert the pins that hold the beading in place, and they wanted to explore the use of a jig to hold the air gun and ensure the pins were consistently going into the doors at the right angle.

"We started by making a CAD model of the air gun which was used as the base for developing the model for the jig. Then, using additive manufacturing, a prototype of the jig was produced. We tested and modified the first design to make sure it remained securely attached to the gun – and when we knew it worked well, we produced ten of the 3D printed jigs, so the company would have enough to last a while."

Dominic added: "The jig is ultimately about ensuring the repeatability and accuracy which brings a business peace of mind with products like this. It also saves costs as fewer products fail the rigorous safety checks they must go through.

"This was a project that really shows how businesses can use additive manufacturing in their processes and to save costs, even if they don't use it to make their products directly."

The company has now invested in its own additive manufacturing capability having seen an impressive rise in productivity, says Ryan Anderson, operations director at Pendle Doors.

He added: "As a result of working with the AMRC, we have purchased our own 3D printer that has been used for a multitude of things, from machine parts, to jigs, to a scaled plan of our factory. It has also helped our business to save a sum of money and we have also seen massive gains in productivity.

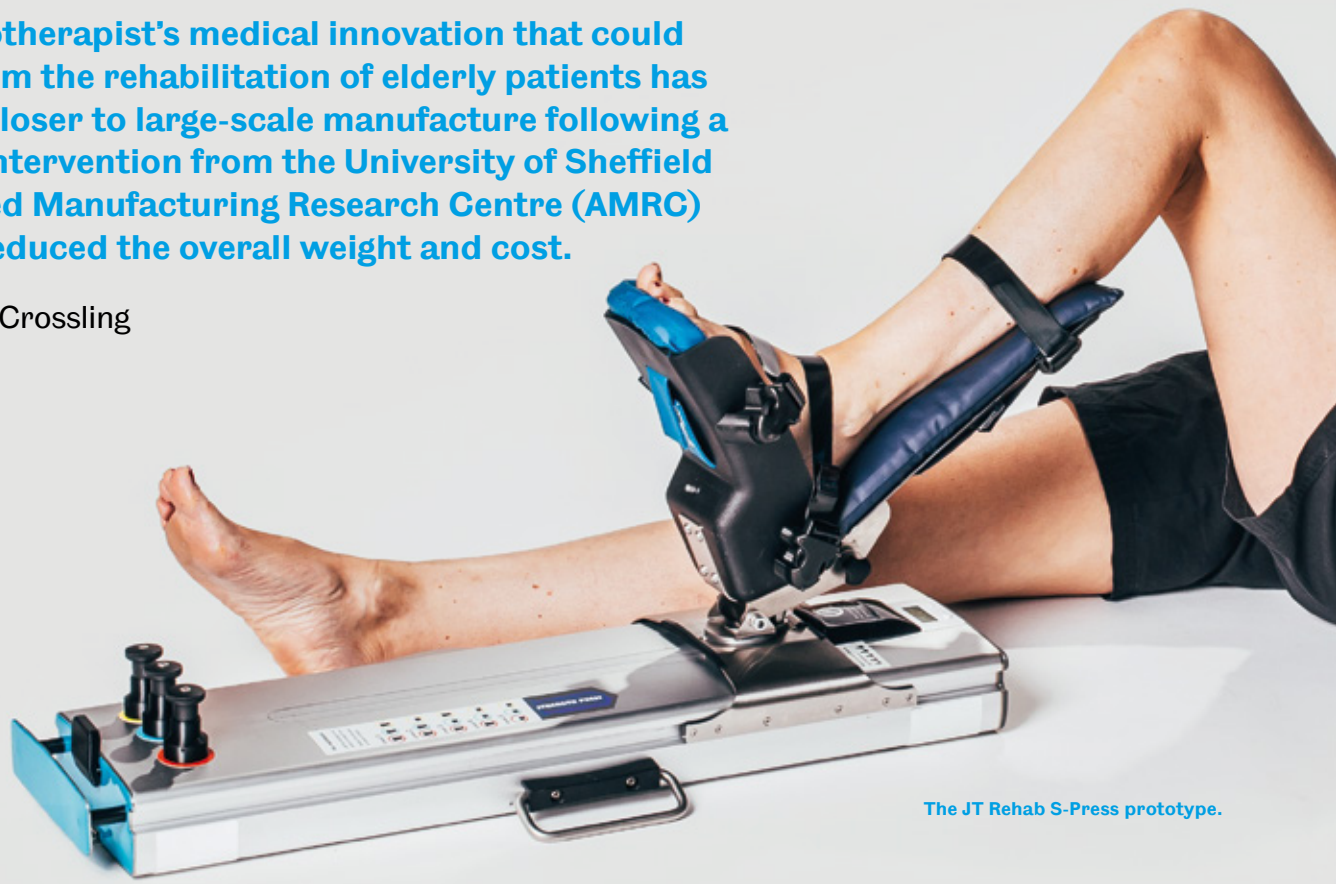
"The team at AMRC North West provided us with a brilliant idea to help us solve a production problem we were having. This enabled us to ensure we were staying compliant in our supply of potentially life- saving fire doors."

The project was fully-funded via the AMRC's ERDF programme. If you want to find out how AMRC North West can help your business, contact **nw-enquiries@amrc.co.uk**

Pressing ahead with rehab revolution

A physiotherapist's medical innovation that could transform the rehabilitation of elderly patients has moved closer to large-scale manufacture following a design intervention from the University of Sheffield Advanced Manufacturing Research Centre (AMRC) which reduced the overall weight and cost.

By James Crossling



The JT Rehab S-Press prototype.

"The changes specified by the AMRC team were exactly what I had hoped for and will make a big difference," said Jen Turner, who founded Sheffield-based JT Rehab in 2016. "The weight has reduced by 11 per cent and the cost of manufacturing for three components was cut by a combined 73 per cent."

Jen, a physiotherapist working in older peoples' rehabilitation, established JT Rehab after becoming frustrated at a lack of equipment available to strengthen patients' leg muscles while staying on hospital wards.

"Most hospital patients spend about 80 per cent of their time in bed where muscle strength can decondition by about 20 per cent in the first week. It is a massive problem, particularly for elderly people who have a low level of physical ability anyway," said Jen.

"I wanted something elderly patients could start using early in their rehabilitation that was affordable and simple to use, but effective in strengthening muscle through resistance. It also had to comply with all the stringent NHS safety standards and no devices like that exist, so I decided to do something about it and that's where I came up with the idea of the S-Press, which strengthens the muscles of patients with leg problems by providing a means of exercise in bed."

Funding was secured from the Design Council, Sheffield City Council and Versus Arthritis to create a prototype for a machine which uses a spring and pulley system to allow a patient to slide their foot up and down with varying resistance, from 3kg to 20kg. Electromyography (EMG) testing proved the progressive resistance works every muscle in the leg.

JT Rehab is a member of Sheffield Hallam University Advanced Wellbeing Research Centre's (AWRC) Accelerator scheme, one of 20 University Enterprise Zones launched with a £20 million investment to increase the likelihood of, and reduce the timescales for, innovations to be brought to market through intensive testing and development.

AMRC engineers provide mentoring to businesses on the AWRC Wellbeing Accelerator and it was through the programme that Jen was introduced to design experts in the AMRC's Design and Prototyping Group (DPG). They were asked to conduct a design review of the manufacturing routes of the high value components, provide alternatives to the

Continues...

manufacturing processes used and to suggest potential improvements.

Jen said: "My prototype was nine kilograms, which is fine to carry for short distances, but too heavy to carry any further. I asked the AMRC to lessen some of the weight and explore different ways of manufacturing the parts to bring the cost down."

Peter Oates, senior design and development engineer, analysed the S-Press piece-by-piece and reviewed how each component's design could be optimised.

"Some elements weren't worth changing as Jen was already committed to a certain manufacturing route. But a lot of things could be changed relatively simply and cheaply," said Peter.

"Some of the sliding blocks were really finely machined and were costing a lot of money, so we suggested 3D printing them. For a couple of the designs, we did quick prints for Jen to try out to see whether it would work. For other parts, I calculated the costs and prices for either 3D printing them or making an injection moulding tool, depending on the quantity, and presented it to Jen."

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

Jen has applied the AMRC's suggestions on three components for the S-Press: the main slider, the internal slide, and the handle.

"The main slider was originally machined acetyl, which was costing £47.34 a unit, but using the AMRC recommendation we're now 3D printing two runners and combining them with an off-the-shelf element which has a total price of £19.20 a unit," said Jen.

"The internal slider was again machined acetyl at £29.58 a unit, but Peter proposed laser cutting plastic. The component slides up and down, so it needs to be smooth; the plastic is not quite as smooth as the metal original, but it is £2.87 per unit to produce and lighter - so it is definitely smooth enough.

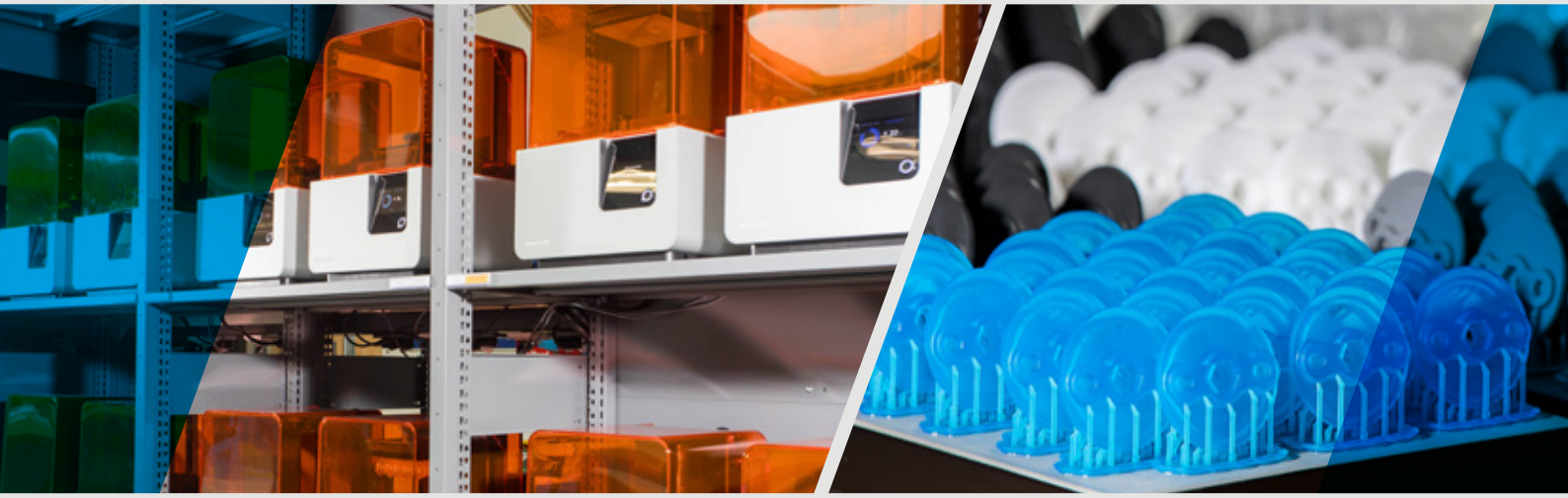
"Lastly, the original steel handle was 245g – three per cent of the total weight – and £12.43 a unit. Peter presented us with four alternatives, and we are now using an option similar to those on suitcases that weighs 70g and costs £3.38. With that component, we hadn't really thought much about it, but changing it makes a significant difference."

Those manufacturing changes will be implemented when the S-Press goes to large-scale manufacture once it progresses through nine months of trials.

"One of the mentors on the AWRC Wellbeing Accelerator programme is the innovation lead at Northamptonshire Healthcare NHS Foundation Trust and has started using the S-Press in four community hospitals in a feasibility and efficacy study," said Jen.

"Sheffield Teaching Hospitals critical care team also want to trial it; that will be good to see what a difference it can make for people who can't get up at all.

"They say it takes seven years to get innovation into the NHS and it's been a long, long road. But I'm convinced it will be worth it."



3D printers, such as the Formlabs printers at the AMRC, enable many components to be produced simply and cheaply.

Lancereal designs and supplies gearboxes, electric motors and drives, clutches and brakes for customers that include JCB, Combilift and Moffet.

‘Informed and intelligent’ growth at power transmission business

A power transmissions supplier tapped into simulation and modelling expertise at the University of Sheffield Advanced Manufacturing Research Centre (AMRC) to understand how it can meet current, forecasted and potential future business demand as it looks to expand and grow.

Lancereal designs and supplies gearboxes, electric motors and drives, clutches and brakes for customers that include JCB, Combilift and Moffet. It is expanding to manufacture electric drives for industrial equipment, and moving into a new, larger facility to accommodate this growing area of the business.

The AMRC carried out discrete event simulation and 2D modelling to help the company understand capacity and capability of the new facility. Nick Hampson, director of Lancereal, said: “It’s important to us to stay up to date with developments in technology, so we can ensure we’re expanding in an informed and intelligent way.

“The AMRC engineers did some preliminary modelling which has helped us understand the capacity of the new facility, and how we can ensure efficiency in the time management of different elements of our manufacturing processes.”

To begin with, three products will be made in the new facility and it is anticipated that more product lines will be added over time. The discrete event simulation carried out by the AMRC included a baseline model of how the new Lancereal factory is proposed to operate, and ‘what-if’ experiments to see how changes to this baseline impacted on throughput, resources and a number of other factors.

Jamie Smith, simulation and modelling engineer at the AMRC, said: “Lancereal is a growing business taking on more work all the time. They’re investing in a new facility in order to meet the demand for their work and, when businesses do this, it’s important to understand what the capacity of a new facility will be.

“In this case, Lancereal wanted to know whether it would be able to meet the demand for their current sales, but also how much more growth it would be able to accommodate.

“We ran a discrete event simulation and 2D model mock-up of the processes at the new facility and found it would be more than enough to cover their increase in business. Beyond this, we also looked at what would be necessary in order to enable Lancereal to take on more work if demand continues to increase.

“Projects like this are all about supporting businesses to grow based on accurate and reliable information.”

The AMRC, as part of the High Value Manufacturing (HVM) Catapult network of research centres, supports businesses to explore development opportunities they wouldn’t otherwise have access to. The project was paid for using funds from the HVM Catapult as part of a commitment to working with small and medium-sized enterprises to help them innovate and grow.

Nick Hampson added: “We’ve been so impressed with the contribution of the AMRC engineers that, as we move forward into larger production volumes, we’ll be calling on their skills and expertise again.”

AMRC keeps watchmakers' machine tool ticking over

A milling machine that lay dormant for two years is back in action producing parts for luxury British-made timepieces after a University of Sheffield Advanced Manufacturing Research Centre (AMRC) engineer re-commissioned the machine tool and trained staff how to use it.

Watchmaker Loomes & Co has a three-axis CNC machine that had been gathering dust in a corner of its Stamford workshop due to a lack of machining knowledge in the workforce. It was put on pause after a previous operator left the company, leaving only one person capable of running the machine - owner Robert Loomes.

But Robert rarely has time to commit to operating the machine so he turned to the University of Sheffield AMRC for help bringing the equipment back into service and upskilling a new member of staff with the basics in computer-aided design (CAD) and computer-aided manufacturing (CAM) to allow in-house production of prototypes and parts for the company's entirely British-made watches.

Emma Parkin, a project engineer at the AMRC Machining Group, stepped in to help. She made several visits to Loomes & Co, undertaking a number of problem-solving exercises to address issues with existing equipment such as on-machine microscopes, CAD/CAM software and machine set up. She also carried out programming and discussed best practices regarding fixturing, tool selection, cutting strategies and general machine health.

> This level of improved precision and cleanliness means we can work faster and crisper. It mean we can get from an idea to a finished product much quicker and we can afford to take more risks and develop more quickly.
>
> Robert Loomes, owner of Loomes & Co.

Emma said: "Loomes & Co is a British watchmakers who make an entirely 'made in the UK' range of watches - every component in the watch is British-made - and the majority of the watch movement is made in-house at Loomes & Co on a three-axis machine tool.

"This machine had been out of

commission for two years due to lack of existing machine knowledge within the workforce. We were asked to re-commission the machine, service it and train the current staff with the basics of how to use a CAD/CAM package and the machine tool so they could produce further watch components."

The result of Emma's work has given Loomes & Co an improved machining process; knowledge of basic machining practices; skills development including design software; redesigned fixtures; and sample part production.

Robert said what was delivered in a few days by Emma and the AMRC, which is part of the High Value Manufacturing (HVM) Catapult network of research centres, could have taken his company 'years of practice and experimentation' to achieve, and has helped boost productivity and spur innovation.

"This level of improved precision and cleanliness means we can work faster and crisper," said Robert. "It means we can get from an idea to a finished product much quicker than we ever could before, and that we can afford to take more risks and have the freedom to be more agile and develop more quickly.

"A lot of what we do is about 'flag-waving' achievements. They might not be what makes money for the business but if you make something amazing, complicated, different or special, that innovation captures attention - so being able to use this machine to produce new things on a regular basis is critical to the future of the business."

The company is based in a former gaol house that dates back to 1588 and is spread over four floors. Its workshops are a showcase of horological expertise, and its watchmaking ancestry can be traced back to Thomas Loomes who, in the 1650s, ran London's largest firm of clock and watchmakers.

Emma said Loomes & Co only began making watches in 2008 but has enjoyed global acclaim in that time, gracing the pages of publications like GQ magazine and the New York Times.

She added: "It is a fascinating place to visit, it is like stepping into another world. The Loomes Original watch is an entirely in-house made movement, every component has been designed and made by them. As an engineer I specialise in micro-machining so it was amazing to be able to go to the Loomes & Co workshop and see for myself a watch movement that has been entirely developed,

Watchmaker Josh Muir who worked with the AMRC to recommission the CNC machine.

manufactured and built in Britain."

Robert said Emma's enthusiasm, expertise and knowledge in commercial machining delivered fast results - upskilling the workforce and halving machining time for some operations.

"She very quickly helped a new member of staff to get used to the software and machinery that we are using and delivered an awful lot of information in a very short space of time to that new member of staff.

"She also helped us to understand how we could make things better; to do things as well as we could and as quickly as we could. She cut down some of our machining times massively - there were some components that were taking us about three hours to make and Emma helped us to work out how to use the optimum speeds and feeds for the materials we were working with to get sharp, crisp results much quicker. For some of the operations we have halved the time it takes to do them.

"It has been really gratifying to work with the AMRC not least because of Emma's amazing breadth of expertise and experience in helping us bring this machine back into operation and making parts for our watches."

The project was paid for using funds from the High Value Manufacturing Catapult as part of its commitment to supporting the UK's smaller and medium-sized enterprises.

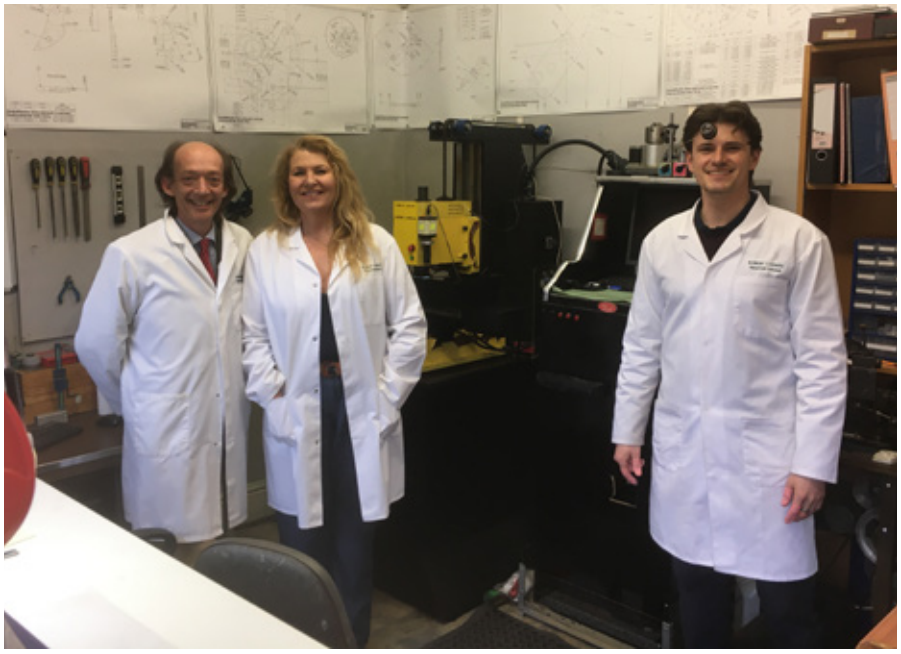
Clocking an opportunity to innovate and grow

Growing up in a family business steeped in horology, Robert Loomes was surrounded by clocks and watches and by tales of namesake Thomas Loomes, the eminent 17th Century horologist who ran London's largest firm of clock and watchmakers. He speaks to Katia Harston.

With a background predominantly in repair and restoration, Robert Loomes, who served a traditional apprenticeship under his father Brian Loomes before taking up the reins to follow in his father's footsteps, was convinced it was possible to design, sketch and manufacture every component required to create an English watch.

Despite being told it was an impossible task, Robert set about creating a workshop and a team of watchmakers who could produce a watch from scratch under one roof. Each component is carefully sketched by hand, before starting the meticulous process of turning a sketch into machined components.

"We're a firm of repairs and restorers. I grew up in the family business doing clockmaking and about 15 years ago I made a couple of watches myself, partly to tease a customer who had brought in a Swiss watch which he had paid £15,000 for. I gently pulled his leg saying I could make something like that for £500 and that what he had bought was £14,500 worth of marketing and £500 of watch.



Loomes & Co's Robert Loomes, Robina Hill and watchmaker Josh Muir.

He said 'don't be ridiculous you can't do that' and I did it to prove a point really.

"I made a pair of watches, one for me and one for him. When he saw them he said we shouldn't be repairing watches, but that we should be making them. So we started, very tentatively, making watches; we imported bits and pieces - cases, dials, hands - built them all together and we had made a watch. It wasn't overly difficult."

The company sold a lot of watches in a short space of time and the business got noticeably bigger. It moved premises, brought in new staff and Robert's partner took over as managing director, leaving him free to pursue research and development.

"My partner said, very quickly after taking over, that it's not enough to make watches, as other people make watches, and what we needed to do was to make British watches; that's what people would pay for - if it was made in this country, people would buy it. So I listened to her.

"I was told it was impossible to build an entirely British-made watch but we knew we had the machinery, and we knew we had the skills.

"We produced the first ones really quickly in about two years; that was from the original germ of an idea to very old fashioned drawings on graph paper and making a prototype to producing the final watch."

But Robert had a problem: "All of the

The Loomes & Co team at work in their Stamford workshop.

machinery we had was manual and we needed a decent CNC milling machine in order to make smaller components ourselves rather than permanently farming out to other workshops around us. It becomes expensive having to outsource almost every component to someone else."

So the company built its own bespoke kit using a cheap milling machine, stripping it down and rebuilding it to meet their own specifications. It's by no means of a commercial machine standard that can be run six days a week, 15 hours a day but Robert says for them, the speed of producing components is not as important as accuracy - so running a little slower isn't an issue.

At less than £20,000 to build and set up, the bespoke machine cost a fraction of the price compared with buying a high-end, commercial machine which would have been in the region of £600,000.

After being used to make prototype parts, the CNC machine was put on pause for a few years but Robert was keen to bring it back into use and approached the University of Sheffield Advanced Manufacturing Research Centre for help re-commissioning the machine and giving staff the skills needed to operate it.

Robert said: "Watchmaking is a small world. There are only a handful of English watchmakers altogether, and many have led the way in research and development by going to experienced machinists and engineers rather than watchmakers.

"We did the same - we had an experienced mechanic build the machine for us, we had someone with a PhD in advanced manufacturing who came and worked for us and ran it for a couple of years for us. But neither of them were watchmakers.

"I'm the technical director so while I know how to use the machine I rarely get days at a time to sit down in front of it and get on with it. We wanted to find the right sort of person to come and work with us who could do that role, someone who was a qualified watchmaker who liked machining and had some experience of CNC.

"That's the right person for the job because they understand what the finished component needs to be and needs to do. They know which parts are critical in terms of measurement and which are immaterial. To give that type of person the right skills means we get so much more out of them.

"We've now got that person with us and through the help of the AMRC and Emma, we've been able to give that person the basic skills they need to operate the machine. They're now running experiments of their own and working out what different tools work best with certain materials."

> I was told it was impossible to build an entirely British-made watch but we knew we had the machinery, and we knew we had the skills.
>
> Robert Loomes, owner of Loomes & Co.

North West motor trade business goes digital with AMRC support

Diverse Automotive Technicians (DA Techs), a rapidly expanding motor trade repair and refurbishment business, has adopted digitalisation of its processes with support from engineers at the University of Sheffield Advanced Manufacturing Research Centre (AMRC) North West.

DA Techs started refurbishing diamond cut alloy wheels in February 2017 with a lathe in a van. It now has seven outlets providing bodywork and tyre services in addition to the core wheels business which includes two mobile pods situated on client sites.

As part of the growth, the company wanted to adopt digitalisation of its wheel refurbishment processes and explore ways to make it more efficient. The company turned to research engineers at AMRC North West for support developing a platform which brings all of the data and analytics about their processes onto one dashboard.

Pete Radcliffe, chair of DA Techs, said: "One thing we've been clear about from the start is a focus on top quality - we will always do things to the highest standard we can. The approach at the AMRC was a great match for this ethos.

"We wanted support to computerise the wheel refurbishment processes. It takes up to eight stages to refurbish each wheel, and we wanted to understand how long each step was taking and how we might be able to make it more efficient. This project has now delivered with the computerised processes working well and helping to improve productivity."

Nick Hall, business engagement manager at AMRC North West, said: "DA Techs is a business that carries out repairs, refurbishments and servicing to alloy

wheels. Initially our project with this business involved mapping out these various stages and elements, some of which are complex and vary depending on a number of different factors. For example, the acid bath which removes paint behaves differently depending on temperature, and this variation needs to be taken into account.

"We have also supported them to use sensors to get accurate information which can then be fed into a digital dashboard giving a full picture of the processes in one place."

The company worked with Amir Kotb, digital manufacturing engineer at AMRC North West, which is based at Preston in a purpose-built £20m facility on the Samlesbury Aerospace Enterprise Zone.

Amir said: "Our work with DA Techs has been about complete digitalisation of the wheel business and building them a platform which brings all the data and analytics about their processes into one dashboard. It can tell you exactly how long each stage of the alloy wheel refurbishment will take and provide other useful information for their customers, so they know when they'll be able to collect their finished product.

"They have already processed over 3,000 wheels using this new technology. We are now working with them to digitalise their portable pods, to provide similar performance measurement data and opportunity to compare and improve productivity across their client sites."

Pete Radcliffe added: "We currently have two of the mobile pods refurbishing wheels based with our biggest clients. It's a win-win, more convenient for clients and more efficient for us. It's exciting to be developing this area of the business further with the AMRC - more mobile pods will mean we can continue to expand in new and innovative ways while maintaining a focus on quality."

Pole position for Rolls-Royce apprentice Kate

'The future of the business and a great asset to the company,' is how engineer-in-training Kate Todd-Davis was described by employer Rolls-Royce after being crowned AMRC Training Centre Apprentice of the Year.

By Chloe West

Kate, a manufacturing engineering apprentice at global engineering giant Rolls-Royce, was announced as the 2021 champion by captain of industry and chairman of Stanley Black & Decker Sir George Buckley, at a virtual celebration in December.

She was also named 'degree apprentice of the year' at the University of Sheffield AMRC Training Centre awards – giving the 21-year-old a double victory. As part of her prize, Kate will be zooming off to the F1 Silverstone Grand Prix in July and will get to visit the McLaren Technology Centre in Woking with the other awards finalists.

Kate's work, which is expected to save Rolls-Royce an estimated £180,000 over the next three years, involves introducing new parts at its Washington-facility; updating manufacturing processes; creating technical documents; and analysing part measures data to achieve process improvements.

The young apprentice says she was 'overwhelmed' by both award wins.

"To have received the 'degree apprentice of the year' award was an honour in itself – but to have also received the overall 'apprentice of the year' award is my biggest achievement so far," said Kate. "I am so overwhelmed but grateful for both awards and for all of the guidance from the AMRC over the last three years.

"I couldn't believe it when I found out that I'd won tickets to the Silverstone Grand Prix, I love F1 and can't wait to go to that and to be given a tour of the McLaren Technology Centre – both trips will be amazing."

Michelle White, apprentice development leader at Rolls-Royce, said: "We're incredibly proud of Kate and both of these awards are truly well deserved. She is a valued member of the manufacturing engineering team at the Rolls-Royce Washington UK site and has been involved in many projects and seeks out where value can be added.

"During this difficult time for most businesses, every cost-cutting measure is greatly appreciated. The amount of money she has saved the company allows the business to be more cost effective and resilient.

"Kate has a very bright future within Rolls-Royce, she is the future of the business and is a great asset to the

company. I am looking forward to seeing what she achieves."

Kate recently graduated from AMRC Training Centre with a first-class honours degree in Manufacturing Technology, having already completed a Level 2 NVQ in Fundamental Engineering, and is now working towards a Level 4 NVQ in Engineering and Advanced Manufacturing, both delivered by the Sunderland Engineering Training Association (SETA).

"I would like to thank everyone who has supported me over the last few years from Rolls-Royce, the AMRC Training Centre and SETA," Kate said. "The mentors I have had have been so inspirational and have continually allowed me to strive to do my best."

Kate, who began working for Rolls-Royce in September 2018, said her most notable work achievement to date has been helping her company to save tens of thousands of pounds after being tasked with managing the implementation of a rounding rule for measured features, eradicating some dimensional non-conformance. By extrapolating information from Red-Amber-Green (RAG) chart data, she predicted the huge savings for seven parts. It has now been authorised for use in production and is expected to be applied to all parts in the future, generating further savings.

"Though I primarily led this project, it wouldn't have been possible without the guidance of my managers and I learned so much during the time I spent completing it," added Kate.

And for anyone considering engineering as their career, she has some sound advice.

"I'd say try and get as much exposure to the industry as you can so that you can understand first-hand what a fantastic industry it is to work in. The apprenticeship route has been critical to my success and I think that apprenticeships are a worthwhile investment for both employers and apprentices."

To be named the AMRC Training Centre's top apprentice for 2021 brings to a close a triumphant year for Kate who also won 'degree apprentice of the year' for the North East region in the National Apprentice Awards in October. She's also making her mark as an ambassador for young female apprentices, regularly attending Women in Science and Engineering (WISE) meetings and has been asked to join the North East Young Apprentice Ambassador Network (YANN).

Looking to the future, Kate wants to progress her career at Rolls-Royce and is looking to complete a master's degree as well as continuing to champion engineering to others.

This year's judging panel, which included AMRC Training Centre leads and representatives from award sponsors including headliner Stanley Black & Decker, Close Brothers and Boeing to name a few, said Kate was an inspirational role model to all future and current engineers and had achieved consistently good grades, impressed her employer and was thought to be more than a worthy winner for this year's award.

Commenting on Kate's win, Nikki Jones, director of the AMRC Training Centre, said: "Kate is a shining example of what an apprentice can achieve. She is academically and practically outstanding. A true ambassador for apprenticeships, with a real community spirit, helping other apprentices within her organisation. She excels in everything she does and is having a real positive impact on her organisation."

Other winners at the annual awards were:

Rising Star: Ben Wright of Tribosonics, sponsored by C&S Fabrications;

Apprenticeship Champion: Rebecca Wright of the University of Sheffield AMRC, sponsored by the Manufacturing Technologies Association;

Advanced Apprentice: Gabriella Spencer of Stanley Black & Decker, sponsored by Sandvik Coromant;

Highly commended Advanced Apprentice: Samuel Thomas Redgrave of Niftylift, sponsored by Hexagon Manufacturing Intelligence;

HNC & Higher Apprentice: Jordan Clayton of Polypipe Building Products, sponsored by NIKKEN;

Highly commended HNC & Higher Apprentice: Louise Brammer of Street Cranexpress, sponsored by Hallam FM;

Degree Apprentice: Kate Todd-Davis of Rolls-Royce, sponsored by Close Brothers;

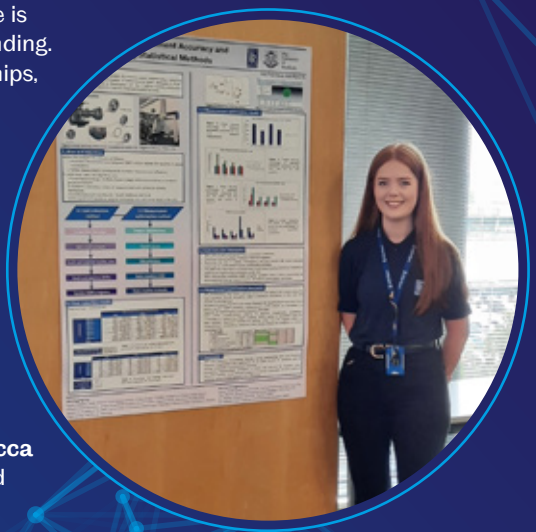
Highly commended Degree Apprentice: Sean Feather of FIRMA Engineering Ltd, sponsored by Boeing;

Special Recognition Award: Liam Shaw of Polypipe Building Products, sponsored by M4S NEWS.

Nikki heaped praise on the finalists and their peers, and said despite on-going work struggles with Covid this year, apprentices had stepped up to prove the benefits they bring to industry.

"It has been a pleasure to see our apprentices thrive and strive for the best with their work throughout this difficult year," she added. "Despite the added pressures of Covid lockdowns, digital working and adjusting to social distancing rules, all of our apprentices have continued to get the best out of their learning - and here at the training centre, we are very proud of them all.

"I would like to say a massive congratulations to all of our 2021 finalists and winners."



Apprentice awards packs a punch with Steph McGovern

Award-winning business journalist, television presenter and former engineering apprentice Steph McGovern launched the 2021 AMRC Training Centre Apprentice of the Year Awards.

By James Crossling.


Credit: Channel 4

Steph, from Middlesbrough, is the presenter of Channel 4's daily lunchtime show Steph's Packed Lunch and has become a panel show favourite on programmes like BBC One's Have I Got News For You.

The 39-year-old was excited to toast the triumphs and achievements of the University of Sheffield AMRC Training Centre apprentices and recognise all the brilliant apprentices who have been doing 'a fabulous job'.

She said: "These are the people with the skills our country needs to keep the economy going. It's so important to celebrate their success."

The awards, now in their seventh year, is a highlight of the AMRC Training Centre calendar and recognises the achievement, innovation, fresh thinking and contribution apprentices and their employers make to industry. Winners were announced by Nuclear AMRC research associate and Great British Bake Off winner, Dr Rahul Mandal, on social media and a celebration event is planned for 2022 to toast the apprentices in person and to hand out the prizes.

For the second year in a row, iconic toolmaker Stanley Black & Decker was headline sponsor for the awards, building on a long-standing relationship with the training centre in fostering a culture of continuous learning and investment in the next generation of engineering talent.

It was at Stanley Black & Decker, the world's largest manufacturer of tools, that Steph began her career with an engineering apprenticeship at its Spennymoor plant in County Durham.

Aged just 18, she saved the company £150,000-a-year with a new design for the Leaf Hog, which vastly improved the garden vacuum's production. For that superb innovation, she was named Young Engineer for Britain.

Steph has repeatedly underline the impact of an apprenticeship on her career.

She said: "My apprenticeship has had a huge impact on me, with the transferable skills I learned helping me in every job I have had: from engineer, to work experience on Tomorrow's World, to BBC reporter and now Channel 4 host."

As a business journalist, Steph visited more than 1,000 workplaces across the UK and on Steph's Packed Lunch she is now on a mission to both explain the real economy and be an ambassador for STEM (science, technology, engineering and maths). In 2021, she was made an honorary fellow of the Royal Academy of Engineering for her outreach work in engineering.

Sir George Buckley, the chairman of Stanley Black & Decker who left school with no qualifications and began his career as an apprentice electrician at Stanley, says the pandemic has shone a light on the importance of innovation, skills and apprenticeships.

He said: "The hardest thing for manufacturing companies to do during the pandemic was to keep factories running - and to do it while also keeping our employees safe. So the production and maintenance workers became key to the successful running of many companies.

"When we work in these stressful and challenging circumstances, it forges a positive attitude and develops people in ways that more normal circumstances could never do. You learn more and are far better prepared for new challenges than you ever would be otherwise."

Nikki Jones, director of the University of Sheffield AMRC Training Centre, says the awards are a chance to say 'thank you' to apprentices, employers and training centre staff.

"Since 2013, the University of Sheffield AMRC Training Centre has nurtured the next generation of engineering talent, supplying Sheffield City Region manufacturers with a pipeline of skilled apprentices who make a real, significant and lasting impact. Our Apprentice of the Year Awards is a highpoint of the year where we celebrate their achievements and show our appreciation to their employers for the vital role they play in developing the talented engineers of tomorrow.

"This year, more than any, apprentices have proven the value they bring to industry. Our apprentices have been critical to the endurance of many businesses in a tough climate, demonstrating their energy, enthusiasm and talents in a uniquely pressurised environment."

Here are our AMRC Training Centre Apprentice of the Year 2021 winners!

Rising Star:
Ben Wright
Tribosonics
Sponsored by C & S Fabrications

Apprenticeship Champion:
Rebecca Wright
University of Sheffield AMRC
Sponsored by the MTA

Special Recognition Award:
Liam Shaw
Polypipe Building Products
Sponsored by M4S NEWS

Advanced Apprentice:
Gabriella Spencer
Stanley Black & Decker
Sponsored by Sandvik Coromant

HNC & Higher Apprentice:
Jordan Clayton
Polypipe Building Products
Sponsored by NIKKEN

Degree Apprentice:
Kate Todd-Davis
Rolls-Royce
Sponsored by Close Brothers

Highly Commended Advanced Apprentice:
Samuel Thomas Redgrave
Niftylift
Sponsored by
Hexagon Manufacturing Intelligence

Highly Commended HNC & Higher Apprentice:
Louise Brammer
Street Cranexpress
Sponsored by Hallam FM

Highly Commended Degree Apprentice:
Sean Feather
FIRMA Engineering
Sponsored by Boeing

From Sheffield slum to the American dream

Sir George Buckley is an irrefutable captain of industry: he holds the post of chairman at Smiths Group; was previously chairman and chief executive of American conglomerate 3M; headed up the Brunswick Corporation and served as chief technology officer at the multinational Emerson Electric Company.

He's also the only British person to run an American Fortune 500 company.

By Katia Harston

Not bad really for the lad who grew up in a playground of poverty in the slums of Sheffield and left school with no qualifications.

"The difficulty for someone with my career is you end up either looking like a modern-day Oliver Twist or Superman, and neither one of those is right," explains George, who splits his time between homes in Florida, Minnesota and the rolling hills of Derbyshire.

"This boy who left school with no training in algebra, trigonometry, geometry, or in any of the science subjects, how can he now hold 20 or so patents, have published more than 60 Learning Society papers, won international prizes and ended up running one of the most innovative and highest value corporations – how could that happen?

"It just proves that God has a sense of humour."

Sir George's illustrious career began aged 15 as an apprentice electrician with building firm NG Bailey. The company treated him 'very well' but following an epiphany while fitting cables in an unfinished science lab at Sheffield College of Technology, the young George knew he needed to bulk up his educational muscle.

"Life really isn't about a single turning point. It's about multiple turning points and realising I needed to get better educated was one of those turning points," says the 74-year-old.

"It was a bit of an epiphany that came about on a day I was assigned to an electrician I had never worked with before. We were working in the labs at Sheffield College of Technology on Pond Street going through a 'punch' list of things that hadn't quite been finished. As we were fitting cables this chap turned to me and said 'George do you know why we're putting in heavier cables for the power circuits?'

"I told him I thought it was because the power circuits would use more electricity and that's when he offered to show me how to calculate the power and to work out the relationships between current, voltage and wattage. 'Sure', I said.

"Looking back now, it was one of these strange, serendipitous moments that happen to people in life. There we were, in a college lab that was still largely unfinished, and there just happened to be a blackboard with a piece of chalk. I look back and think how can this be

> **"I had a wonderful time being an apprentice.** It was probably the first time in my life I realised I was actually good at anything."
>
> Sir George Buckley.

possible? So, this man started to write a little bit of algebra on the board and I was completely lost. On the way home that night I realised that if I didn't do something about my education I was going to be ignorant for the rest of my life."

The following day, Sir George asked his company if he could take day release and although he wasn't able to start until he was 16 (in fact he was almost 17 when he began) he signed up for a five-year City and Guilds electricians course, attending Granville College one day and one night a week for three years, and one day and two nights for two years.

"I had a wonderful time being an apprentice. It was probably the first time in my life I realised I was actually good at anything. I was a good apprentice, a skilled apprentice. And I was a good student too. I never missed a class and I think I came top of every subject in every class because I was so motivated."

His drive and ambition to become an electrical engineer took him to the University of Huddersfield in 1969 where he studied a BSc in Electrical and Electronic Engineering. His thirst for knowledge continued, later gaining a PhD in engineering.

"I think growing up in those days as a member of the working class you are trained to believe and treated to believe you are in fact inferior through social stratification. I believed that I was inferior and I think the pursuit of an engineering degree was about me trying to prove I wasn't inferior. Not to anyone else but to myself.

"In a way the beauty of the story of my life, and other people like me, I think, is that we break the mould."

The Yorkshireman not only broke the mould, he re-engineered it and took with him across the pond the land of hope and glory.

"When I moved to America it turned out my British engineering education was really very good relative to what I was surrounded by, and the standard was high. Over a period of years I got to be the one who was always given the hardest problems to solve; I became a kind of engineering Sherlock Holmes looking for solutions. It's really bizarre and I absolutely loved it."

Sir George moved to the States in 1978 after being offered a job by General Motors Research in Detroit. He went on to work for Detroit Edison and the Emerson Electric Company and, after a brief return to the UK with British Rail, he went back to America to take the helm of the Brunswick Corporation in Chicago.

"It was hypnotic to be able to work on ideas for new products and conceive of things that might be and then invent them. There's a wonderful line from playwright George Bernard Shaw: 'Imagination is the beginning of creation. You imagine what you desire, you will what you imagine and at last you create what you will.' This is the story of my life. Having that desire, the burning force inside of you."

His advice for young people hungry to succeed boils down to two things: education and hard work; qualities he has seen in spades when taking part in the judging panel in previous years for the AMRC Training Centre Apprentice of the Year Awards.

"I was looking at the future," says Sir George, "Seeing these young folk who are just brilliant. I wasn't that good when I was 34-years-old, never mind 20 or 24. I think to myself this is a wonderful melting pot for the future for manufacturing in Britain.

"And of course, what we are doing is giving people skills that can help that conversion from raw material to finished goods; we're accelerating that conversion. That's why I think places like the AMRC and the training centre are so vitally important to the future of Britain."

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>
> Sir George Buckley.

New partners at the AMRC

PEAK INDICATORS

Peak Indicators is a visionary data services, data science and advanced analytics consultancy based in Chesterfield. It brings together a diverse and passionate team with best-in-breed technologies and methods to deliver innovative solutions that drive transformational results. As a People-First business, it believes data can be a force for good; helping people make better decisions, helping companies grow and improving the world around us.

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

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March 21-24 & April 25-28
Introduction to TIG Welding
Rotherham

March 28-31 & May 16-19
Introduction to Manual Metal Arc (MMA) Welding
Rotherham

March 7 & May 9
Oxyacetylene Gas Safety
Rotherham

March 7 & May 9
Abrasive Wheels
Rotherham

April 18-19
Introduction to Robotics
Rotherham

May 16-17
Introduction to CAD
Rotherham

May 18-19
Intermediate CAD
Rotherham

May 30
Introduction to Drawing Techniques
Rotherham

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