

## Sheffield to Shanghai Young robotic titans take on the world

### Growing ambitions

How the spectacular growth of the AMRC is driving productivity and performance improvements in the UK.

### Autonomous robots

Wing assemblies could be transported by intelligent, autonomous robots working with humans at Airbus in North Wales.

### Winning the weight race

How lightweighting will be one of the most significant developments for the future of mobility.



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# Welcome to the AMRC/Journal

## Optimism and hope



**Two themes run through this Journal like Blackpool through a stick of rock: themes that have been a constant in the life of the AMRC. The first is growth. And the second is the expanding number of talented people we attract who drive and sustain it. In less than two decades, the AMRC has gone from being a handful of misguided manufacturing missionaries to become an engineering centre of excellence with a truly global reach. A centre that employs sixty-times more people than were huddled in our first home on the old airport site, close to where the Secretary of State for Business opened the new Boeing facility late last year.**

The wider Advanced Manufacturing Park has also expanded, as high-value manufacturing companies, from dynamic young start-ups like PES and Iceotope through to major players like Rolls-Royce, McLaren and Boeing, seek to cluster around one another, not for economies of scale, but to create a collaborative climate which sparks bright ideas and stimulates innovation and competitive advantage. This is what the Brookings Institution's Bruce Katz identified when he said: "Your capability in advanced manufacturing and materials is distinctive globally, and your culture of collaboration across business, university and local government aligns well with the new network model of innovation growth."

Bruce also identified the importance of devolved decision-making and elected city region mayors as a catalyst for attracting the strategic inward investments needed to spur the city region's transition to a high value-added, high-wage economy. While Merseyside, Greater Manchester, the Midlands and the North East all have fully functioning elected mayors, Yorkshire has still to seize this opportunity. The Sheffield City Region has an elected mayor, Dan Jarvis, but his ability to draw down much needed resource and exert influence in London is severely hampered by the failure of the four big councils to unite behind his banner.

There is an irony in this, of course, as the success of the AMRC is built on a collaborative model of shared endeavour and shared success. Without the support of national and European government, and agencies such as Innovate UK and UKRI, we would still be in that shed shivering through winter. Without the support of the university, and those

doing fundamental and basic science, we would lack the pipeline of research talent that is essential to the translational work we do in collaboration with our industry partners. Without the support of hard-pressed local authorities and local enterprise partnerships, whose officers are determined to make an impact, the AMRC's growth and that of our region would be seriously impaired. This approach creates a win, win, win model.

Imagine what we could achieve then, if we came together as a united Sheffield City Region. We could turn bold ideas like the Advanced Manufacturing Innovation District and the Global Innovation Corridor into a reality: raising skill levels and, with them, the performance of the region's expanding advanced manufacturing base; opening pathways to higher education for thousands of young people who are increasingly seeing apprenticeships and engineering as a pathway to high earning, secure careers that challenge, stimulate and reward; expanding STEM across all our schools, from primary to sixth-form colleges, to build the sustainable talent base essential to a high performing economy and the inward investors needed to accelerate growth.

This issue of our Journal is rich in stories that reflect these twin themes of people and growth. They are a cause for optimism and hope. But they leave no room for complacency and division.

**Prof Keith Ridgway, CBE.**

Executive Dean of the University of Sheffield Advanced Manufacturing Research Centre Group

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# Growing ambitions

Rising demand for the talents of the AMRC's engineers has seen spectacular growth in the organisation over recent years. John Yates looks at how this growth is impacting on the AMRC's existing footprint and how expansion plans elsewhere in the UK will enable it to support productivity and performance improvements in the wider economy, and open new opportunities for collaborative research projects for the University of Sheffield.

**No sooner had the Duke of York cut the ceremonial tape to declare the very first AMRC building open in 2004 than its new occupiers were facing a dilemma: such was the demand for their talents, what had seemed a huge building was fast approaching capacity.**

Encouraged and supported by Rolls-Royce and a growing body of Tier 1 industrial partners, the construction of a much larger Factory of the Future just four years later seemed to solve that problem. With a footprint close to the size of the pitch at the new Wembley Stadium, surely this one would match the limit of their ambitions?

"When we first moved in we just laughed at the sheer scale of it," says AMRC founder and Executive Dean, Professor Keith Ridgway. "We thought we would just be sitting in one corner of it, and have to either sub-let the rest or play five-a-side."

A decade – and six new builds later – the Factory of the Future and all the other buildings that comprise the AMRC Group are bursting at the seams with equipment and people.

The Factory of the Future itself is now not only home to machining – the research discipline that put the AMRC on the global map and continues to do so – but also to composites, whose remarkable range of expertise proved an irresistible attraction to UK supercar manufacturer McLaren.

The company recently opened their own Composite Technology Centre next to the AMRC, but not before first engaging our researchers to prove out technologies and processes to reduce the weight of the next generation of supercars to be built in their new £50m factory following a decision to onshore the process from Austria.

Looking back to when the AMRC was little more than ten men in a shed on the

Sheffield Business Park, even Ridgway admits that when he and Adrian Allen joined forces with ex-Government Office civil servant, John Baragwanath, they had no idea how fast and large the centre would grow.

"We had a vision of a big park, as you can see from the architect's drawings," said Keith. "But we had no idea that just over a decade later what is now called the Advanced Manufacturing Park would be employing 1,750 people, most of whom are highly skilled engineers, and be home to production facilities for three incredible global brands – Rolls-Royce, Boeing and McLaren – all of whom are taking apprentices from our own dedicated AMRC Training Centre."

The success of this collaborative, partnership model – university researchers working with industrialists and



Royal approval: Prince Andrew at the opening of the first AMRC building in 2004 and an aerial photo showing the site as it was then.



#### The AMRC as it is today.

government policy makers and funders – has since been adopted by government in a national network of seven High Value Manufacturing (HVM) Catapults, including the AMRC, the Nuclear AMRC and the Advanced Forming Research Centre in Strathclyde, where Ridgway has played a pivotal role in establishing the National Manufacturing Institute of Scotland.

However, with the publication of the Building Our Industrial Strategy Green Paper, followed by the Made Smarter Review, and culminating in the Industrial Strategy itself, government made it clear that universities would be expected to

do even more to enhance and rebalance regional economies, to narrow the gaps between rich and poor regions.

As John Morgan of the Times Higher Education said the ‘industrial strategy pledges a key role for universities in regional growth’, commits the government to ‘increasing university-business collaboration funding’ and reaffirms the commitment to a major review of tertiary education funding.

With physical and funding constraints pressing in on the AMRC in Rotherham and Sheffield – a decision is still pending on local and national funding for the delivery of a much-needed

Lightweighting Centre – expanding the AMRC’s research capability and capacity into other regions, where existing and new partner demand is high, is a way of both supporting the government’s Industrial Strategy, while fulfilling the university’s strategic mission as ‘a civic institution... driving growth and vibrancy for the city, the region, and the globe.’

As a university led organisation the AMRC has a clear sense of ‘place’, and that, according to the University’s strategy means: ‘driving the regional economy through our research-led innovation district, and transforming



the UK's approach to infrastructure manufacturing and employer co-designed and funded apprentice degrees.'

For Ridgway and the senior leadership council around him, the AMRC is critical to the expansion of this emerging innovation district. "The recent big inward investments are all about smart, high-value manufacturing companies wanting to be close to the AMRC, our people, our capability and our leading edge technology. From the £100m Rolls-Royce invested in their Advanced Blade Casting Facility across the road from our own casting facility, to the £50 million McLaren plant on-shoring production to Rotherham from Austria, and Boeing opening their first ever production facility in Europe, here in Sheffield next door to our own Factory 2050, the place where digital meets manufacturing."

But the AMRC finds itself the victim of its own success. Land, which 15 years ago was being given away for £1 an acre, is now fetching closer to £750,000. "We are keen to expand here in the Sheffield City Region where we have great support from both local councils and from the LEP who understand the magnetic attraction of the AMRC to inward investors and home-grown talent. With the support of the university we can accelerate this clustering effect, supporting existing partners who want to expand their activities in the region, and attracting synergistic companies who see the benefits of living and working alongside other advanced manufacturers," said Ridgway.

But the university's mission extends beyond the city and the region to the globe. "The University of Sheffield has researchers in every faculty grappling

with the grand global challenges of our time, and that means collaborating with others often far from our own region, establishing projects and a presence in far flung parts of the world.

"That's why the AMRC is now working with colleagues in Korea in collaborative research centres developing smarter materials and manufacturing processes. And it is also why we are creating collaborative centres with regions here in the UK whose political and higher educational institutions want to understand how best to work with industry to grow their local economies and improve the well-being of their local people.

"Long-term this means we need to develop a strong network of centres that can share resources and participate in collaborative projects. The goal is not to duplicate what we do here in Rotherham and Sheffield, but to develop complementary research and innovation capabilities that strengthen our offer to high-value manufacturing and the small and medium sized firms who comprise its supply chains," says Ridgway, following University Council approval for satellite AMRC and Nuclear AMRC facilities in North Wales, the North West and the Midlands.

"The business model hasn't changed, it remains one where industry, academia and government all work together to create a 'who shares wins' approach to delivering affordable and effective solutions to strengthen the long-term competitiveness of the UK's advanced manufacturing. It will also enable us to develop partnerships with other universities around the country to tackle four grand challenges identified by the Government in its Industrial Strategy:

clean growth; future mobility; artificial intelligence and machine learning; and an ageing population," says Ridgway.

Take North Wales: a region whose economic challenges and opportunities are best met by a coordinated strategy between industry, academia, Welsh Government and the Deeside Enterprise Zone Board to maximise the opportunities.

A £40 million investment by the Welsh Government is now seeing the construction of a state-of-the-art facility which AMRC/Wales will operate. An early anchor tenant is one of our senior partners, Airbus, who employ 6,000 people at its nearby Broughton production facility making wings for the entire family of the firm's commercial aircraft.

Airbus are already Tier 1 partners of the AMRC so the organisation has been able to hit the ground running setting up early joint projects to help secure the future of wing development in the region – a matter of strategic economic concern for both the Welsh and UK governments.

With space running out at the Rotherham and Sheffield sites, AMRC/Wales gives the AMRC the chance to deepen and expand research capabilities and innovation assets in the aerospace sector, the largest of its kind in Europe, supporting 240,000 jobs both directly and indirectly and worth £32 billion last year to the UK economy.

One of the recent





research projects – featured elsewhere in the Journal – has helped Airbus develop and deploy smart autonomous robots to move tooling around the huge facility: freeing operators to focus on higher value added tasks. The project has been so successful it is being rolled out across the company and, within five years, could see robots moving entire airframe structures around the Broughton facility.

While the work done in collaboration with Airbus is crucial, the facility will also be supporting the wider manufacturing base of North Wales, including automotive, food and drink, and the energy sector with an emphasis on next generation nuclear power generation.

“It’s a privilege to work with the Welsh Government on developing the Advanced Manufacturing Research facility and to extend the reputation and research reach of the University of Sheffield across the country,” said Ridgway. “It aligns perfectly with the university’s strategic identity as a civic institution, proud of our urban character, driving growth and vibrancy not just for

the city region but the wider world.”

As with North Wales, the proposed expansion of the AMRC into the North West is a strategic partnership with significant local actors in both the private and public sectors. In this case, the Lancashire LEP, Lancashire County Council, the University of Lancaster and University of Central Lancashire (UCLAN).

The development aligns perfectly with the University of Sheffield’s recent Science and Innovation Audit which outlined a vision for a: “Northern Advanced Manufacturing Innovation Corridor, bringing existing, emerging and new science and innovation assets and programmes into collaboration with industry to drive productivity growth in advanced manufacturing and key linked sectors across the region to world-class levels. The opportunity is to invest in key schemes which will enable the region to deliver innovation so the UK can maximise the benefits of Industry 4.0.”

Initial work will take place in a temporary facility provided by UCLAN, but the aim is to move into a purpose built centre on

the Lancashire Aerospace Development Zone in Samlesbury, which is home to another of the AMRC’s Tier 1 partners, BAE Systems.

Once again, the North West is an underperforming region (the worst Enterprise Zone in the UK) with commercial and national security assets that are of strategic importance to the UK economy and the government. The forecast is for a new 4,500 square metre facility to be up and running in two years’ time, with substantial public investment in new equipment and people. The AMRC is already in advanced talks with a major player in the field of electric vehicle production to develop a demonstrator which could prove hugely attractive to those major motor manufacturers reluctant to use the JLR-dominated assets in the Midlands.

As neither the North West nor North Wales is served by an existing HVM Catapult centre, these





developments are being seen as a key element in the Catapult's goal of providing 'local demonstrators' and research and innovation assets that supply chains and SMEs can easily access to drive up their own productivity and performance.

"A key part of our growth strategy is to support central and devolved government such as City Region Mayors, in implementing key elements of both the Industrial Strategy and the Made Smarter Review. The key message from government and industry is that the UK universities and their research and innovation assets have a vital role to play in delivering these strategies. The University of Sheffield, in creating the AMRC, has been a pioneer in this arena for more than a decade helping to ensure the UK's best companies retain a global competitive edge, and that their SME supply chains become early adopters of the digital and Fourth Industrial Revolution technologies that will drive up productivity, performance and quality," says Ridgway.

The most recent announcement is

the expansion of the Nuclear AMRC's activities into Derby and the Midlands. Derby, like the North West and North Wales, lacks a Catapult centre to drive innovation among even its most significant companies – Rolls-Royce (Aero-Engines & Nuclear), Bombardier (Rail), Toyota (Automotive) and their supplier chains – let alone its diverse and underperforming SME base. Discussions with both Derby City Council and the Local Enterprise Partnerships, known as D2N2, have been hugely supportive and plans are well developed to move into the recently built iHub which is part of Infinity Park. From the Nuclear AMRC viewpoint, the attraction of moving to a new centre outside the region is driven by the need to expand its footprint and research activities and to take advantage of new funding that will become available through the Industrial Strategy Sector Deal.

As with the other centres, Nuclear AMRC Midlands will be taking research into new areas essential to the UK's future energy needs and transferring

technologies developed in the nuclear sector, such as safety critical systems design and manufacture, for the benefit of other manufacturing sectors, including green energy. We are in close conversations with universities in the region with the aim of developing larger joint projects that have significant impact in the Midlands while contributing to our own Research Excellence Framework impact case studies.

"This growth is testimony to the vision of a university that sees its mission as having a local, regional, national and global dimension. Our core purpose hasn't changed," says Ridgway. "The goal is still to inspire and transform the UK manufacturing base using research and innovation as our tools. If we can do that across the country, and around the world, that will bring benefits to the economy, the University of Sheffield and the Sheffield City Region."

# Autonomous robots could be transporting huge aircraft wings for Airbus within the next five years

Entire aircraft wing assemblies could be transported by intelligent, autonomous robots at the vast Airbus production facility in North Wales following a collaborative research project with engineers at the AMRC's Integrated Manufacturing Group.

By Rebecca Ferguson

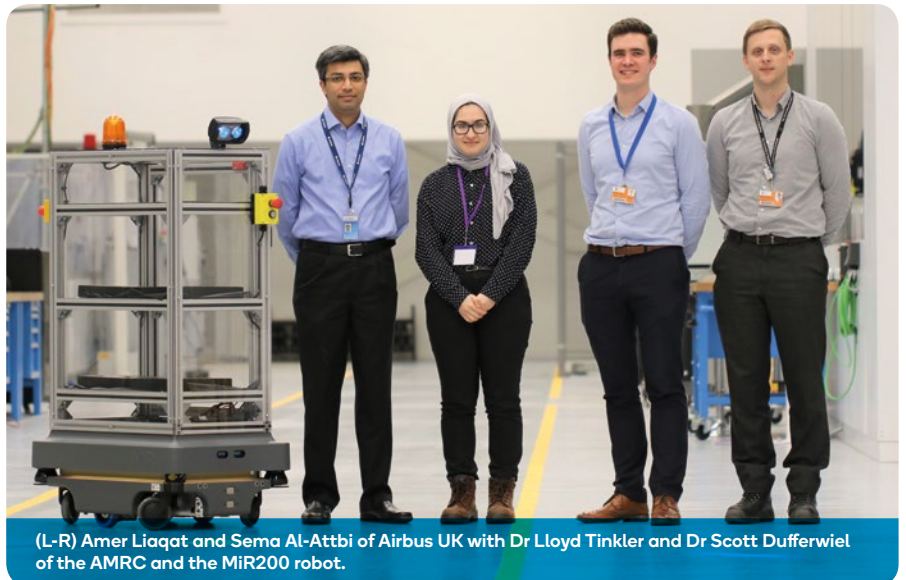
**The ambitious project began by developing safe, automated means of delivering tooling supplies internally within the Airbus factory at Broughton in Wales, but could be expanded rapidly as the benefits of using small, autonomous robotic vehicles are being realised on the shop floor.**

Amer Liaqat, Technology Manager for Assembly Innovation and Development at Airbus UK, said: "This project has been Airbus' first trial of autonomous mobile robots (AMRs) on the shop floor. We have made a number of enhancements to the standard off-the-shelf technology to make it safe and suitable for our factory environment and are now setting a benchmark for its roll-out to other Airbus sites worldwide."

The project was initiated to fulfil Airbus' vision of automating component handling which involves a significant amount of manual work due to the sheer size of the components and precision required during aircraft assembly. Automating this process will eliminate the non-value added operations and give significant benefits to Airbus in terms of capacity and rate ramp-up.

"Doing small scale trials with this AMR has given us a good idea of the challenges involved in adapting this technology and the needs for future development work," added Amer.

AMRC Senior Project Engineer, Dr Lloyd Tinkler, said: "Supervised trials of the robots have already taken place and estimated that utilising them could save the whole time equivalent of one operator per shift in the current use case at Airbus, freeing time for the



(L-R) Amer Liaqat and Sema Al-Attbi of Airbus UK with Dr Lloyd Tinkler and Dr Scott Dufferwel of the AMRC and the Mir200 robot.

operators to work on highly-skilled tasks, ultimately improving shop floor productivity.

"This outcome has led to Airbus exploring opportunities where such robots could be used to optimise processes, including specially adapted versions to pull trolleys with aircraft parts and tooling already in use at the Airbus site."

Amer said: "We can see the potential to go even further and work with the AMRC to develop autonomous mobile robots for precision assembly tasks such as component positioning and certification. Developing it further, we could see this technology being utilised to transport an entire aircraft wing between factories on site at Broughton."

The robots have been developed by the AMRC based on the Mir200 robot

from Danish company, Mobile Industrial Robots ApS. They have a payload of 200kg and top speed of 4km/h and the engineers have been adapting them to safely transport small items such as drilling tools in a storage rack designed and validated for use using augmented reality technologies at the AMRC's Factory 2050.

In-built laser scanners map the environment for the robots, so they can navigate their surroundings unaided by human intervention; whilst flashing lamps and beacons indicate current status and intended direction to those in the vicinity.

Beyond this initial deployment, the AMRC and Airbus are drawing on simulation models of Mir200 robots developed by the Department of Automatic Control and Systems

Engineering at the University of Sheffield to provide an assessment of how these robots will interact with the shop floor environment.

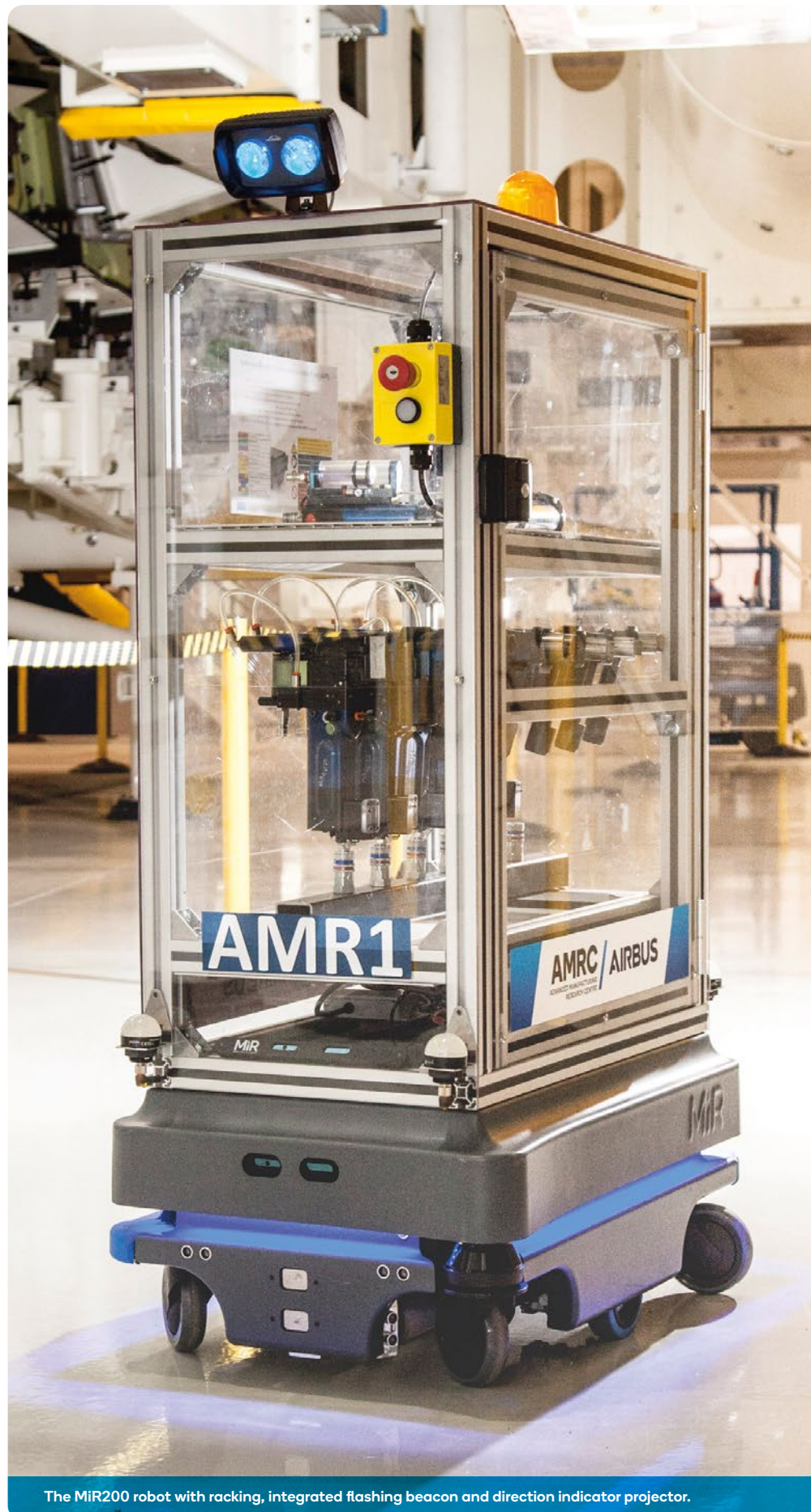
Professor Ash Tiwari, Airbus/RAEng Research Chair in Digitisation for Manufacturing at the University of Sheffield, said: "Our simulation models have led to the identification of problem scenarios that informed physical testing and modifications on MiR200 at AMRC's Factory 2050."

The University of Sheffield researchers are also working with AMRC to establish a business case for future deployments of AMRs across the Airbus shop floor. To support this, the AMRC has been making further adjustments to the AMRs, including the addition of cameras to monitor the number of tools delivered per shift and industrial laser scanners mounted vertically that will detect over hanging obstacles and enclose the robot in a protective field which will alert operators to any errors; disabling the robots safely if there are any problems.

Lloyd said: "The further developments will enable us to complete a trial of the AMRs unsupervised by humans at the Airbus Broughton site, the aim of which is to validate the estimated time-savings, the number of movements and how many tools the robots are delivering between the engineers per shift. This will ensure they are ready to roll out live onto the workshop floor to assist engineers by delivering supplies from a number of locations."

Amer added: "This project has also provided the opportunity to work with the AMRC to conduct a feasibility study on product inspection and tooling certification through mobile photogrammetry. The advantage of having a mobile platform instead of a fixed station is the flexibility that would allow us to improve factory flow, eliminating bottlenecks as the system could measure on location."

Ash said the project is an excellent example of a three-way collaboration involving Airbus UK, AMRC's Factory 2050, and researchers at the University of Sheffield: "The project team is now collaborating to develop and publish a highway code as an industrial standard for communication and interaction between autonomous systems and surrounding machines, objects and humans. This could be used by a range of companies exploring the potential benefits and regulatory compliance of autonomous mobile robots on their shop floors."



The MiR200 robot with racking, integrated flashing beacon and direction indicator projector.



# BOEING

## Sheffield



# A region ready for take-off

The flags of three great global brands fluttered in the breeze when the Secretary of State for Business, Greg Clark, officially opened Boeing's first production facility in Europe on what was once the runway of Sheffield city airport.

By John Yates

**With the flags of Boeing, Made in Sheffield and the Union Jack flying high above the new 6,200-square-metre facility, Mr Clark said this was truly a 'red letter day for Sheffield, the city region and the country' opening new opportunities for young people to become the engineers of the future.**

"There is no better place on the planet than Sheffield to become an engineer, and no better company on the planet to work as an engineer," he said. "Boeing choosing Sheffield as its first European home is testament to the region's capabilities, talent pool and strong manufacturing supply chains which are vital to job creation and creating value for local economies."

Jenette Ramos, Senior Vice President of Manufacturing, Supply Chain and Operations for Boeing, who led the high-

level delegation flown in for the day, said that the £40 million investment Boeing had made was more about people than buildings.

She welcomed the 25 young apprentices in the audience to the Boeing community and presented a short film that highlighted their role in the new facility which will manufacture more than 100 different high-tech actuation components for the 737 and 767 wing trailing edge.

Roisin Chapman-Allison, 17, from Sheffield, comes from a family of engineers. She is a second year AMRC machining apprentice. Speaking at the opening of Boeing Sheffield, she said: "I never thought that when I left school at 16 that I would be operating a £500k machine for Boeing. It makes me feel really proud and you feel like you have

done something to help create it, as we are the future."

"We appreciate all the community support for Boeing's new advanced manufacturing factory in the UK. This is a fabulous example of how we are engaging global talent to provide greater value to our customers," Jenette added.

"In Boeing Sheffield, we are building on longstanding relationships and the region's manufacturing expertise to enhance our production system and continue to connect, protect, explore and inspire aerospace innovation."

But none of this would have happened, Jenette added, without the vision and inspired leadership of two men: Adrian Allen and Keith Ridgway, founders of the University of Sheffield Advanced Manufacturing Research Centre. "They

“There is no better place on the planet than Sheffield to become an engineer, and no better company on the planet to work as an engineer.”

Greg Clark, Secretary of State for Business.



had the vision, we are just the people who are operationalising the vision,” she said.

After the speeches AMRC Executive Director and founder, Adrian Allen, said: “This has been a dream day for all of us. Twenty-years ago we went knocking on the doors of countless potential partners in the belief that if we kissed enough frogs one day we would find a prince. Boeing is that prince.

“They have been with us from the beginning; a constant source of support, inspiration and challenge. The one thing you learn working with Boeing is that they think big, so they were able to buy into our vision from the very start. It’s been great to open this facility and see so many young people from across the region who will be playing a vital role in the manufacture of Boeing airplanes. But this, I believe, is just the beginning. There is much, much more to come.”

His friend, co-founder and AMRC Executive Dean, Professor Keith Ridgway, said: “Jenette is right; our success is all down to our people and the relationships between our partners. The University of Sheffield had faith in us from the very start, when we were just a handful of people with a fanciful dream.

And Boeing had faith in us because they connected with our passion and commitment to engineering and manufacturing excellence. If we retain that passion and keep to the vision, the sky is the limit.”

Dan Jarvis, Mayor of the Sheffield City Region said: “Make no mistake, there is no doubt something very special that is happening here in the Sheffield City Region. What’s emerging is a compelling story and for the first time in a generation we are witnessing very significant advances in the manufacturing story, adding new chapters to this great city’s reputation for innovation, research and for making.”

The opening also celebrated the UK-based suppliers who have partnered with Boeing on this significant expansion in the UK. Amongst the suppliers, Aeromet International Ltd, a Worcester-based supplier of advanced aluminium and magnesium cast parts will provide Boeing Sheffield with high-strength, complex and multi-core aluminium cast parts.

In addition, Sheffield based Maher Ltd, a first-time partner with Boeing, will supply bespoke steel bar and pre-machined components made of UK-sourced steel

from Liberty Speciality Steels, located three miles from the new Boeing factory.

Also recognised was MetLase Ltd, a first-time supplier to Boeing, which is based at the Advanced Manufacturing Park in Rotherham and which is Boeing Sheffield’s tooling and fixturing partner. Mettis Aerospace Ltd, a designer and manufacturer of precision forged and machined components from Redditch, will supply Boeing Sheffield with steel alloy precision-forged components. The other partners are AMRC Training Centre, D5 Architects, JF Finnegan, Mills CNC, Mitutoyo, Mott MacDonald, Nikken, Starrag and WFL.

Boeing established a presence in South Yorkshire in 2001 when the company co-founded the AMRC with the University of Sheffield in Rotherham. Boeing Sheffield is a direct result of this longstanding and successful relationship with the AMRC and its world-class research and development. The company has initiated a major new research programme with the AMRC to develop new manufacturing techniques that can be applied to the new Boeing Sheffield facility.



The future: Dan Schofield and Andrew Chapman who are both second year Boeing apprentices working on a Doosan Puma twin spindle, twin turret lathe. Boeing Sheffield, shown right.



Digital leaders: Dr Ruby Hughes working at the AMRC's Factory 2050.

# Real benefits of virtual simulation

Even before the official opening of Boeing's first production facility in Europe, simulation experts at the AMRC have proved the new factory will be able to increase through-put by up to 50 per cent in the future.

By Rebecca Ferguson

**The AMRC's Manufacturing Intelligence team at AMRC Factory 2050 used virtual reality (VR) modelling for factory layout planning and Discrete Event Simulation (DES) to determine the facility's potential and validate productivity targets.**

The modelling has proved so successful that Boeing could soon be rolling it out worldwide to new and existing sites as the simulation involves no disruption to the workshop floor, since it all takes place in the virtual world.

Technical Fellow and Head of Manufacturing Intelligence, Dr Ruby Hughes, said: "DES is an Industry 4.0

technique for modelling a system in the virtual world as a discrete sequence of timed events.

"We created a work package modelling Boeing Sheffield to simulate the proposed work-flow on the factory floor to validate productivity targets, examine any uncertainties or what-if events and identify resources such as machines and materials required in a risk-free environment before the factory went live."

Boeing's Chief IT Engineer for Vertical Integration, Gary Hilton, said: "Boeing is always keen to use Industry 4.0 technologies to optimise production.

Through this project we have leveraged our relationship with the AMRC to explore different technologies such as VR and DES and see how the factory floor would be laid out and operate; including the ability to see areas where we could optimise or increase production capacity in the future."

The project is the biggest simulation project the AMRC has collaborated with Boeing on, and is the first time the aerospace giant has used the technology to plan an entire new facility. It created the opportunity for Boeing to plan factory processes from scratch and showed how production processes



One of the machine work cells within the virtual simulation model of Boeing Sheffield.



would work in real-time.

“Linking a virtual simulation model to Boeing’s production data in real-time will provide continuing benefits for Boeing such as real-time factory monitoring,” Ruby added. “As the workshop floor becomes live, the data will increase the accuracy of the model and allow validation of on-going operational changes, new technology introduction and identify opportunities to further increase through-put.”

She said the project has already validated that Boeing will be able to increase through-put at the facility by up to 50 per cent in the future.

Gary added: “In the future we will look at how we can deploy the Industry 4.0 model and technology we have used for Boeing Sheffield worldwide across the Boeing Company, on sites that are already operational to gain the same kind of benefits in validation of operations, look at capacity planning and identify areas where we can optimise resource requirements; with the major benefit being there will be no disruption to the workshop floor as it all takes place in the virtual world.”

Tim Underwood, Manufacturing Engineer for Boeing Research and

Technology, said: “This technology allowed us to look at whether we were investing in the right number of machines for the workshop floor, to check we had an adequate workforce and the resources available to support operations and identify any bottlenecks in production to validate our targets against our intended operations, saving us both time and money during the planning and construction phases of the new facility.”

Gary said: “This is the first time Boeing has used this technology to measure the capabilities of a factory and it has become an essential tool in the arsenal of Boeing’s planning and monitoring providing real benefits that will continue to identify areas where we can optimise our productivity.

The AMRC is developing its DES research to link to artificial intelligence, solving complex real-world problems in shorter experimental time. Ruby said the methodology developed is suited to applications across many sectors, such as aerospace, automotive, defence and healthcare; where increases in productivity and reduced resource usage are critical to maintain productivity levels.

“These Industry 4.0 technologies are important tools for any manufacturer, where low-risk validation and what-if analysis can be a major benefit, whether planning a new facility, or looking to optimise production at an existing one.

“With the expertise in house at the AMRC, the simulation model development time is fairly short, making this kind of technology accessible to any business that can access these capabilities through working with us.

Combining leading-edge technologies with the AMRC’s expertise in design and prototyping, machining, casting, welding, additive manufacturing, composites, robotics and automation, digital manufacturing and structural testing, has created a manufacturing resource far beyond anything previously available in the UK.



# Intelligent workbench key to factory of the future

A smart workbench using cobots to improve efficiency has been developed by engineers at the AMRC's Integrated Manufacturing Group and is now being tested on BAE Systems Typhoon production line as part of a pilot scheme being run at the company's site in Warton, Lancashire.

**First showcased at the Farnborough International Airshow, the smart workstation will be a key feature of BAE Systems' factory of the future, and is fitted with a range of digital technologies including operator recognition and a sensor-enabled cobotic arm.**

AMRC Senior Project Engineer with IMG, Ben Fisher, said: "Working with BAE Systems, we have been able to integrate and demonstrate a range of digital assistive technologies ranging from projection systems through to kit-by-light systems, into an intelligent workbench platform.

"This has provided BAE with an Industry 4.0 connected workstation with which to demonstrate assistive manufacturing techniques. The AMRC will be furthering the capability of the workstations post-Farnborough International Air Show, with additional upgrades due to be implemented."

Dave Holmes, Manufacturing Director at BAE Systems' Air business, said: "We've only really started to scratch the surface of what automation can do in industry and some really exciting possibilities

are emerging as we enter the fourth industrial revolution.

"Cobotics is the next, natural step in developing manufacturing technology that will allow for a blending of skilled roles. We envisage that people will make larger, more strategic decisions while delegating the repetitive and intricate aspects of production to a robot.

"Through the factory of the future technology, automation will empower employees to work safely at greater speed and with maintained accuracy, leading to increased productivity and quality."

Integrated sensors allow workers to make strategic decisions while delegating repetitive, machine-driven tasks which require consistency to the cobotic arm. This enables engineers to focus on highly-skilled tasks, adding greater value to the manufacturing process.

Another smart feature is a 'skills passport' that recognises operators and automatically loads optimised individual profiles using wireless technology - delivering tailored cues and instructions suitable for an operator's

level of expertise to guide them through practical tasks. This allows employees to work at a greater pace, with increased accuracy. The workstation also boasts light-assisted assembly, with 'pick by light' technology prompting the user towards the correct components or consumables during the manufacturing process.

The introduction of new digitally integrated advanced manufacturing technologies builds on existing investments in robotics to drive productivity, quality and safety improvements into future combat aircraft programmes, helping to increase the company's competitiveness and manufacturing agility.

BAE Systems worked with the AMRC to develop and test the advanced kit and collaborated with other partners including Siemens, which is providing the MindSphere software. This software will connect technologies through the workstation and output manufacturing data that will help engineers analyse and improve the advanced manufacturing processes.





# Winning the weight race with the AMRC

**Future mobility and clean growth are two of the big ticket items in the Government's Industrial Strategy: that means electric drivetrains and weight-reducing composites and metals. But the relentless focus on electric risks losing sight of lightweighting. For it is only when the two come together that we will create fit-for-purpose future mobility. John Yates and Katia Harston report.**

**The opening of McLaren Automotive's new production facility in Rotherham may have been rich in pomp and ceremony – a 3,850 horsepower convoy of supercars racing to meet the more sedate Royal fleet of Bentleys – but behind the showmanship there are vital lessons for UK manufacturing and a government that has staked the economy's future on an Industrial Strategy that targets just four grand challenges: future mobility, clean growth, artificial intelligence and an ageing population.**

The first lesson is that the UK has a great future in high-value manufacturing. The second, especially in the case of automotive and

aerospace, is that this requires industry to lose weight (composites and new materials), and possibly people (robotics, automation and artificial intelligence/data analytics). The final lesson is that all this happens best when three key partners learn to collaborate: industry, government and the research and innovation talent inside our universities.

All too often, however, this doesn't happen. Industry can be sceptical about academics. They inhabit a different world, talk a different language, and breathe a more rarefied air. Academics can be equally sniffy about industry and the profit motive. And the Treasury can be sceptical about both.

In the case of Rotherham, however, all three of these ingredients are well blended.

Take McLaren and lightweighting. Research shows that a ten per cent reduction in vehicle mass improves fuel consumption by seven per cent, and every litre of fuel saved reduces CO<sub>2</sub> emissions by 2.6kg. Advanced carbon fibre composite materials have higher strength-to-weight ratios, better chemical and heat resistance and greater design flexibility compared to conventional vehicle construction materials.

If the UK – through this partnership between industry, government and



New tech: The radial braider, left, and other market leading equipment installed by the AMRC to manufacture preforms and develop enabling technology for commercialisation including joining, automation and impregnation.

research – could develop processes that significantly reduce the cost of using these advanced materials in vehicle structures, this would not only benefit the car industry, but other industrial sectors such as wind energy and aerospace (the airframe of the Boeing 787 Dreamliner is close to 50 per cent carbon fibre reinforced plastic and other composites: a weight saving of 20 per cent compared to traditional aluminium designs).

McLaren know this. They have been winning the ‘power’ race for decades. But now CEO, Mike Flewitt, wants to win the ‘weight race.’ But his company cannot do that on its own. As he said at the Royal opening of the McLaren Composite Technology Centre (MCTC) in Rotherham, getting to this position on the manufacturing starting grid has ‘been an incredible team effort.’

It has been made possible, in no small part, by getting alongside some of the most talented composite research engineers in the world at the AMRC; by engaging with responsive local councils to find the right location close to the capabilities of the AMRC; and

by working with national government funding agencies such as Innovate UK to help finance and direct research that will enable them shed pounds, improve productivity, maintain quality and win the ‘weight race.’

“We now have a fantastic opportunity for the UK to be at the very forefront of a new automotive ‘weight race’ that can help achieve increasingly tough environmental targets,” Flewitt told a recent gathering of the Society of Motor Manufacturers and Traders.

“While McLaren has a long history in using lightweight materials to boost vehicle performance, it’s something we are also heavily investing in as part of our future with the opening of the brand-new MCTC in Yorkshire. It will lead to innovations in the technology going into our cars and not only provide a significant boost to the Sheffield City region, to jobs and the supply chain but also to the UK’s reputation for innovation,” he added.

The AMRC Composite Centre’s Hannah Tew agrees: “Lightweighting does exactly what it says on the tin – it’s all about making designs lighter, in turn

saving money, fuel, and meeting those all-important emissions targets being driven by government legislation in the coming years to meet its climate change obligations.

“It also plays a major role the Government’s Industrial Strategy which identified future mobility and clean growth as its grand challenges. This involves a shift to electric vehicles – and ultimately aircraft – which will require lightweight materials and processes to offset the increased weight of power systems, such as batteries, and to improve their efficiency and range.”

Tew and the AMRC team clearly share Mike Flewitt’s desire to win the ‘weight race,’ which is one of the reasons why she and her colleagues are so excited by the McLaren partnership and its new facility. McLaren may only have a relatively small share of the automotive market, but they are innovators and ambitious to develop new materials and processes which will have a major impact

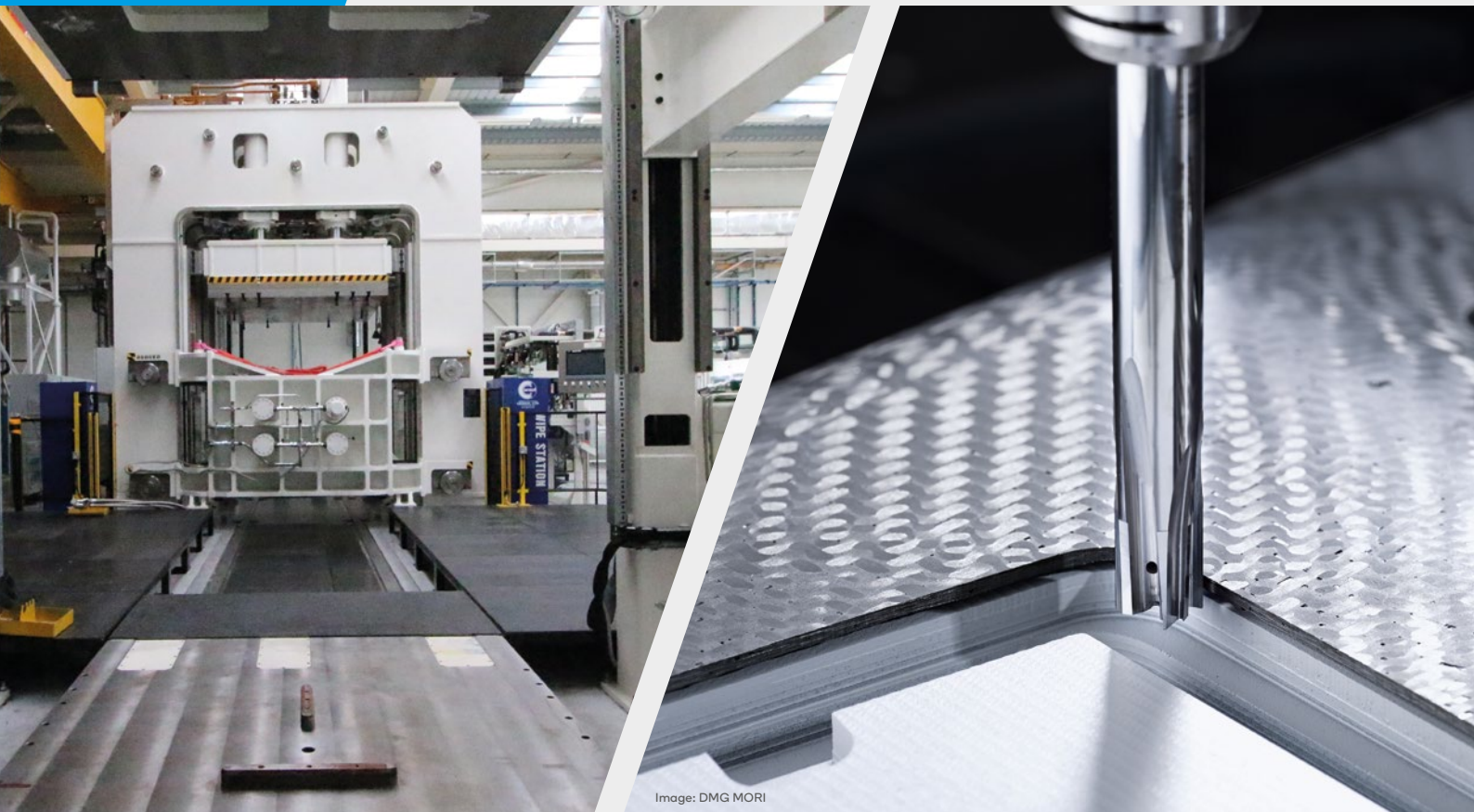


Image: DMG MORI

on the future of the mass market, especially as we move towards electric vehicles.

“For AMRC, and for those innovative businesses like McLaren who believe lightweight manufacturing is important to grow UK GVA, you can’t do batteries and power electronics and maximise the value to the UK without addressing the weight issue as well,” Tew said.

“If you have powertrains and lightweighting working in harmony you have a really strong base to put the UK at the forefront of electrification. With the Faraday Challenge, the UK has made the statement that we intend to lead the world. To secure the greatest possible value then lightweighting is the key to anchoring the whole thing in the UK.”

Having developed the advanced materials technologies that were the key to helping McLaren Automotive move its supercar body manufacture from Austria to Rotherham, Tew says the AMRC is keen to keep its foot on the lightweighting accelerator.

“With the help of the Aerospace

Technology Institute and other public and private funding streams such as the Advanced Propulsion Centre, we are investing heavily not just in state-of-the-art technology, but also in developing engineers who are at the top of their game. For us, the essential ingredient to driving technological change is the culture of the organisation, and that comes by building great teams of talented, ambitious people who want to make difference: that is the way to deliver impact,” said AMRC Executive Dean, Keith Ridgway.

The AMRC has installed new state-of-the-art equipment including a braiding system, Jacquard loom, tailored fibre placement, a high temperature-high tension filament winder, tow-spreading machine and robotic end effectors for automated handling and through-thickness permeability testing. This new kit will be used to not only manufacture preforms but also develop enabling technology for commercialisation including joining, automation and impregnation.

A wide range of materials can be used with the radial braider including

carbon, thermoplastic, glass, aramid and co-mingled tows. It is also capable of processing ceramic fibre such as alumina and silicon carbide which would otherwise be difficult to process on a conventional braiding machine.

It has widespread application for components used in aerospace and automotive, and the technology - which is open to research projects for AMRC members, external companies and grant funded projects - can be combined with any of the other technologies at the AMRC, including the 1000T Rhodes press and the KraussMaffei RTM equipment, the most sophisticated in the country.

These composite materials and processes are increasingly being used in aerospace to make aircraft lighter and more environmentally-friendly solutions and there are huge opportunities to adopt composites in many other industries in order to reap economic and environmental benefits.

The research undertaken with this equipment by the AMRC will bring down the cost of complex composite components, making it easier for

**“It has been made possible, in no small part, by getting alongside some of the most talented composite research engineers in the world at the AMRC.”**

Mike Flewitt, CEO, McLaren



aerospace and automotive to win the ‘weight race’ and help UK manufacturers to secure a larger share of the lucrative and rapidly-expanding aerospace and composite markets.

But this is not all about digitally enabled, high-tech equipment. It’s about people. “We’ve recently set up a dedicated Advanced Textile Composites team to develop these capabilities to produce composite components in ways not currently available in the supply chain from composite suppliers,” said Tew.

“This will improve the fit of the UK composites supply chain to the needs of the global aerospace and automotive markets and growing the economy through expansion in these sectors with composite materials and multi-material solutions, tooling and advanced manufacturing – positioning the country as Europe’s number one aerospace and

automotive manufacturer.”

The team consists of Prasad Potluri, Professor of Robotics and Textile Composites at the University of Manchester, and Chris McHugh, who has joined the AMRC Composite Centre with decades of textile experience under his belt having previously worked for James Dewhurst, NWTexnet and Sigmalex. They will be joined by Richard Scaife, Head of the AMRC Composite Centre; Hannah Tew, Partnership Lead at the AMRC Composite Centre; and Dr Hassan EL-Dessouky, a senior research fellow with the AMRC.

To win the weight race, however, Tew believes the UK has to get up to speed and fast. Changes to emissions regulations mean the UK needs both lightweighting and powertrain solutions in place by 2021 and then for the manufacturing processes to be nailed down by 2023.

“To develop the right materials and manufacturing choices for the next generation of vehicles in four or five years’ time, we need a strongly collaborative approach involving industry, government and research and innovation assets such as the AMRC,” says Tew. “If we get the timing wrong, if we delay too long, the UK risks value chains being lost and investment may be made elsewhere.”

Professor Ridgway echoes this view: “We need to take lightweighting seriously as a country. It’s vital that the government makes the positive connection between electrification and lightweighting. Without the latter, the focus on power will not win us the race. That’s the message. We have the talent and the technology, but we need government backing to get us to the chequered flag in first place.”

# A powerhouse partnership

**Digital and electrification pioneer Siemens UK has joined forces with the AMRC to support our work in becoming the go-to place for digitally connected manufacturing.**

**With major facilities in renewable energy and rail transport across the Yorkshire and Humber region, and close research links with the University of Sheffield, Siemens is a natural fit for the AMRC's ambition to promote leaner, greener and cleaner ways of manufacturing using high-tech digital processes and solutions.**

"Siemens not only provide a very close fit with our aerospace and defence work, they share our passion for industrial digitalisation. It's a privilege to be working with Juergen Maier, the moving spirit behind the Made Smarter Review and a tireless advocate of digital and advanced manufacturing technologies," said AMRC Executive Dean, Professor Keith Ridgway, as he welcomed the Siemens UK CEO to Factory 2050 and Tier 1 membership.

The £200,000 Tier 1 AMRC status enables Siemens to work much more closely with all the leading players in the aerospace and defence industry: sharing research projects with global brands such as Airbus, BAE Systems, Rolls-Royce and Boeing, who recently opened their first European production facility

next door to Factory 2050.

Juergen Maier, CEO for Siemens UK, said: "We're proud to support the AMRC – and its vital role in shaping the Fourth Industrial Revolution. The team has been leading the charge from Sheffield which has a proud and rich heritage in manufacturing. We are delighted to be stepping up our engagement and support for Factory 2050 and look forward to a long-lasting collaborative relationship with everyone involved."

Head of Digital at the AMRC, Professor Rab Scott, said that Siemens is a standard bearer for digital technology: "Their software is at the cutting edge of digital and gives us the opportunity to connect robot cells and display them in the virtual world to create extremely powerful digital tools, such as the digital twin we created for the new Boeing factory."

Having Siemens as Tier 1 members also strengthens the AMRC's position as a key player in the delivery of digital technology for manufacturing in the Northern Powerhouse.

It was here in Factory 2050 that he came to deliver a keynote speech on the need for the North to lead the Fourth Industrial Revolution, which is at the very heart of the Made Smarter Review.

"He and his team also share our passion for developing the young engineers of the future; engineers more familiar with gaming and coding than with the skills of the more traditional engineer. Combining these two worlds is central to unlocking the UK productivity puzzle, bringing leading edge digital thinking to modern manufacturing," said Professor Scott.

**"We're proud to support the AMRC – and its vital role in shaping the Fourth Industrial Revolution."**

Juergen Maier, CEO for Siemens UK



# National Research Council of Canada to develop novel composites with AMRC

**The National Research Council (NRC) of Canada has signed a collaborative research agreement with the AMRC in a ceremony that took place at the Canadian High Commission in London.**

The Memorandum of Understanding (MoU) agreement is to develop novel composites for aerospace and is the first project under the broader CAN-UK science, technology and innovation research partnership.

The objective of the complete two phase research project is to develop the analysis methods and manufacturing knowledge required to design and produce optimised curvilinear variable stiffness laminates fabricated by automated fibre placement and demonstrate application of the technology on a representative civil aircraft structure.

Professor Keith Ridgway, Executive Dean of the AMRC, said: "We are delighted

to have the opportunity to work with our academic colleagues in Canada and look forward to a long and fruitful relationship."

As well as the AMRC and NRC, additional project partners will be required for phase two onwards. Industry partner involvement will ensure the technology and specific applications being developed are directly relevant to near-future aero-structures.

François Cordeau, Vice President of the Transportation and Manufacturing Division of the National Research Council of Canada, said: "Manufacturing makes up nearly half of Canada's aerospace sector. The NRC is excited to work with the global aerospace industry by collaborating with the University of Sheffield on advanced manufacturing methods for cost-effective and environmentally-friendly aircraft."



AMRC CEO Colin Sirett, left, signing the collaborative research agreement at the Canadian High Commission in London.

It comes as the UK Research and Innovation and NRC signed an MoU to facilitate the delivery of collaborative, jointly-funded research and innovation programmes.

# TOYOTA Motorsport looking to lose weight with AMRC

**The high-performance testing and development engineers at TOYOTA Motorsport GmbH (TMG) have joined forces with the AMRC to remain at the front of the automotive technology grid.**

TMG, whose parent company is Toyota Motor Corporation, has built its reputation in motorsport via World Rally, Formula 1 and now the FIA World Endurance Championship, which includes the 24 Hours of Le Mans.

In parallel to its motorsport activities, TMG also carries out a wide range of automotive projects and to enhance its knowledge base, joined the AMRC as a Tier 2 partner with a focus on research and development of lightweight materials.

The company, which has its own facilities for CNC, composites and additive manufacturing, will therefore put itself at the front of the pack when it comes to keeping track of the latest trends in materials and manufacturing techniques.

Professor Keith Ridgway, Executive Dean of the AMRC, says TMG is a superb new addition to the AMRC's stable of high-performing, high-value automotive manufacturers looking to stay in pole position with the use of novel materials and cutting-edge lightweighting processes.

"I'm extremely pleased the AMRC is working closely with TMG, which is part of the world's number one endurance racing team - winners of the recent 24 Hours of Le Mans event. This is further proof that the Sheffield City Region's Global Innovation Corridor is the come-to place for manufacturers who want to take on the world's best and win.

"The AMRC now has a global reputation for its expertise not just in the development of new composites and processes but also within the increasingly important arena of lightweighting where we lead the way.

"It will be fascinating to work closely with a company involved in high-level motorsport. Like us, they want to make



Image: TOYOTA Motorsport GmbH.

things faster, leaner and cleaner."

Ben Kitcher, Head of Automotive Strategy at the AMRC, said the partnership consolidates the AMRC's reputation for using Industry 4.0 technologies to drive changes in performance.

He added: "We'll be applying innovative technology from other industries to inject fresh ideas and processes into motorsport, as well as setting out a collaborative roadmap of where new technologies will be delivered to motorsport."

Pictured above is the wind tunnel model of the Le Mans-winning TS050 HYBRID race car undergoing testing in one of TMG's wind tunnels.



# outreach at the AMRC

The AMRC STEM and Outreach team vision is to inspire young people to explore the opportunities of a career in STEM (science, technology, engineering, and mathematics) related subjects by providing a creative and innovative environment to capture the imaginations of young minds.

The team works closely with underrepresented and hard-to-reach groups, challenges stereotypes and misconceptions, breaks down barriers, supports young people, education providers, parents and their community and provides an opportunity to explore and experience STEM related subjects.

They work with groups and schools through a bespoke programme of activities that can include everything from coding clubs, robotics, 3D printing and rapid prototyping to virtual and augmented reality. They also help organise tours around the AMRC buildings such as Factory 2050, the Nuclear AMRC and Factory of the Future.



## Meet the team



**Cathie Barker**

Cathie has experience of working in further education with a particular focus on apprentices. Having worked within an engineering specialist centre she is keen to see more women enter the world of engineering.



**Ami Swales**

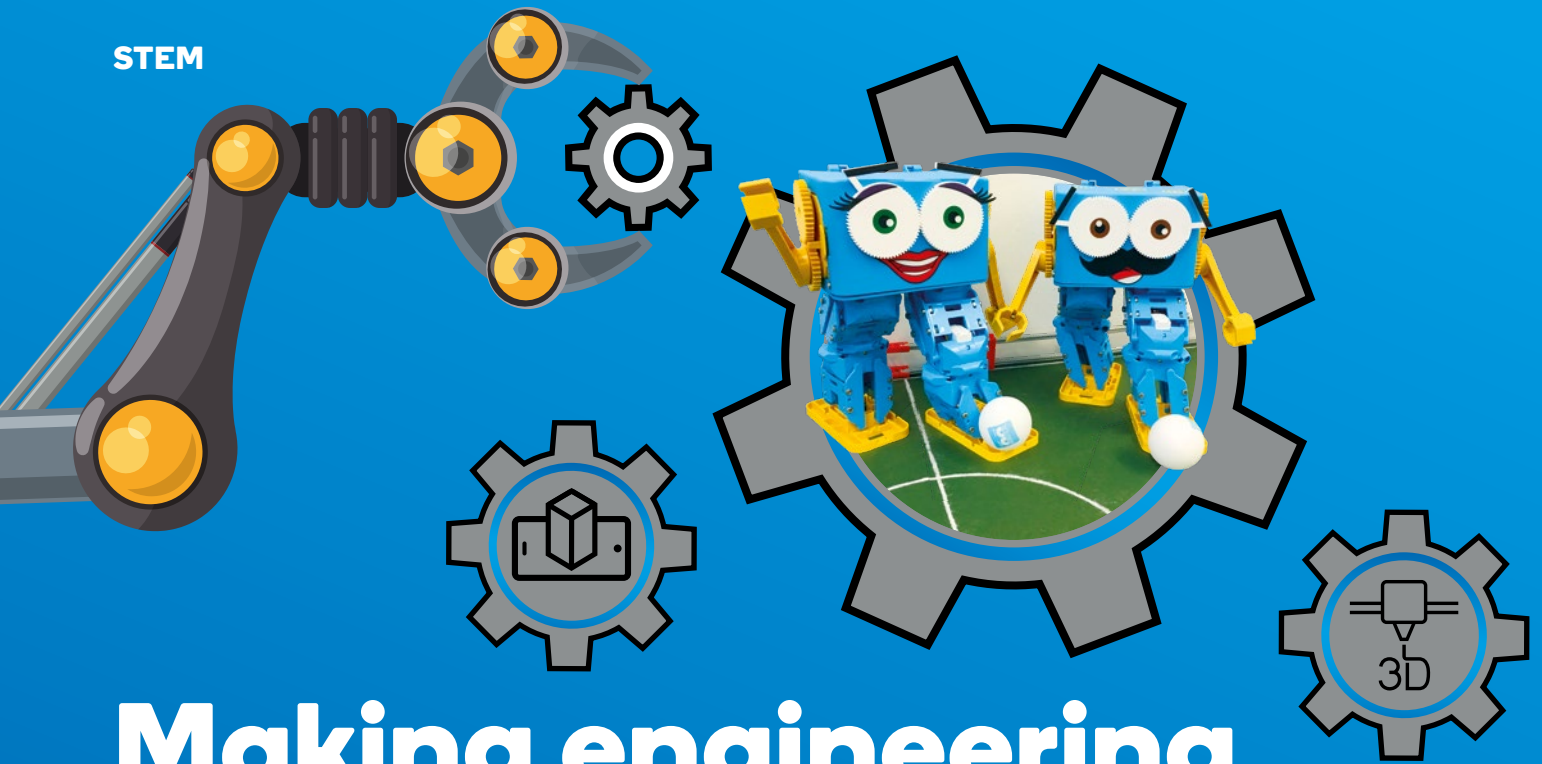
Ami has a degree in biochemistry from Newcastle University and has worked for Teach First as a secondary science teacher in South Yorkshire. Ami is passionate about helping disadvantaged young people enhance and realise their educational and career goals.



**Jack Forrest**

Jack has experience of leading a team of science teachers in a local secondary school. He is committed to addressing misconceptions in STEM related subjects to break down barriers into engineering.

STEM



# Making engineering our primary goal

With a dedicated STEM team and engineering ambassadors across the campus, the AMRC is bringing engineering to life for school teachers, children and their parents across the Sheffield City Region. Katia Harston reports.

**Pompoms, sequins and sticky back plastic aren't the typical engineering tools used by Nuclear AMRC researcher and STEM ambassador, Rahul Mandal, but the Great British Bake Off winner found himself surrounded by them at the launch of our Primary Engineer campaign at the AMRC Training Centre.**

Rahul – who says that if you can do baking you can do science and engineering and if you're doing engineering, then you can bake – took time out from his work on light-based measuring technologies to shed a different kind of light on engineering. His aim was to inspire pupils at Dinnington Community Primary that science, technology, engineering and maths (STEM) are creative and fun.

The event was the launch of a partnership between the AMRC and Primary Engineer – a national not for profit organisation bridging the gap between industry and education – to develop engineering skills for teachers

and enable children to see themselves as the problem-solvers and innovators of the future by bringing engineering to life in classrooms across the Sheffield City Region.

In the inaugural year, partnership schools from Sheffield to Doncaster are taking part in Primary Engineer and Secondary Engineer teacher training programmes where teachers are partnered by 'classroom engineers' from the AMRC and trained to deliver whole class engineering activity for pupils.

Deputy Lord Mayor of Sheffield, Councillor Tony Downing and children from Dinnington Community Primary School kick-started the programme by using basic engineering skills to build shoebox cars. "We desperately need the engineers and skills to continue to excel to compete globally which is why I'm delighted to launch the Primary Engineer scheme here at the AMRC Training Centre," Councillor Downing said.

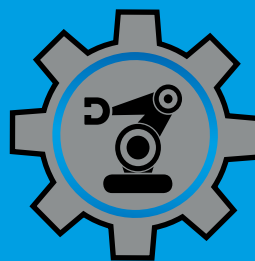
"As we can see with this magnificent

facility, advanced manufacturing is a major success, particularly in aerospace and automotive. There really never has been a better time to get into engineering technology and there has never been more opportunities. We need to provide industry with the talent it requires and provide young people with the brilliant careers they need."

He was joined by Rahul, who became a STEM Ambassador to enthuse the next generation of engineers. Rahul praised the partnership between the AMRC and Primary Engineer, saying: "Programmes like this are incredibly important for empowering teachers with the right skills. They need to bring engineering to life in the classroom in a fun and creative way. We need to make a real impact on young minds to try and inspire more children in the Sheffield City Region to consider engineering as a cool career.

"That's why I became a STEM Ambassador, to help inspire young kids to do science and engineering because





I think there is a huge need for more engineers. If we want to inspire people, we need to do it from school age level."

Nikki Jones, Director of the AMRC Training Centre, said: "Working in partnership with schools from across the Sheffield City Region not only helps raise the aspirations of our children by putting engineering at the heart of their learning, it shows them the possibilities of what they can achieve. It also cements our commitment to developing and nurturing the ambitions of future engineers that are needed in order to grow our economy on a local, regional and global scale."

Rotherham Council's Deputy Leader, Councillor Gordon Watson, said: "This scheme inspires children to get involved in science and technology at an early age. It gives pupils the opportunity to try something new, get creative and develop their engineering skills in the classroom. The AMRC also provides teachers with the resources and expertise to guide engineers of the future."

Councillor Jayne Dunn, Cabinet Member for Education and Skills at Sheffield City Council, said: "We are breaking down the barriers by making sure people can develop a career in engineering, whatever their background, location or gender – everyone can access a career in engineering."

"The recent investment by Boeing and McLaren Automotive show the

opportunities available for young people, male and female, in pursuing an exciting and challenging career in engineering and manufacturing. As a council we are committed to championing equality and diversity and events like this can only help us to achieve that."

Young people across the region will be designing the future of engineering through the Primary Engineer Programme's 'If you were an engineer, what would you do?' competition. This is open to all pupils from more than 600 schools across the Sheffield City Region. The pupils are asked to interview engineers, identify a real-world problem and design a solution to it. Pupils also write a letter to engineers saying why they should build it. Every pupil that submits an entry will have their design graded by an engineer and receive a certificate.

To spark pupils' imaginations, engineers from the AMRC will visit schools to talk about engineering and their role within it; they will also give examples of how engineers solve problems.

The programme then culminates in a celebration challenge at the AMRC where teams from each school will bring along their project entries and compete against fellow Sheffield City Region schools.

Awards will be presented to the winners at an annual prize-giving event hosted by the AMRC followed by a public exhibition of entries from all participating schools. Staff and students from the AMRC will select and build a prototype of one or more of the shortlisted designs.

Dr Susan Scurlock, CEO and founder of Primary Engineer Programmes, said: "Immersing children in the world of engineering shows them that anything is achievable and that they can be part of designing the future of engineering. Last year we engaged with over 56,000 school children to encourage them to consider a career in engineering. Partnering with an organisation such as the AMRC is key to achieving this in the Sheffield City Region and beyond."



# From Sheffield to Shanghai: AMRC helps dream trip come true

A talented group of young AMRC-sponsored engineering titans put South Yorkshire on the map competing against thousands of kids from across the globe at the World Educational Robot Contest in China.

By Katia Harston

**The University of Sheffield Advanced Manufacturing Research Centre (AMRC) sponsored the two groups of children – Team Titan and Team Spider – in order to make the dream trip possible and the youngsters are the first to represent the UK at the world finals.**

The whizz kids arrived safely in Shanghai on December 14 ahead of the competition on December 15 and 16 to pit their coding skills against 8,000 of the brightest young minds from more than 60 countries.

Team Titan's Kirin Harrington, 11, was selected to take the World Educational



Photo: Lungeni Sibanda

Robot (WER) oath on behalf of the contestants – in front of an audience of more than 10,000 – because the WER committee were so impressed with a radio interview he gave to the BBC that was broadcast in English with a Mandarin translation across China late last year.

The two Sheffield City Region teams were also interviewed by China's national news station CCTV and Team Titan received an award for outstanding contribution to World Educational Robot for all of their extra efforts surrounding the contest.

Dr Melissa Butt, chair of WER UK, accompanied the kids to the event. She said: "The teams worked incredibly hard and took part in a lot of high level international collaborations.

"They gave postcards of Sheffield to children from across the globe and exchanged email addresses with children who would like to collaborate with them about their robotics and coding problem solving.

"They were also selected as models for posters for future contests."

They made lots of new friends at the competition, collaborated with robotics

specialist counterparts from Mexico and China, and even managed to squeeze in some sightseeing in Shanghai.

World Educational Robotics UK was also presented with the 2018 Outstanding Organising Committee award at the international event and encouraged to pass on the WER spirit to others.

The AMRC stepped in to help the two teams after they earned a place at the international finals in the UK heats. They were given the good news during a special visit to the AMRC's flagship Factory 2050 facility late last year, which is home to the Integrated Manufacturing Group (IMG).

Ben Morgan, head of IMG, welcomed the children ahead of their Shanghai showdown, telling them they are 'engineers of the future' and that their interest in robotics is inspirational.

The AMRC had followed their story





Photos: Lungani Sibanda

closely and wanted to help with their quest to reach the finals. During the visit, Ben told them: “You will be ambassadors in China for the Sheffield City Region, spreading the word that this is the place to come for engineering and industrial digital technology. We’re delighted to be able to sponsor such a talented team of young people from the region’s schools, and to show the world that engineering and our region has very bright future if we work together.”

As part of the visit the children enjoyed a fun Virtual Reality experience playing games and completing engineering tasks; they played ‘splat-a-rat’ using advanced LED pick-and-place kitting technology; and were given a special memento to take on the trip – a 3D-printed jet engine with the words ‘Sheffield to Shanghai’ on it and the AMRC logo.

Liz O’Carroll, mum of Team Spider’s seven-year-old Alexander O’Carroll was blown away by the donation. She said: “This is a truly amazing opportunity for them that we never imagined they would get at such a young age.

“Not only will it give them the chance to complete against the best in the world but the opportunity to see what the world has to offer them in the future; the cultural experience alone will be amazing. It also shows the world that the UK is on the map in fostering young STEM talent and this could be the springboard to greater things. As parents we can’t believe the generosity the AMRC has shown towards the kids - it truly is fantastic.”

She said the visit to Factory 2050 was such a treat for the kids - and parents.

“To see so much futuristic technology really gave the kids a taste of what they could be involved in if they carry on with their STEM work. The guys at 2050 planned the day so well with loads of interactive activities for the kids to engage in. They all really enjoyed the AR and VR experience and probably will be fancying getting the technologies at home.

“An awesome experience from and awesome team.”

The children secured their places in Shanghai after scoring high at a WER competition held at Sheffield University in July, where they competed against 50 UK children and 50 of the best robotics students on a visit from China to build a robot and programme it to complete certain tasks.

The teams were brought together by the Discovery STEM Education organisation based at Kelham Island in Sheffield, which is supporting eight schools across Sheffield to be able to train their students for the next contest in July 2019, as well as training 60 children at its own centre.

Dr Melissa Butt, from Discovery STEM Education, said: “The UK has a shortage of individuals entering important STEM careers. Those young people that have shown not only

enthusiasm but also the commitment to develop their STEM skills and must be afforded further opportunity.

“This is the first time the UK has been represented in this industry related robot engineering and coding contest. The finalists worked incredibly hard at training sessions leading up to the UK contest and worked hard preparing for the finals at their weekly training sessions.

“Without the generous sponsorship our bright young UK finalists would not have been able to compete at the world WER contest final in Shanghai. We’re extremely grateful for making this dream come true.”



# Apprentice of the Year Awards inspires apprentice to reach new heights

**When Ben Siddall was nominated for the ‘Apprentice of the Year’ at the 2018 AMRC Training Centre awards ceremony, he didn’t imagine he’d be flying to the United States of America on a 787 Dreamliner for a VIP tour of the headline sponsor’s production facilities, at Boeing Everett, Renton and Portland as his prize.**

**The Production and Perforation Department Manager at C&S Fabrications in Sheffield – a company that specialises in fabricated and perforated sheet metal – was welcomed to his week in the US by Jenette Ramos, Senior Vice President of Manufacturing, Supply Chain and Operations for Boeing.**

“She is responsible for 60,000 staff, but she recognised me from social media coverage of the awards,” said 22 year-old Ben. “It was fantastic to have the opportunity to meet someone with so much responsibility at Boeing and see what an impact she makes.”

Ben said Boeing’s Everett Factory (which produces the 747, 767, 777 and 787 aircraft) was definitely the one which sparked his imagination. “The Everett Factory is the largest manufacturing building in the world, it makes the

aircraft they are producing look tiny,” he added. “But seeing the passion for success in the Boeing staff and their commitment to quality is what was really inspiring.

“It’s certainly impressive that for such a large organisation, their leadership, ideas for success and key messaging on the big things like their exceptional safety policy is so consistent, right from the top from figures like Jenette, down to the operators on the shop floor building the aircraft.

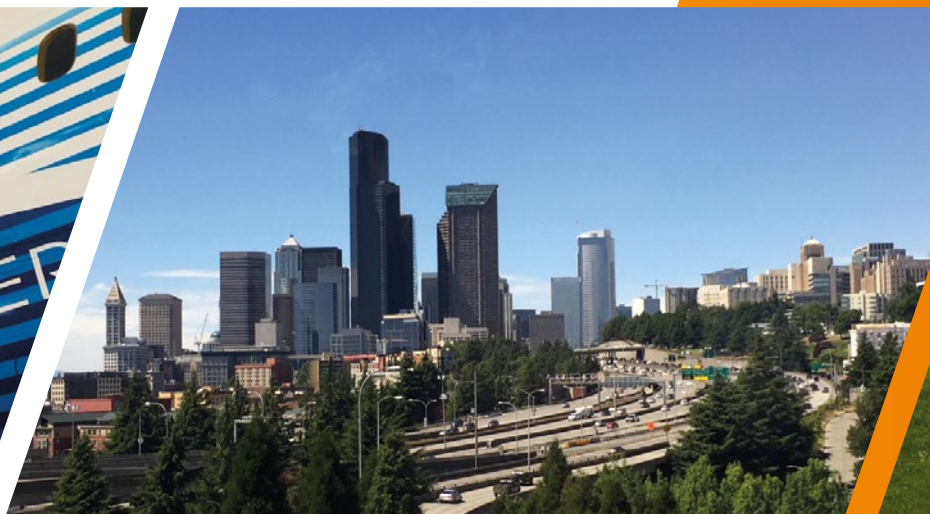
“The level of standardisation achieved by Boeing’s manufacturing processes is remarkable, especially in sites as big as Everett, with such a big operation to keep the manufacturing lines moving, it was great to see how efficient it was. I learnt a lot from it all, a lot of organisational expertise I have taken back to my own workplace and used to

implement further improvements to our own processes.”

Ben was joined on his trip by a group of apprentices from the core team of Boeing’s first European manufacturing facility: Boeing Sheffield. This offered Ben a unique opportunity to join them on their training and orientation:

“We had some brilliant training and lab workshops which helped us embed some of the skills we learnt and explore how to think creatively and embed process improvement into the manufacturing processes.

“It was a privilege to see how the apprentices were welcomed into the Boeing community and train with them, and just have the opportunity to see things most people won’t have



the chance to. For me the prize was a really interesting chance to see how to make and do more, whilst saving on resources; I took lots of notes to take back to my own company!”

Ben said his experiences after winning Apprentice of the Year have helped him on his path to become an ambassador for other young people thinking about a career in science, technology, engineering and mathematics (STEM).

“Becoming a STEM ambassador has opened my eyes to how much of an influence I can make within the industry. It’s been fascinating to speak to younger people who are inspired by the work I do as an engineer and to see them take interest in this at an early age is fantastic.”

“I have been able to help with events like launching the AMRC Training Centre’s Primary Engineer campaign which will develop engineering skills for teachers and inspire children to be the next generation of innovators. But it’s not just younger students I have been able to influence, I’ve also had the opportunity to be involved in events where my experience will influence how those in government view apprenticeships, such as speaking to MPs visiting the Training Centre from the government’s Education Select Committee about the value of apprenticeship education.”

To round off his 12 months as AMRC Apprentice of the Year, Ben will celebrate in February as one of the finalists of the GTA England Apprentice of the Year Awards. Taking place at the Manufacturing Technology Centre in Coventry, the awards celebrate

exemplary apprentices working in engineering, construction and business services and the difference they have made to their companies, through commitment to personal development, outstanding contributions or success in their apprenticeship.

“I’m both thrilled and excited for the final of the GTA awards in February. I think it’s important to recognise the hard work of apprentices such as myself and the impact we have within the workplace, and it’s a privilege to have my success recognised on a national level.”

All these accolades haven’t gone to Ben’s head though, he says his achievements have given him focus going forward to develop his career: “My plans for the future are to continue working hard to make a change in both my company and the industry I work in, and over the next couple of years I aim to look at progressing my education further to a degree level.”

“Winning Apprentice of the Year was a valuable opportunity to show the manufacturing community the real difference apprentices are making to industry in the region and inspire more young people to show what’s possible with an apprenticeship,” said Ben.

The AMRC Training Centre will celebrate its fifth annual ‘Apprentice of the Year’ Awards on March 1, 2019. The awards

are a chance for the organisation and its partners to celebrate the achievements of their apprentices and the contributions they make to their companies.

This year the Training Centre will be introducing a new award, which will recognise apprentices that have triumphed over adversity to study and work on an AMRC apprenticeship.

Nikki Jones, Director of the AMRC Training Centre, said: “All our apprentices work hard to achieve the best results, and it is a pleasure to celebrate with them through our annual awards.

“As Ben’s success shows, our apprentices all demonstrate the inspirational qualities and commitment to their companies that make them magnets to companies seeking the practical skills as well as the academic qualifications so in-demand by industry; making them a crucial part of the UK’s future economy.

“Our new award is the chance for us to honour those apprentices who have overcome barriers to be able to work and study with us, setting themselves on the path for a rewarding career as one of the next generation of engineers; and showing that with the right attitude, commitment and support, just what anyone can achieve.”



Ben and Boeing Sheffield Senior Manager for Operations, James Needham on the tour of Boeing’s production facilities.

# Low cost sensors have high impact on productivity

**An intelligent, low-cost tooling insert, embedded with smart sensors, has been developed to deliver in-process condition monitoring that reduces machining stoppages and improves productivity for UK manufacturers.**

The prototype device, developed with Innovate UK funding, allows a machine tool operator to determine the condition of a cutting tool without manual inspection and is the first 'plug and play' system of its kind with no process learning time required on installation.

"Currently, the task of monitoring the wear on the tool cutting edges is carried out by an operator who inspects the cutting tool using a laser or touch probe system; thus

causing stoppages of machine tools which results in poor productivity and potentially higher costs," said AMRC Machining Group Technical Lead for Control Systems, Sensors and Data Acquisition, Hatim Laalej who has been working on the development of the device. "These are real concerns for manufacturers as stoppage costs in production can be high.

"Manual inspection also varies according to the skills and experience of the operator



Hatim Laalej with the tool embedded sensor fitted on DMG MORI NT5400 machine tool.

monitoring the tool wear. When tools are not changed at the right time, damage can be caused to a work piece, leading to increased costs due to scrappages and rework. Equally, if tools are changed before the end of their useful life this can increase consumable costs.

“The cost of the system is relatively low as it involves using low-cost electronics. The device has been designed to be accessible to small and medium sized companies who are looking for ways to improve the efficiency, performance and quality of their operations, which is vital to improving the productivity of the wider UK economy.”

Monitoring tool wear during machining processes is essential to achieve the desired accuracy and surface finish of a work piece. The tooling insert is embedded with sensors which produce data about the current condition of the cutting tool. This data is converted and sent wirelessly to the machine panel or a machine operator’s control pad for them to make a decision about the condition of the cutting tool, whilst machining is in-process.

“The sensor monitors the resistance generated within the tool-embedded-sensor, so if its resistance increases this indicates tool wear, chipping or breakage.” said Hatim. “This means errors can be recorded and operators can move to preventative maintenance planning to free up valuable time on the shop floor when operators could utilise extra capabilities increasing productivity.”

The AMRC Machining Group successfully installed the prototype on its DMG Mori NT5400 DCG five-axis turning machine, to trial cutting operations and validate its capabilities.

The cutting operations were simulated before trialling the prototype on the DMG, where Polycrystalline diamond and Polycrystalline cubic boron nitride cutting inserts with embedded sensors were used to machine Titanium Ti-6Al-4V and Inconel 718 bars respectively.

But Hatim is not resting on his laurels. His goal is to eliminate tool wear, machine downtime and eventually tool breakage altogether: “Further development of the technology will look at extending the process for various milling processes as well as turning and adapt the system to send diagnosis and data to a portable device, such as a laptop, so an operator can be working remotely to the machine.”

The Innovate UK project was a collaboration between fellow High Value Manufacturing Catapult partner CPI, alongside Element Six, Advanced Manufacturing (Sheffield) Limited, BAE Systems, Printed Electronics Ltd, National Physical Laboratory and DMG MORI UK and the resulting prototype device is now ready to be scaled up into an industry-ready solution.

The AMRC is keen for partners, especially tool-holding manufacturers, who might be interested in developing the prototype as a commercially available product, as the new system will have massive benefits for machinists in all manufacturing sectors.



A low cost cutting tool with an embedded sensor.

# Game changing immersive twins

Digital twins have the potential to radically disrupt manufacturing processes and their younger immersive siblings, built using software taken from the gaming industry, are opening a whole new world of industrial monitoring and control.

By John Yates

**When Jonathan Eyre presented his research findings into immersive digital twins to the prestigious Euro2018VR conference last month, little did he expect that his work would scoop the Best Industrial Paper award at the end of the two-day event at Savoy Place, the IET’s London base.**

“It’s an honour to receive the award, but it really belongs to the amazing team of software engineers and AI specialists that we have at the AMRC,” said Jonathan, Technical Lead in Advanced Visualisation at AMRC Factory 2050 and author of the paper, Immersive Digital Twins: are they worth the investment?

His colleague, Professor Rab Scott, Head of Digital at the AMRC, said: “Jonathan is being modest; it is a great piece of work. But he is also right.

We’ve been growing our digital talent over the last few years to the point where we have real strength in depth in augmented, virtual and mixed reality, in discrete event simulation, in immersive digital twins and in artificial intelligence (AI) and machine learning.

“Collaborative work with our partners, from OEMs to smaller supply chain companies, is revealing how AI and digital processes can unlock massive improvements in productivity, performance and quality. Projects we hope to be able to talk about shortly, so watch this space.”

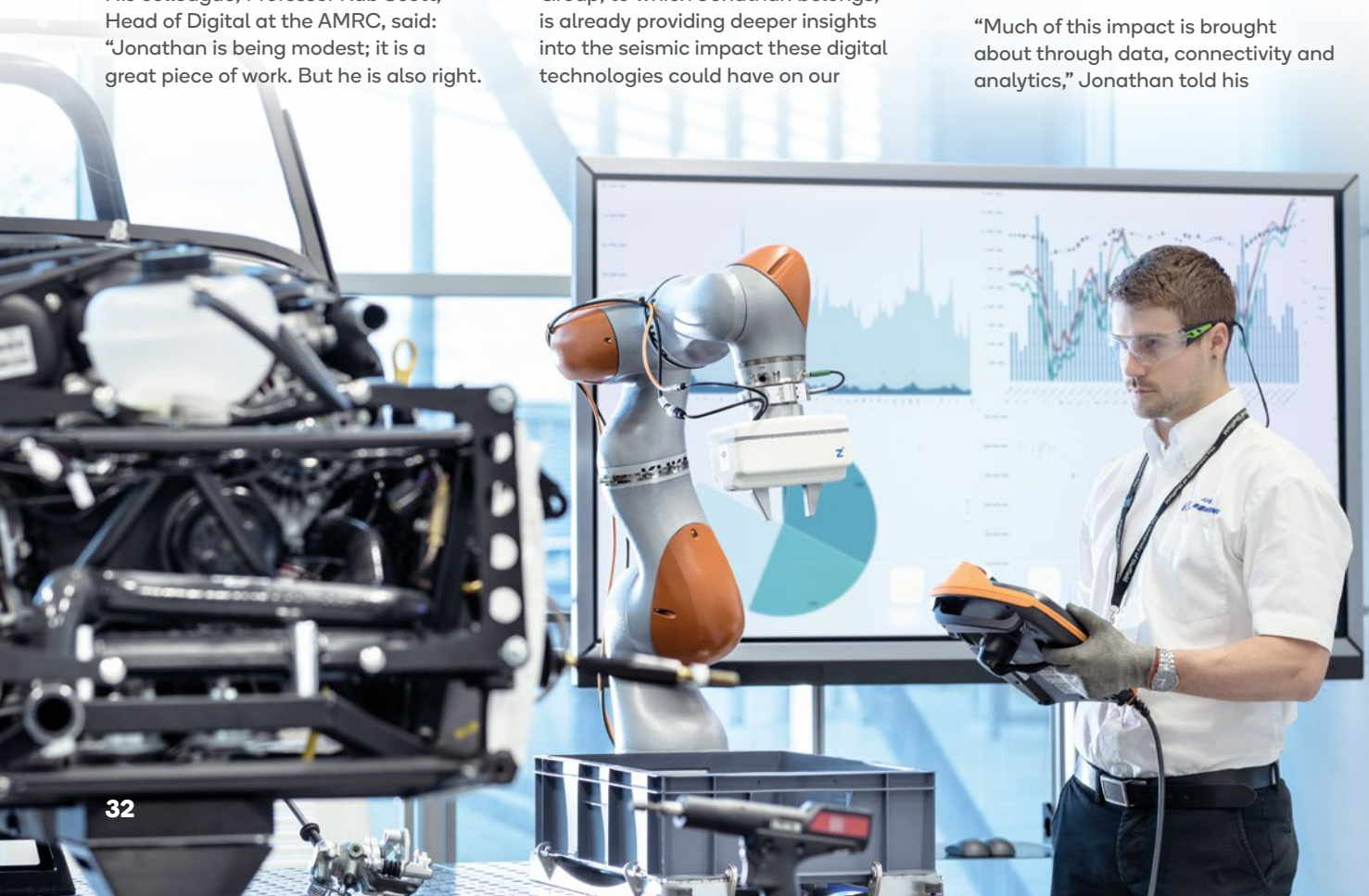
The AMRC’s Integrated Manufacturing Group, to which Jonathan belongs, is already providing deeper insights into the seismic impact these digital technologies could have on our



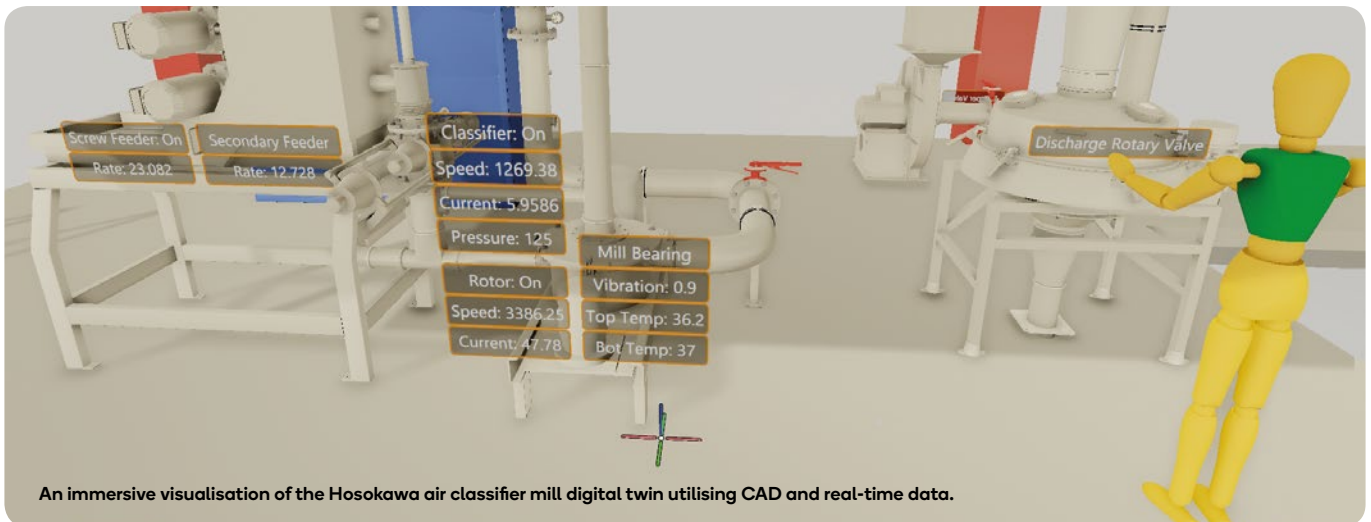
Jonathan Eyre, Technical Lead in Advanced Visualisation at AMRC Factory 2050

manufacturing partners who want to be trailblazers in what has been called the Fourth Industrial Revolution.

“Much of this impact is brought about through data, connectivity and analytics,” Jonathan told his







An immersive visualisation of the Hosokawa air classifier mill digital twin utilising CAD and real-time data.

Euro2018VR audience. “We now have the ability to not only capture sensor data but to process it at, or close to, the point of capture. In addition, we can take data sources such as machines, devices, sensors and people, and connect them so they can communicate with one another.

“But none of this data has value to the business until the final element in this network – the ability of the systems to analyse data from many different sources and to act on that information in a way that changes the business for the better.”

The digital twin uses this real time data to create a virtual mimic of a physical asset, and Jonathan highlighted the work he and his team are doing with Hosokawa Micron, the North West-based particle and powder processing equipment and technologies specialist. A dynamic and forward looking company, Hosokawa has already invested in remote monitoring applications for displaying information. Having been an early adopter of data analytics, Hosokawa wondered whether there was a way of bringing the virtual and data analytic technologies they were developing together in a way that would drive improvements in performance: in particular, process and lab efficiencies; increased plant uptime; reduced operator error; improved product quality; and faster changeover and preparation processes.

“The next step was to investigate the monitoring within an immersive environment and to create a digital twin of an air classifier mill,” said Jonathan. Using CAD data with labelled

information, scripting allowed the labels to be updated showing live information of the physical asset being monitored.

“The outcomes were very positive, enabling faster responses to changes; better informed decisions; and significantly improved efficiency,” said Jonathan.

His paper follows hot-on-the-heels of the Feasibility of an Immersive Digital Twin report published by the UK’s High Value Manufacturing Catapult (HVMC), and produced by a team of researchers within the HVMC.

Sam Turner, Chief Technology Officer at the HVMC, said: “We know the digital twin market is going to grow to over US\$15 billion over the next five years, and that much of this growth will be in manufacturing applications. The HVMC is not only making industry aware of the opportunities that these technologies open up, but also supporting them in developing the capability to exploit these technologies to the full.”

A key feature of the Feasibility report is a long interview between Jonathan and Paul Haines, of the US-based, global IoT technology platform provider, PTC.

Haines, whose firm has more than 30,000 global customers and 1,000 technology and service partners, says: “I think we are on the verge of some hugely disruptive phase, where somebody is going to come out with eyewear that is unintrusive, cool from a consumer point of view, safe to use in an industrial context, and all of that, together with things like GPS locations and GEO-fencing, will be explosive in the five years, or as soon as a device comes around that is capable of delivering that.

“The data will be streamed to us based on our location, based on our role within the business, based on consumer buying habits from our general lives and so forth. All of that will explode in terms of the way we consume information.”

But the report questions whether industry or policy makers are ready for this explosive and disruptive impact. “When it comes to digital twin, the most common reference is maintenance and keeping assets running. For example, we are just doing some work with a forging company that has connected one of its forging lines that historically failed every three to four months,” Haines said.

“In that instance, through connecting the line and not having any machine learning ability here, the operators learned to understand the signals and the feeds coming off the line to the point where they were then able to spot where problems were developing with the clutch. They were then able to proactively fix the issue before a failure happened just in time rather than after the case. That is now saving them around US\$200,000-a-year and the line running for nine months without any failure.”

The challenge, however, is the way in which data is conditioned so it becomes valuable for the user. “It comes back to Steve Jobs with his phrase that simplicity is the ultimate complexity,” says Haines. “The way in which we are able to condition data to deliver what is necessary is one of the key challenges of the Fourth Industrial Revolution that we are rattling towards now. And this report gives us a deeper understanding of that challenge.”

# The big ideas of the Fourth Industrial Revolution not just for the big players

Tinsley Bridge has always been a company at the very forefront of manufacturing innovation, so it is no surprise that it has embarked on a project to demonstrate how Artificial Intelligence (AI) and machine learning can optimise machine utilisation rates to boost productivity on the shop floor.

By Rebecca Ferguson

Joining forces with the engineers at the University of Sheffield Advanced Manufacturing Research Centre's Factory 2050, the project is using AI to learn what machine utilisation looks like on the workshop floor of the Sheffield-based award-winning SME; which specialises in large-scale engineering for challenging environments.

The aim is to create a demonstrator to show other SMEs in the Sheffield City Region just how accessible Industry 4.0 technologies are and how they can potentially revolutionise shop-floor productivity.

The demonstrator will be the first created under an emerging AI strategy

being created at Factory 2050, which seeks to harness the innovative work being done with AI and machine learning techniques across the AMRC to provide real-use cases for these techniques in industrial environments.

"Using edge computing devices retrofitted to the company's CNC machines we have collected power consumption data during the production of automotive suspension components," said Rikki Coles, AI Project Engineer for the AMRC's Integrated Manufacturing Group at Factory 2050. "It isn't a complicated parameter to measure on a CNC machine, but using AI and machine learning we can actually do a lot with

such simple data."

Data from the edge computing devices at Tinsley Bridge was sent to the AMRC's cloud computing services and, using the latest data science techniques, ran through an AI algorithm to provide new insights for the control and monitoring of manufacturing processes.

Analysing the power signatures from the data, the algorithm looked for repeating patterns or anomalies, working out how many components were machined and deduced that three different types of components were manufactured.

Rikki said: "The project demonstrates to industry that with a low cost device



collating quite simple data, AI and machine learning can be used to create valuable insights from these data back to the manufacturer."

Director of Engineering at Tinsley Bridge, Russell Crow, said: "Interrogating our machine utilisation rates means we have better visibility of what is being manufactured and when, and the ability to assess if we are scheduling effectively. This data will allow us to look at optimising our machine utilisation rates to boost our productivity on the shop floor.

"Rather than investing in significant cost and time for new digitally integrated smart machining centres, we were able to work with the AMRC to retrofit our existing capabilities to achieve the same results and enhance what data we were collecting by fitting a simple current clamp to our machines; an unobtrusive solution that caused no disruption or downtime."

Aiden Lockwood, Chief Enterprise Architect for the AMRC Group, said the project demonstrator will show other SMEs how easily and cheaply Industry 4.0 technologies can be accessed.

"Traditionally these tools were built into commercial packages which could be out of the reach for some SMEs, so there is a misunderstanding that Industry 4.0 manufacturing techniques are for the big players who handle incredibly complex data collected over a long period of time," he said.

"But AI is evolving and these techniques now give smaller businesses the ability

to do so much more with their data. In this project we are using a simple data set, collected over a short period of time to provide real benefits for the company."

Aiden said the AMRC wanted to show what using AI in manufacturing looks like for small businesses.

"The formation of our AI strategy will allow us to lead the way in developing new capabilities and bringing the academic, tech and business communities of the region together to educate and demonstrate AI technologies for manufacturing industries; learning from developments in retail, finance and marketing."

The next phase of the project will see the engineers at the AMRC train the system further so the algorithm can detect non-conforming components whilst in production or identify a problem when a machine is requiring intervention, such as inconsistent tool wear which affects component quality.

"Alongside the power consumption data, the plan is to feed the algorithm with available data about which of the manufactured components were non-conforming. So as well as providing clarity around machine utilisation, the algorithm will essentially learn what a 'good' manufacturing process looks like and be able to actively monitor on-going manufacturing processes," said Rikki.

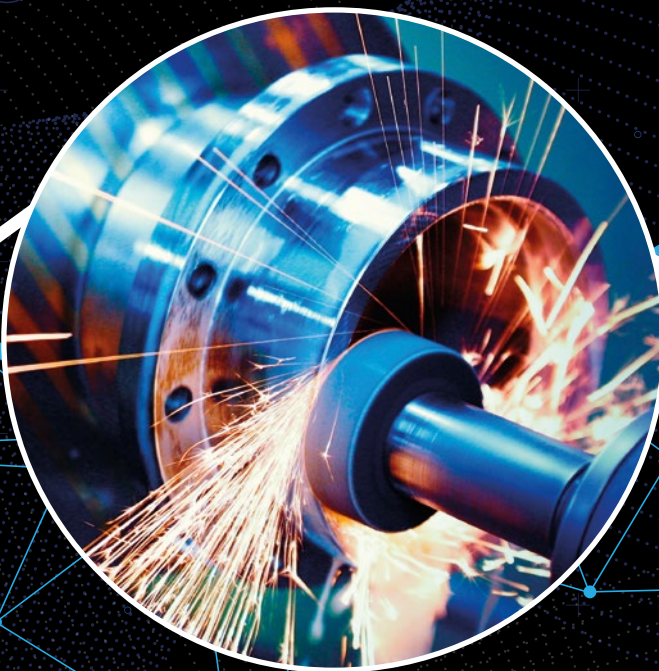
Russell said: "We started out with the aim to find out about retrofitting our machines for data capture to give us

an idea of our machine utilisation to optimise our production schedules. But as the project moves forward, we expect to gain even more visibility around our production processes so we can begin to move towards a predictive maintenance model on our machining shop floor which will provide improvements in quality and process capability.

"The insights the AI will provide will allow us to identify when our machines will require intervention for tool changes or how long we can run them without intervention. Predicting tool failure and prolonging tool life will also affect our right first time rates, reducing non-conforming parts and boosting productivity.

"In the future the insights into our data will allow us to run our machines more effectively, so we can free time for our engineers to work on value-added tasks such as programming for multiple jobs or machines, creating a smarter factory that will help us manufacture technically advanced products."

65.296



87.502

89.698

91.205



97.275



# Alpha-I lead the pack at Rolls-Royce hack

**A software company specialising in AI-powered maintenance solutions for aerospace is flying high after taking the top spot at a two-day hackathon organised by Rolls-Royce.**

By Katia Harston

**Alpha-I – which builds machine learning platforms working with some of the largest aircraft and component manufacturers in the industry - beat 11 other teams to be named champions of the manufacturing hack held at the AMRC, winning £10,000 and a partnership with Rolls-Royce.**

The 12 teams – made up of engineers specialising in artificial intelligence (AI), machine learning and data science – were tasked by the engineering giant to tackle a real business challenge by looking at a collection of data, ‘cleaning’ it and creating a super-human decision making engine to try and develop and enhance manufacturing processes at Rolls-Royce.

The Alpha-I engineers merged their expertise in predictive maintenance with data analytics to propel themselves to victory, and were chosen as the winning team by a panel of Rolls-Royce judges at the event’s finale.

Alpha-I’s CEO, Giacomo Mariotti, said winning had been ‘a great validation’ for the team, comprising chief technical

officer Daniele Murroni, machine learning engineers Parvez Alam Kazi and William Tai, and software engineer Gabriele Alese. They will use the prize money as seed funding to help develop their winning solution into a proof of concept in partnership with Rolls-Royce’s Manufacturing Technology and R<sup>2</sup> Data Labs teams.

Giacomo said: “It was a very tough 48 hours. We were here very late on the first night and came in early the next morning and I think we did a good job trying to work towards something we could achieve and squeezed in every tiny bit of detail.

“The quality of the other teams’ work was really high and it feels great to have won. I think to some extent we knew what to shoot for and that helped us a lot.

“The aerospace industry is something we are very interested in and Rolls-Royce will be a great partner going forward. We hope this could be the beginning of something very interesting for us.”

Judge Caroline Gorski, Group Director of R<sup>2</sup> Data Labs at Rolls-Royce, said the hack had been an extraordinary couple of days – attracting teams from across the UK and as far away as Belarus, bringing with them bucket loads of ‘dynamism, enthusiasm, intelligence and a difference in thinking’.

She said: “I’m thrilled at the sheer diversity of the thinking and intelligence that we have seen displayed here; people from different cultures and backgrounds applying different sorts of techniques on a challenging data set on a domain that is not necessarily easy to apprehend and understand.

“We had a very challenging conversation in the judging room. There were several teams in strong contention and we ended up with a healthy debate around two specific outlying leaders – there was a lot of backwards and forwards, and some blood, sweat and tears left on that judging room floor.”



Leaders of the pack: The hack’s winning team Alpha-I, left, and right, the teams busy working on the Factory 2050 shop floor.

She said there were a number of reasons Alpha-I soared to victory.

“It was partly about their ability to show how the data science techniques and machine learning techniques they used would have a direct influence on our processes; and partly to do with the sheer understanding and inquisitiveness they showed in trying to get close to Rolls-Royce as a customer and thinking about the real way that their solution would land within Rolls-Royce’s employee base and how that might really affect the way our business would change.”

Both Rolls-Royce and the AMRC fielded home teams in the event and Julia Groß, Head of Innovation at Rolls-Royce, said the judges were astonished by the quality of their results but more so by the courage they showed leaving their comfort zones to hack against professionals.

The event, held at the AMRC’s flagship Factory 2050 facility, was hailed a tremendous success by Faizan Patankar, Venturing and Incubation Lead for R<sup>2</sup> Data Labs at Rolls-Royce, who declared Factory 2050 as ‘a great and inspiring space’ which brought out the best in the teams and mentors.

He is keen to continue a relationship with the teams beyond the hack, telling them: “Everything I have seen over the last 48 hours is amazing. Let’s be clear, this isn’t a ‘Fight Club’. Whatever happens at a hackathon should get out there. So go out there, share what you have done, and connect with Rolls-Royce outside of this event.”

# Hack to the future

**Rolls-Royce selected Factory 2050 for a bold experiment in hackathons using real company data and a real business challenge to start-ups. It was an amazing success and the first step in building a smart external digital ecosystem. Katia Harston reports on the aspirations of the aerospace giant.**

**When Faizan Patankar was tasked with hosting a hackathon, the Venturing and Incubation Lead for R<sup>2</sup> Data Labs at Rolls-Royce began scouting suitable venues in London but he also wanted to come and look at the AMRC. He wasn't disappointed.**

"We turned up and walked through the doors and I was like 'wow, how is it that we've not been here before?' I think it took about five minutes to decide it was where we should host a hackathon. It's very important to get the business and tech community together in the right context and the right space.

"When you walk into Factory 2050, you go 'this is a shop floor, an advanced manufacturing shop floor' – you don't have to be told what it is, it's neat and advanced, you can see cobots around you.

"It hit me that I meet so many start-ups and they don't know about the AMRC so for me it was all about getting this space out to the start-up community and getting the name out.

"Before you come here you have an

image of manufacturing and when you turn up here it shatters that image. Not many manufacturing sites, if any, have ever done that to me.

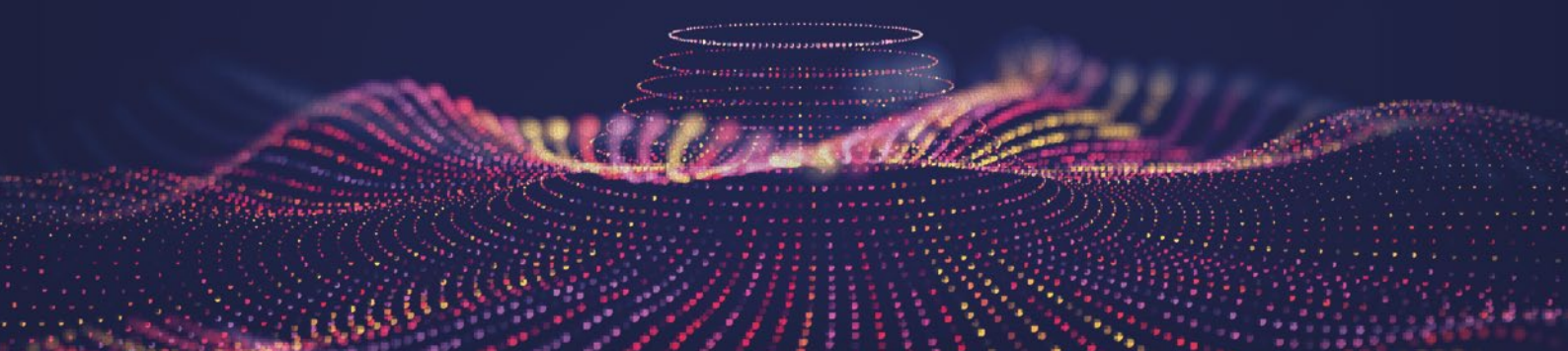
"We have people from Rolls-Royce who had never been here before and they were inspired by the AMRC and blown away by the space at Factory 2050."

There's a number of reasons for Rolls-Royce to run hackathons but first and foremost it is about getting start-ups to play with data to try and solve a real



**"We have people from Rolls-Royce who had never been here before and they were inspired by the AMRC and blown away by the space at Factory 2050." Faizan Patankar.**

“This is the ecosystem at play, where the large corporates and start-ups are coming together. We’re not against each other, we’re working together. It’s blazing a trail.”



manufacturing challenge – in this case it coming up with a decision-making solution that automates inspection, trend detection and measurement adjustments for aero-engine components.

“A hackathon brings the business and technology community together and is all about more action and less talking, more prototyping and iteration and less procrastination. And for Rolls-Royce this is what matters to us,” said Faizan.

“We want to be an industrial technology company and with that there has to be a change in how you work. You have to be more agile. A hackathon is all about being more agile, taking rapid action and also working with this external start-up ecosystem.

“This is the first time that Rolls-Royce has gone out there saying we will bring our data and a real business challenge to start-ups – it is complete external innovation. And that’s Rolls-Royce being bold and saying talent doesn’t just reside within Rolls-Royce.

“This is the ecosystem at play, where the large corporates and start-ups are coming together. We’re not against each other, we’re working together. It’s blazing a trail.”

But why now?

“Technology is rapidly changing,” said Faizan, “I don’t think we are in a space anymore where one company can be on top of digital technology forever. So business models are changing and disruptions are happening in some of the key sectors that we’re working in.”

There were three key drivers behind

the Rolls-Royce Manufacturing Hack – solving a business challenge, engaging with start-ups and talent spotting.

“Start-ups now have access to the same digital environment that Rolls-Royce or any other corporate has access to. But through their nimble nature, start-ups can develop technology in a way that would be challenging for us to replicate in the same time frame. So with the pace of change being so fast, it just makes sense that we collaborate and work together on solutions – it’s a good thing.

“We want to support the start-up ecosystem and now is a golden opportunity with the amount of data disruption that’s happening in the industrial world. Corporates will start understanding how much more value start-ups can bring and instead of it being ‘us versus them’, there is way more value if we are together.

“We are building an ambitious ecosystem of 500 start-up partners.

“The hackathons are essentially saying to the rest of the UK – and the world – that if you are a start-up come and talk to Rolls-Royce.”

Faizan said hackathons are a great way to tap into the student community and nurture the next generation of data scientists.

“Two University of Sheffield student teams took part in the Rolls-Royce Hack at the AMRC which had more than 25 teams apply and I could only have 12. To give two of those spots to two university teams shows how committed we are to nurturing the next generation of data

scientists. We have to show them that as well as the big software giants there are other industrial companies like Rolls-Royce that exist that you could work for. It’s not a binary choice.

“The AMRC is a good example – manufacturing didn’t necessarily have people dealing with data before but now this is core to its future.”

As well as talent spotting, hackathons also provide an opportunity for Rolls-Royce R<sup>2</sup> Data Labs to pitch itself as a great place to work. “We are the data innovation catalyst within Rolls-Royce,” said Faizan. “We use advanced data analytics, industrial Artificial Intelligence and machine learning techniques to develop data applications that unlock design, manufacturing and operational efficiencies.

“We have a high level of maturity using data to understand how to keep engines in the air, but how do we use this expertise to support manufacturing, HR, purchasing and procurement or sales and marketing who have lots of data. It might be in documents but it is data nonetheless.”

Rolls-Royce has a long and well established history of working with the AMRC and the team at Factory 2050 is now developing a portfolio of Digital Innovation projects, which the engagement with Faizan and the R<sup>2</sup> Data Labs team will now bolster.

“I’m really looking forward to how Rolls-Royce and the AMRC progress working together on digital innovation. My work really starts now.”



# Vehicle conversion firm enters fast lane with help of Virtual Reality technology

**A family-run vehicle conversion firm is embracing Virtual Reality technology to boost productivity and reduce turnaround times for designing and kitting out vehicles for customers.**

**A team from the AMRC's Integrated Manufacturing Group (IMG) worked with Clarks Vehicle Conversions to show how it can use Virtual Reality (VR) to revolutionise the design stages of converting a vehicle and that with some clever optimisation of its CAD models, the process time can be improved and complexity reduced.**

Clarks Vehicle Conversions (CVC), based in Doncaster, kits out vehicles such as welfare vans, lifestyle vehicles and crew carriers to clients' individual specifications. Customers include firms such as National Rail, Enterprise and Lex Autolease.

The work by the IMG group was carried out as part of a five-day funded project and is part of the AMRC's commitment to SME engagement, funded by the HVM Catapult.

Currently, when a job comes in for CVC, a skilled team of fitters, electricians,

engineers, mechanics and designers has to build a physical prototype to show the customer.

This involves kitting out a van to the customer's exact requirements. The customer then has to visit the CVC's Conversion Centre to approve the van layout before it can go into production. However, if the customer wants to make any changes, and depending on the scale of alterations they want to make, this can push delivery time back as it requires the customer to go back to the Conversion Centre to approve the final build for a second time.

IMG Digital Software Engineer, Jake Senior, showed the company how established VR technology could be used to transform the design stage of a conversion by allowing the customer to wear a VR headset and 'build' a virtual prototype to their own specification – rather than having to wait for a practical

demonstrator to be built, reducing the turnaround time between an order being placed and the vehicle leaving the shop floor.

Jake used the company's existing CAD models to recreate an empty van in the virtual world where the customer can pick items from a displayed bill of materials and place them in the van where they want them to go. The bill of materials also lists the mass of each item selected, the installation time and cost – updating in real time whenever a new item is chosen.

The idea is the customer has full control over the design process which minimises the risk of them wanting to make changes down the line due to a wrong layout. It also means when the customer is happy with



the fit out in the virtual world, the design can be rubber stamped and sent for manufacture.

The use of VR technology to help with design and prototyping slashed the 'order to manufacture' turnaround time from up to six weeks down to 30 minutes.

IMG's project manager for SMEs, Matt Bacon, said: "CVC knew they wanted to utilise VR technology in regards to kitting out vans but didn't know how to go about it or what the technology is used for, what the benefits are and which is the best tech to use. They just knew it was there, holistically.

"It was up to us, within those five days, to demonstrate the functionality of some of this VR kit specifically. We

wanted to show them what we could do and what was achievable.

"The company were happy. We had some good feedback. They are digesting the information we've given them and then we can start planning out a roadmap in regards to the kind of projects we feel they need to complete to get a fully integrated system to replicate the VR demonstrator."

Matt also carried out some CAD optimisation work in relation to geometries inside the van – replacing CVCs tried-and-tested method of using cardboard to convert curved surfaces into flat panels with a simpler and quicker digital process.

The company currently uses traditional skilled prototype build engineers to

profile the inserts by hand to determine panel sizes. Instead of profiling by hand into a void on a panel and then flattening this out to convert the curved surface into a flat panel for machining, Matt created digital geometries to make the process easier.

The CAD models used during assembly were also streamlined as they were too detailed and data hungry, making it difficult to run and manipulate the model due to lack of process power. Matt overcame this by making sure all the necessary features were available to reference but without the need of manipulating an entire assembly, improving process time and reducing complexity.



# The ring of confidence

**When Rufino Bolado-Gomez first stepped on to the shop floor of CW Fletcher's precision engineering factory in Wales Bar, Rotherham, all the former computational neuroscientist could see around him was 'a world of opportunities.'**

**"It's a great company with a rich tradition of high-value manufacturing and a strong order book in aerospace and nuclear," says Rufino, who joined the company full-time last summer after completing a Knowledge Transfer Partnership with the University of Sheffield AMRC. "But there's a world of opportunities to bring the benefits of digital manufacturing to the business through data analytics."**

There is no doubt the company has an impressive pedigree with a long history of adapting to new market conditions. In 1891 Charles William Fletcher set up as a silver forger supplying all the leading silversmiths with blanks after assay. A decade later the company moved to Arundel Street, in the heart of Sheffield, and started to produce finished silver cutlery itself.

As the Second World War approached many of CW Fletcher's staff were called up and the silverware business was wound down as the company signalled a change in direction, with engineering coming to the fore. Orders for components for the Spitfire's fabled Merlin engine led to precision engineering contracts and an enduring relationship with Rolls-Royce which continues to this day with the manufacture of a range of components for jet engines.

"We are very proud of our tradition and experience in precision engineering," says Steve Kirk, the firm's Managing Director. "But we know that if we are to continue to grow the business and thrive, we need to bring in new blood, new ways of doing things. And Rufino has been key to this. He has not only shown the added value that data collection and analysis can bring to the business, he has also motivated and engaged our workforce by showing them the benefits that can be gained from embarking on this digital journey together."

Mark Duff, who operates one of the firm's bigger Mazak machines agrees. As one of those in the vanguard of Rufino's digital revolution, Mark has seen first-hand how these new approaches can improve the lives of those on the shop floor.

"By collecting data in this way we know what we need to do to improve," says Mark who has been with the company for 14 years. "That's a benefit to the company and a benefit to the



workforce. If we have a more robust manufacturing system that means I am able to make 12 pieces a week rather than ten. That means a better bonus and more job security.”

There are other immediate benefits too. In the past, Mark would have to leaf through reams of paper looking at drawings, instructions and reports. Now he has all the data next to him on a touch screen computer. “It is so much easier, no more jotting things

down on batch pads. That’s why we have embraced it. I love it, it is fantastic because everything is there on the computer. When a part left the Mazak in the past we didn’t see it again, so you might think – was it right or was it wrong? Now we can look at the data and we know.”

It is this ability to bring the operators and engineers along on the journey that has most impressed the AMRC’s Jon Stammers who was Rufino’s supervisor

on the KTP. “You can have all the smart technology in the world on your production line, but if you don’t bring your people with you, it will amount to nothing. Rufino has formed a real bond of friendship with his co-workers, winning their trust and respect. They’ve become a very strong and innovative team.”

Rufino is certainly no conventional engineer. Having gained a degree in physics in Mexico, he returned to Sheffield and embarked on an MSc in



Rufino and Mark Duff discussing data from the Mazak machine.

**“Using data in this way can be a powerful tool. It enables us to reduce non-conformance which can be a significant cost in terms of time and money.”** Rufino Bolado-Gomez.

control systems looking at machine learning, ‘fuzzy logic’ and ‘engine health monitoring’ with the help of Professor Visakan Kadirkamanathan, Professor Mahdi Mahouf, and Dr Andy Mills in the University of Sheffield’s prestigious Department of Automatic Control and Systems Engineering. A doctorate in computational neuroscience saw Rufino blurring the boundaries between psychology, engineering and biology. “We were building models of the brain with maths and then applying them in virtual or real robots to look at how these brains work and then back to actual neural recordings to match and compare,” he said.

While he loved the science, the prospect of a being a post-doc had a down side. “It can be very lonely at times,” says Rufino who is a naturally gregarious, social animal. A chance encounter with Tom McLeay, Head of Research in the AMRC’s Machining Group, opened an entirely unexpected door, however. “I hadn’t really thought of a KTP, but the

idea of working on the shop floor to help transform an engineering business sounded very different and interesting,” Rufino added.

CW Fletcher’s Engineering Manager, John Walker, is glad that Rufino changed career direction. “We are a busy company, but we need to keep moving, keep ahead of new technology and new ideas, and Rufino has become crucial to guiding us on the digital journey.

“We have a lot of people in all areas that have been with us a long time with a huge amount of knowledge and experience, but we don’t have the systems across the place that are capturing and exploiting this knowledge, we have just relied on people knowing how things are done. Creating these systems is a big part of what Rufino is doing and will help us improve quality and performance and develop resilient succession planning for an ageing workforce.”

The early idea behind the KTP was to investigate and develop CW Fletcher’s advanced manufacturing processes by focussing on technologies such as on-machine inspection (OMI) and utilising real time data to reduce product lead time and improve right-first-time figures. But, during an early audit of their activities, Rufino and Tom shifted the emphasis towards developing a process monitoring and control system to collect essential data related to key dimensional features on components.

The result is a complete digital infrastructure that robustly captures data in real time and sends it into a central database. Rufino also developed an in-house software platform behind this digital system with a front-end graphical user interface (GUI) that enables operators like Mark to input specific part information and feedback data analysis and visualisation tools via a touchscreen PC.

“We have now arrived at a point where our data collection system is

successfully working with two machines and two parts capturing data from three different sources of measurement: on-machine probe, Coordinate Measurement Machine and manual gauges during production. Ultimately, as the central database continues to grow, an intelligent use of the data will enable us to develop preventive and predictive guidelines, leading to a more efficient use of machine time and a reduction in wastage.

“Using data in this way can be a powerful tool. It enables us to reduce non-conformance which can be a significant cost in terms of time and money when you are working with expensive exotic alloys. If we can use data to eliminate this problem and get things right first time, that is very big achievement,” Rufino said.

“Increased data can help us predict when things are going to go wrong, and thus avoid that happening. We could, for instance, find that a part fails when a certain operator is on. This is not Big Brother; we all have to be honest here. Simple changes to the way that operative works, and some retraining, could quickly sort an expensive problem.”

So what is his role? The title on the business card says Head of Technology Applications and Strategy. But Rufino sees himself simply as a ‘disruptor’. He is already looking at how combining Information Technology and Operational Technology could bring the office floor and the shop floor closer to the ultimate goal of a connected factory – and a connected supply chain.

Logistics, he argues, has a big impact on the business. “If we can collect data from the supply chain in real time it will enable us to better plan our machine time, but it could also give us visibility of the product, showing us in real time what is happening to a forging,” he said.

“There are fantastic opportunities with software companies, right now. You can use their products for three months for free. That means, if you prepare properly you can run a project in those three months to test the benefits of that software in something that could soon be used in our production processes. This makes it much easier to tell the directors, look guys we have proved that this works and they will be more likely to say let’s invest,” said Rufino.

For him the ‘great thing is that we have an MD who is embracing change’. Steve



Kirk was an early adopter of the Sharing in Growth programme, which helped the company secure a £7 million three-year export deal with Kawasaki Heavy Industries of Japan. “Sharing in Growth set us on the path to transforming both our technical and leadership capabilities. In an increasingly competitive global market, successful businesses need to combine world-class products and services with world-class people, operating in world-class facilities,” Steve said.

And Rufino has an idea of where that path could lead. Ensuring CW Fletcher’s products precisely match their design brief will dramatically reduce waste. But this verification process can itself account for a significant part of the product’s overall cost. Streamlining procedures to spot these problems early will make a big impact on a company’s

bottom line, as well as the quality of its finished products.

“Digital manufacturing is helping the operators improve quality and performance, but there is more we can do. We want to move to something much closer to predictive modelling. If we get good data with context from the operator and the engineer, that will give us such a rich resource. It will tell us that this part got scrapped because of this.

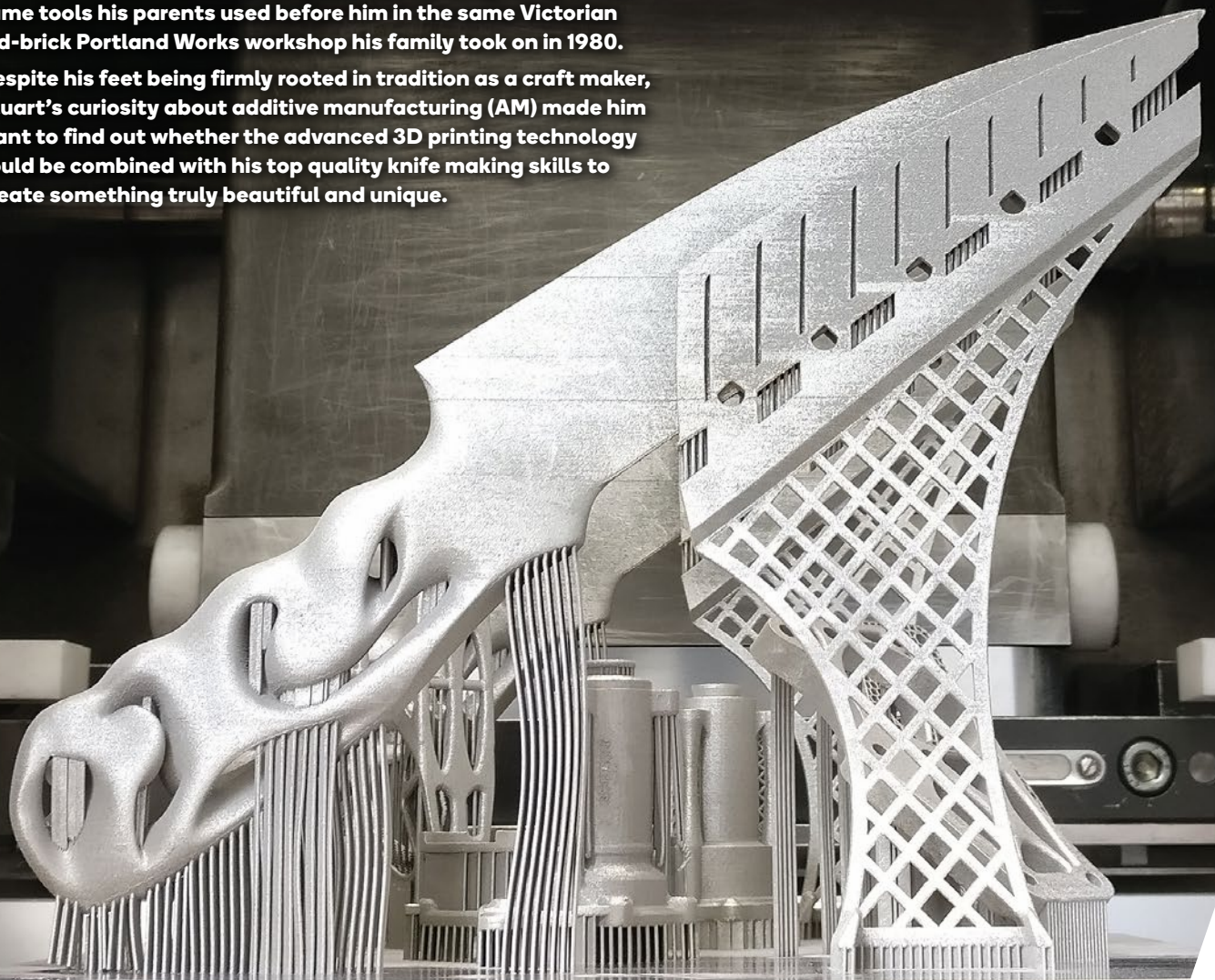
“In my utopian scenario, connectivity would link us to the supply chain, providing us with data sets in real time from forgings through to machine monitoring. Data analysis, cross reference and multivariate analysis would enable us to see the problem before it happens, so that we can stop it happening. That really would be right-first-time.”

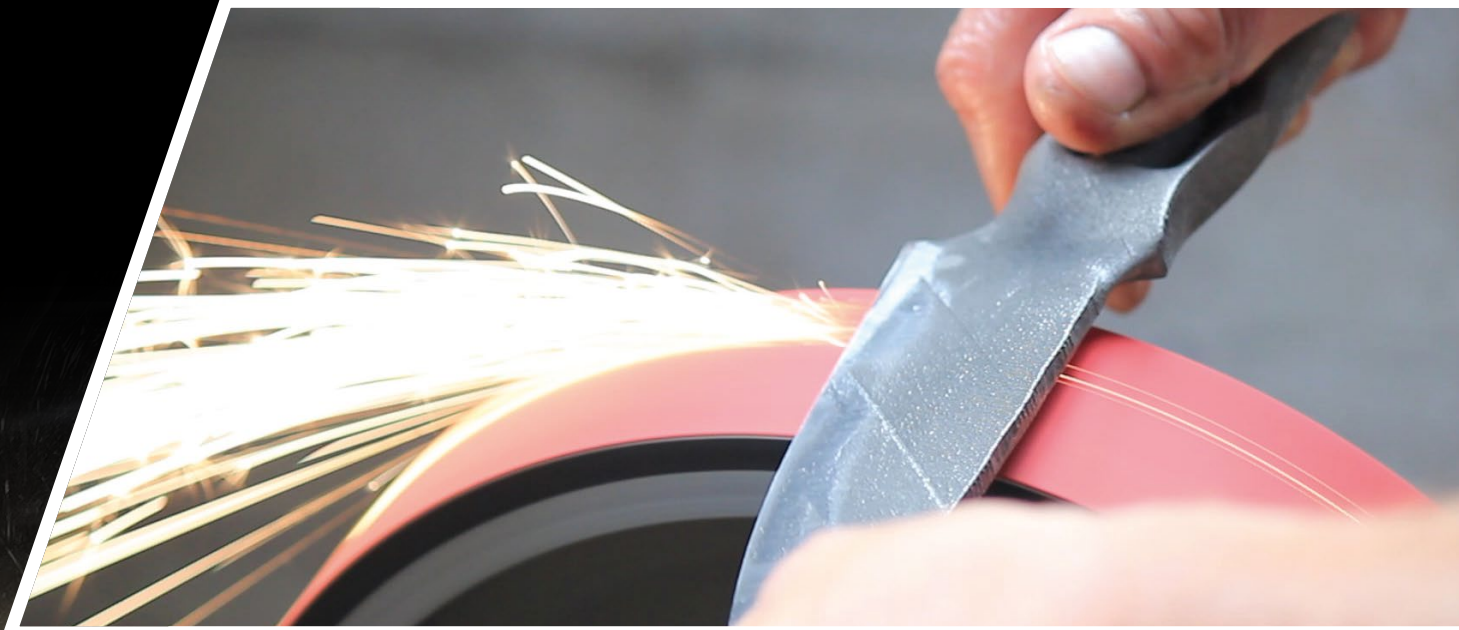
# Knife maker at the cutting edge of 3D printing technology

**A highly respected Sheffield knife maker has put himself at the cutting edge of advanced technology by joining forces with the AMRC to design and develop a bespoke, 3D printed titanium chef's knife.**

**Stuart Mitchell, 48, has been making knives for more than three decades, cutting his nose in the trade as a keen ten-year-old at his father's knee. He makes bespoke blades using many of the same tools his parents used before him in the same Victorian red-brick Portland Works workshop his family took on in 1980.**

**Despite his feet being firmly rooted in tradition as a craft maker, Stuart's curiosity about additive manufacturing (AM) made him want to find out whether the advanced 3D printing technology could be combined with his top quality knife making skills to create something truly beautiful and unique.**





**It led to a project with the Design and Prototyping Group at the AMRC to produce a titanium chef's knife to demonstrate the technology and allow Stuart to compare and contrast the end product with his own handcrafted knives.**

Design Strategy Manager for the DPG, Andy Bell, said: "We were curious whether we could 3D print a viable chef's knife using a titanium alloy.

"This is design-led disruption in the truest sense of the word; a craft maker applying advanced manufacturing technologies and exploring how this could change their business model now and in the future.

"Design methods allow us to explore, through different frames, how we can approach a wicked problem like the introduction of AM to an organisation which would never normally approach this technology due to the high perceived risk, cost and knowledge gap.

"We can use design to change perceptions by understanding the way in which small businesses work, their needs and wants, and then developing a response to this in a risk-free way.

"The project has been about understanding what the opportunity is. We provided Stuart with an AM blank which he would normally make himself from sheet metal, grind it and sharpen it up. The difference with what we've done is integrating the blade and the handle, which was moulded and customised to a chef's hand. We then delivered the printed knives to Stuart for finishing."

Engineers at the AMRC's Design and Prototyping Group used Autodesk's Simulation Utility for Netfabb to aid their design and AM build optimisation work for the additively manufactured knife.

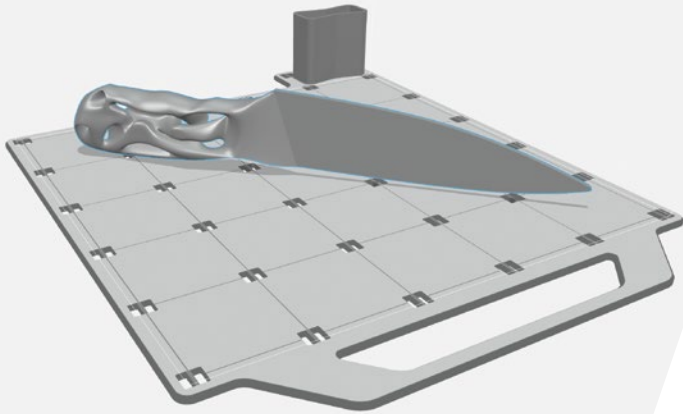
Luke Hill, Project Engineer, said several AM build simulation packages were employed to analyse the distortion of the knife using a standard support strategy. The results delivered by each package were analysed and it was decided that a non-conventional support strategy could also be applied in order to reduce distortion of the long blade section.

Simulation Utility for Netfabb was used to analyse the non-conventional support structure design due to its ability to simulate the influence of multiple parts on a build platform. This allowed engineers to tailor the support design methodology by creating the non-standard support structure that provided a physical connection to the knife in addition to the non-contact thermal shrouding.

Luke added: "Results delivered by the simulation package highlighted a likely reduction in distortion of the knife blade thanks to the thermal shroud support structure. The speed, ease of use, and multi-part simulation ability of Simulation Utility for Netfabb quickly gave us confidence that both knives to be printed during the build would benefit from reduced blade distortion thanks to the novel support structure."

Stuart – whose knives are used across the world in Michelin star restaurants and by members of the Royal family – took receipt of the AM knife at his workshop in Portland Works and was struck by the quality of the piece.

"I was impressed by the profile of the blade – it replicated very well what I would do by hand, particularly the taper from the spine to the edge," said Stuart. "It did need a degree of grinding to apply an actual cutting edge but the tolerances of the edge were good to start with, very fine. I didn't



A GrabCAD print setup up of a concept knife model.

Stuart Mitchell in his Sheffield workshop.

realise it would print that fine.

“The curvature and the detail in the handle, the hollowed out sections – I realistically can’t do any of that. It’s possible but not practical because there’s probably a week or more’s worth of hand work there. The fact that all that can be added or taken away as it were by changes to a CAD model and then adapted to suit – to increase or reduce weight – none of this I can do, it’s all very hands-on for me. Experience has given me a knowledge of the weight and balance of a handmade knife, what to expect and where to aim, there is also almost always a ‘suck it and see’ element though.

“I love the AM knife; it’s different and hasn’t been done before. Working in that very traditional way and to have something brand spanking new in the workshop is great – what’s not to like? What it perhaps also shows, particularly with all the advances in AM, is that there is still a place for what I do as well.

“An ideal product would perhaps marry the two.”

The idea for the project came about over a brew in Stuart’s workshop.

“I didn’t know a lot about AM and it was curiosity really,” said Stuart, who began full time employment as a knife maker aged 15 working for his parents who taught him each aspect of the trade, from forging through to grinding and finishing.

“A good friend and colleague of mine, Professor Peter Marsh from the University of Sheffield, was the mutual connection. He knows very well what I do and it was through his connections with the university and with the AMRC that the project came about.

“A couple of engineers from AMRC came to the workshop and I think, because it’s such a different place here, that inspired the imagination that led to us doing this.

“The knife is designed around the hand of a chef from Freeman College, Chris Harrison. I made a version of the knife how I would make it and this AM knife comes from that, it is the next generation.

“A chef can come to me and I can mould his hand and create a knife which is very close to the AM knife but that’s it. There are bits then that I am restricted to do, the design features and different things. The limitations are that I am working by hand and the methods I use, which are the same as what my dad worked with when he was 15.

“The fact that working by hand doesn’t have the accuracy of AM is part of the charm for me. A glaring inaccuracy is just that, and unacceptable, but when you look at a handmade object in hand, whatever it is, and you’d need to very accurately measure it to identify any imprecision, when your eye cannot detect it, there lies the beauty of hand made for me. It’s practice over the years of knowing what to look for.”

Stuart first saw the potential of AM when a company printed the first full working composite wrench but at that point he couldn’t see an application for his craft.

“What’s been restrictive up to now is all the materials that can be used to print – the polymers and such don’t really have anywhere that I can take it, even for a handle, because sometimes it can be quite brittle,” he said.

“I think the thing I saw change was the materials that became available. All of a sudden then, when we’re talking titanium, I started to think about how AM could work.

“Is it disruptive technology or does it enhance it? It’s about how you see something. I think it can enhance it.

“I don’t think it would be cost-effective for me to produce knives using AM but there might be aspects of that which could be married to aspects of what I do. Even if it’s a more traditional metal blade to an additively manufactured grip or handle – I think there is maybe space for both to be married together.”

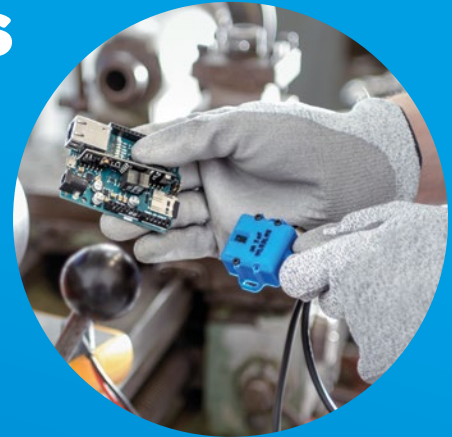
Stuart accessed the expertise and state-of-the-art capabilities at the AMRC and benefitted from a grant-funding scheme run by the AMRC specifically to help small to medium enterprises fund research projects, under the Catapult SME assistance scheme.





# Partnership to explore innovation barriers faced by SMEs

A collaborative research project between the AMRC and Sheffield University Management School (SUMS) is exploring ways to overcome the barriers small and medium sized firms face when adopting new technologies to improve performance and drive innovation.



The University of Sheffield Advanced Manufacturing Research Centre (AMRC) and SUMS are combining their expertise to deepen the understanding around the obstacles SMEs face adopting new technologies, and how businesses can be better supported to overcome those barriers.

The programme is being led by AMRC company engagement manager Shirley Harrison and Tim Vorley, Professor of Entrepreneurship at SUMS. They want to help businesses think about how to practically address the issue of

improving productivity – a key driver behind the government’s Industrial Strategy.

Shirley said: “The AMRC does lots of great work on technology – it is a world leader in the research and development of advanced manufacturing techniques and demonstrates the benefits of these technologies to companies of all sizes – but we also recognise there are lots of obstacles to adoption for SMEs and how they make technology work day-to-day in the business.

“There are many reasons why an SME

may find it difficult. It might be about integrating new technologies with existing systems and processes, it may be about skills or resistance to change.

“We’re working with the Management School to help find solutions to some of these obstacles and the series of projects will look at what the challenges are – aside from the technology itself – which stops SMEs from actually using new technology in the business. We really need to understand that if we want companies to innovate and adopt new technology to improve their competitiveness and performance.”

The collaboration between the AMRC and SUMS builds on Prof Vorley’s work with Innovate UK to think about innovation as being about more than ‘creating new products’. It will also contribute to the existing programme of SME engagement at the AMRC by providing new research insights about the challenges smaller manufacturing businesses are up against.

Prof Vorley said: “There is an opportunity for businesses to think about other ways to create value and grow. This partnership between the AMRC and SUMS is an important step in linking up technical challenges with the managerial and organisational issues many businesses face.

“The AMRC is at the frontier of innovation and wants to advance that and improve the technical elements but there are other elements as well and if you get those right, the social science side, then the more effectively you’re going to advance the innovation.”

**For more information on the projects, or how your business can be involved, contact [s.harrison@amrc.co.uk](mailto:s.harrison@amrc.co.uk)**



**Image above and top:** The AMRC has demonstrated that digitalisation of legacy machines is accessible to the SME community through simple and low-cost sensing and cloud technologies. Initially, for only a few hundred pounds, it is possible to enable Industry 4.0 readiness of any type of machine, irrespective of age.



# Additive manufacturing gives high-tech audio company good vibrations

Engineers have turned up the volume on additive manufacturing to collaborate with a high-tech audio company to develop parts for some of its luxury products.

**A team from the Design and Prototyping Group at the AMRC were approached by local firm Wilson Benesch to use its additive manufacturing (AM) capabilities to realise a selection of new titanium components.**

The choice of components consisted of a tonearm mount for a state-of-the-art record player, fluted cups to go between the shelves and carbon fibre bars on a Hi-Fi rack, and load-bearing steel spheres that sit on the four corners of each section of the rack to isolate the shelves.

Wilson Benesch, a Sheffield-based business owned and directed by Craig Milnes and Christina Milnes, specialises in the manufacture and design of high-end audio loudspeakers, turntables and Hi-Fi furniture built from advanced materials technology, such as carbon fibre composites.

The company, which has worked with the AMRC on a number of developments, recognised the considerable potential for creating highly optimised structures that

benefit from both advanced materials technology and manufacturing processes. Wilson Benesch tasked the Design and Prototyping Group (DPG) with helping to develop improved functionality of the three product parts with the objective of optimising the control of resonant energy in these structures. The net result has been the development of highly functional, but also aesthetically striking components to give Wilson Benesch the edge over its competitors.

Project Engineers from the DPG, Abdul Haque, Luke Hill and Daniel Tomlinson worked on the project alongside project manager Marcus Crossley and James Hunt, Head of Strategy for Near Net Shape Processing at AMRC.

The team were given a clay model of how the company envisioned the tonearm mount could look. They were then able to reverse engineer this by using a CT scanner to create a scan image that was uploaded onto a computer and interpreted to create a new CAD part geometry.

Luke said: "The initial challenge was to

try and work with the complex organic tonearm surfaces that director Craig Milnes wanted based on the clay model. When we created a form Craig was happy with and that we were confident could be manufactured using additive manufacturing processes, we could continue with the detailed design work ensuring the tonearm would fit the Wilson Benesch system requirements. We used the capabilities of selective laser melting AM with Ti-6Al-4V powder to create an internal through channel to feed a wire through the back of the tonearm.

"This is something unique, and as far as performance goes is an ideal solution because Wilson Benesch wanted to create a vacuum within the tonearm. There was a tight tolerance specified between the component and the mounting point, but a wire also needed to be fed through somewhere, so this was a perfect approach. The internal wiring keeps the tonearm aesthetic uninterrupted and organic and the wire is not trailing about so it will not get tangled or spoil the appearance."

AM is a sound choice where there is a high degree of complexity in a part or to add functionality into an assembly – like the tonearm mount. The advanced technology also meant the mount's part count was reduced from 15 down to just two.

The 500g steel spheres were also redeveloped, stripping away material and weight but at the same time improving performance.

Luke said: "When we evaluated the current steel ball design, we realised that it was a smart solution but it wasn't actually particularly weight efficient as far as load transfer goes. After running topology optimisations and structural simulations, it was clear that what we really needed was a cylinder to transmit the energy in the ceiling to floor direction.

"That meant we could strip a lot of weight out and therefore increase the specific performance by using the high-stiffness titanium alloy material more efficiently. Then we added through-channels which have an energy dissipation perspective to them that stripped out further weight."

In terms of efficiency, when compared with conventional machining methods, Luke said AM was a less wasteful option for the complex parts created within the project as it used a very high percentage of the material to create the final part and was more flexible.

He added: "AM brings the flexibility desired by manufacturers because of the ability to quickly and iteratively make design improvements without requiring tooling changes or involving different processes, but simply changing the CAD model and sending it to print on the machine."

The Wilson Benesch project showcases the AMRC's capabilities – working collaboratively from conceptual design through to creating prototype parts and understanding application – which can benefit companies, particularly SMEs.

James said: "A lot of the approaches we have taken here are making the best of AM.

"That's why we were interested in taking up this project because it allowed us to demonstrate a number of processes, techniques and technologies that we are using within AM that could be applied to anything.

"In having the facilities here available for companies and SMEs to come and try,

it allows them to de-risk the activities so they don't have to go and buy a piece of equipment at £500k or they don't have to even go as far as paying someone to make parts for them.

"As can be seen through this process, it's not just a case of sending a drawing and someone printing it off, there is a development cycle that in turn feeds an understanding of how the process works so that the new parts fit the process better. So having that as an available service is of great benefit to companies."

Craig Milnes, design director of Wilson Benesch, said: "James and Marcus, along with the DPG engineers, Abdul, Luke and Daniel have been invaluable in this project, allowing Wilson Benesch to push through design concepts into finished prototype components that extol all of the virtues of the Wilson Benesch brand. That is to say, conceptually unique, technologically and materially advanced, aiding the ultimate goal of advancing the

state-of-the-art in audio design and high fidelity music reproduction."

Christina Milnes, managing director of Wilson Benesch, said: "Wilson Benesch have collaborated consistently with centres of excellence in engineering, design and manufacturing since the foundation of the company. Indeed this is one of a number of projects that we have worked on with the AMRC since the centre was established in 2001. Having access to this kind of technology is a major asset to the Sheffield City Business Region and manufacturing centres that serve it."



# New partners at the AMRC



**ATS Global** is the independent solution provider for smart digital transformation. Since 1986, ATS has been undertaking continuous improvement initiatives and manufacturing IT solution design, deployment and 24/7 support assignments delivering tangible business value to customers world-wide.



**Austin Consultants** offers design, development and build engineering services for test and measurement supervisory control and data acquisition solutions.



**China Railway Hi-Tech Industry Company Ltd**

As a leading manufacturer in the field of infrastructure construction equipment in the world, the main products of CRHIC include railway turnout, bridge steel structure, shield machine, TBM among others.



**Gardner Denver** is a leading global provider of flow control technology, application expertise and support services to a diverse customer base through a family of trusted brands.



**Johnson & Johnson Vision Care Companies UK & Ireland**, is committed to transforming the world's vision. They strive to increase awareness of the importance of vision and vision care and to provide the world's best vision correction choices.



**Multipix Imaging** is a dynamic and energetic company dedicated to distributing top class vision products in the machine vision industry from major manufacturers around the world.



**The Manufacturing Technologies Association**

**The Manufacturing Technologies Association** is the UK's Trade Association for the companies who create and supply the technology that manufacturers use to make the products we use and rely on.



**Shape Technologies Group** is the parent organisation for a growing family of companies that provide manufacturing process solutions across a broad spectrum of industries.



**Pryor Marking Technology**, the trading name of Edward Pryor and Son Ltd, is a world leader in the manufacture and design of both traditional and innovative marking, identification and traceability solutions.

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