

quarterly journal

Issue 06 amrc.co.uk



Advanced Manufacturing
Research Centre



Boxing clever:

Smart technology delivers SME productivity gains

Boeing supplier of the year

Second Boeing 'Supplier of the Year' accolade for the AMRC

THREAD

AMRC develops 'game-changing' hybrid 3D printing process

Digital Construction

AMRC applies a digital manufacturing approach to the construction industry



Advanced Manufacturing
Research Centre



Welcome to our quarterly journal



From global trailblazers to family companies, collaborating with the AMRC creates competitive advantages

One of the strengths of the AMRC is our work with new and emerging technologies and how they can be developed to create real competitive advantages for the businesses we work with.

In this issue of the AMRC Quarterly Journal you can read about how our Integrated Manufacturing Group (IMG) is applying this strength to engage regional SMEs.

IMG is developing a new research cell at Factory 2050, dedicated entirely to small businesses, which will allow them to work with our engineers in trialling new technologies and processes before putting them into production (page 18).

This de-risking of investments is not only vital for SMEs, but also to major global businesses such as Laing O'Rourke.

Laing O'Rourke has been collaborating with the AMRC to de-risk key investments in emerging digital technologies to drive performance, quality and productivity. On page 20 you will see how we are using technology to create real gains on the shop floor with minimal lead times and investment.

We have also recently celebrated the new membership of Doncaster-based Polypipe, who became the 100th member of the AMRC with Boeing. We are delighted the honour of this significant milestone went to a locally owned business.

Collaborating with Polypipe will allow the exploration of options for the horizontal integration of production processes. This will allow Polypipe to satisfy future demand and ensure the continued success of its Doncaster base, where a third of their 3000 global staff are employed.

Recently the AMRC has exported its world-leading research model all the way to Oman, where we are working with our peers at Sohar University to develop

their own AMRC, known in-country as Intaj-Suhar.

Intaj-Suhar will be the anchor for an industrial hub developing advanced manufacturing techniques, technologies and processes that will assist in the diversification of Oman's economy and attract foreign investment, replicating the success of the AMRC in the UK.

This issue also celebrates a number of awards. We had the pleasure of being awarded Boeing's Supplier of the Year for 2017. This is the second time The Boeing Company has awarded the AMRC this accolade and it is a tribute to the work of our engineers, read more on page 8.

Alongside this, IMG has been honoured with three separate awards from BAE Systems (page 10). The awards recognise the impact of a project which has matured into a full production system; one that will help BAE Systems achieve its affordability targets over coming years.

Lastly I leave you with coverage of our annual AMRC Training Centre's Apprentice of the Year awards. This event is the highlight of the year for the Training Centre and a fantastic celebration of the achievements of our talented apprentices who will become the next generation of UK engineers.

This year the award went to Leigh Worsdale, the first time it was awarded to one of our female apprentices, read about her achievement on page 14.

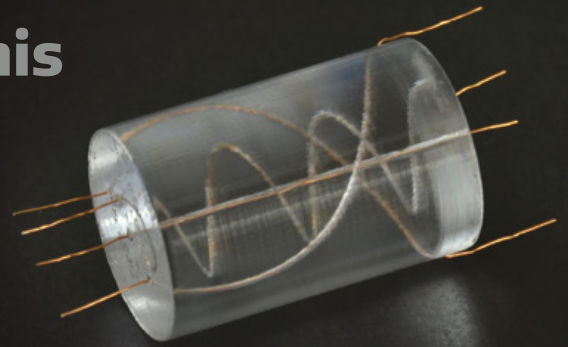
Prof Keith Ridgway, CBE.

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



“ The development of this process is a potential game-changer ”

AMRC Development Engineer and AM specialist,
Mark Cocking [page 17](#)



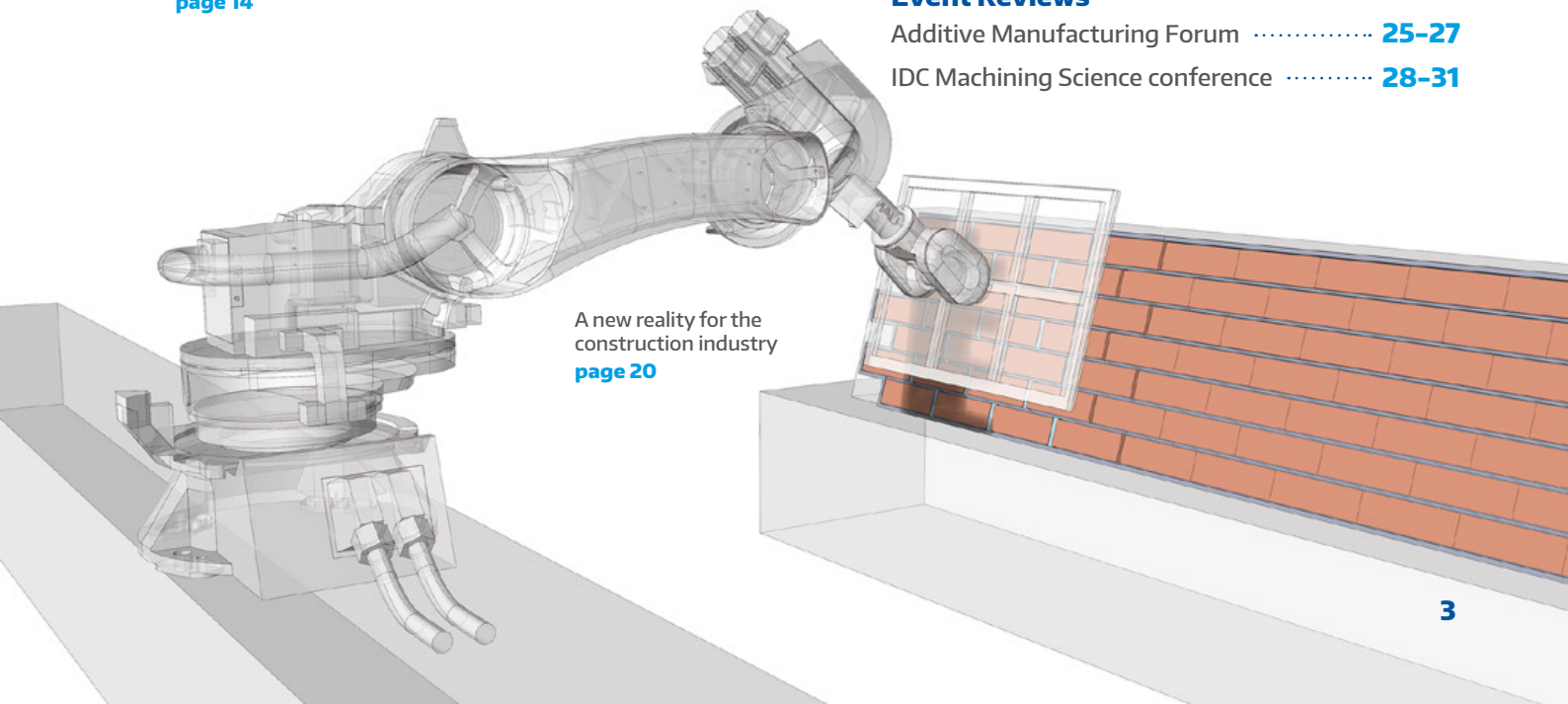
SME collaborates with the AMRC to develop low-cost robotic manufacturing solution [page 19](#)



AMRC Training Centre apprentice Leigh Worsdale wins 'Apprentice of the Year' award [page 14](#)

contents

- Partner News** [4-7](#)
- AMRC News** [8-11](#)
- Commentary**
 - New apprenticeship levy will help raise the profile of apprenticeship training [13](#)
- Features**
 - AMRC composites experts help luxury car maker to reduce weight [12](#)
 - AMRC Training Centre apprentice awards [14-15](#)
 - House of Commons visit for AMRC apprentices [16](#)
 - AMRC invents game-changing hybrid 3D printing process [17](#)
 - Access to world-class facilities at AMRC Factory 2050 made easier for SMEs [18](#)
 - SME collaborates with the AMRC to develop low-cost robotic manufacturing solution [19](#)
 - A new reality for the construction industry [20-22](#)
- Case Studies** [23-24](#)
- Event Reviews**
 - Additive Manufacturing Forum [25-27](#)
 - IDC Machining Science conference [28-31](#)



A new reality for the construction industry [page 20](#)

South Yorkshire company Polypipe become the 100th member of the AMRC



Doncaster-based company Polypipe have become the 100th member of the AMRC with Boeing.

The company which was founded in Doncaster in 1980 has grown to employ over 3000 staff globally. It enjoys a market-leading reputation for manufacturing a wide range of plumbing, drainage and ventilation systems for residential, commercial and civil infrastructure and construction.

Polypipe's membership of the AMRC will allow it to continue to develop autonomous manufacturing methods that will support the company's expansion into new markets and sectors.

The development of the AMRC's Factory 2050 - the UK's first research facility entirely dedicated to collaborative research into reconfigurable digital assembly and flexible component

manufacturing - was a big draw for the company.

Polypipe Managing Director, Cameron McLellan said working with the team based at Factory 2050, the AMRC's Integrated Manufacturing Group, will allow Polypipe to expand its support for the construction industry through its network of industrial partnerships:

"Their expertise in automation, augmented reality and collaborative robotics will provide opportunities for us to explore the horizontal integration of our production processes and how we can satisfy future demand for high-customisation of products; all whilst retaining the high-repeatability of manufacturing processes we currently achieve."

The AMRC has enjoyed a recent flurry of companies eager to join as members, with Polypipe bringing the total for 2017 so far to 22 new members. Polypipe has now become a member of a group of 100 global companies, enjoying access to world-leading high-value advanced manufacturing research and state of the art capabilities at the AMRC.

Professor Keith Ridgway, Executive Dean of the AMRC, said: "It is fantastic that our one hundredth member is a local company. The aim of the AMRC has always been to help the regeneration of this region so it is particularly pleasing to see a company such as Polypipe working with us to develop new manufacturing techniques and train the workforce of tomorrow."

Alicona launch the Compact Cobot Measuring System

Alicona have launched a portable compact cobot 3D measuring system for multipurpose use.

Based on a collaborative robot with an Alicona R25 sensor head, the system can be used for the measurement of surface finish, edge break, valve seats and edge radii on a wide range of products; especially on large objects or for entry into machining centres.

Being portable the system can be moved to a position to measure large components, such as engine housings, disks, blisks in the aircraft industry and cylinder heads and engine blocks in

the automotive industries. It can also be used for cutting tool measurement for wear studies and edge condition. The system can be used manually or programmed to do defined automatic measurements.

Measurement capabilities (depending on optical magnification) include height steps down to 20nm, height range up to 16mm, Ra values down to 0,08µm and software is included for surface finish and profilometry.



The Alicona Portable Compact Cobot 3D Measuring System.



Strathclyde's AFRC to oversee new £8.9 million Lightweight Manufacturing Centre

The University of Strathclyde's Advanced Forming Research Centre (AFRC) will run the Scottish Government's new £8.9 million Lightweight Manufacturing Centre.

The specialist centre will develop new manufacturing processes for lightweight materials such as titanium and carbon fibre and will be the first step towards creating a National Manufacturing Institute for Scotland.

The centre will support highly-skilled jobs and help place Scotland at the forefront of lightweight manufacturing.

Making the announcement in front of over 130 aerospace industry representatives at a supply chain seminar held at the AFRC on Monday 19 June, First Minister Nicola Sturgeon said: "The Lightweight Manufacturing Centre will help Scottish businesses take advantage of the fact that sectors such as aerospace and the automotive industry are making more and more use of lightweight materials. It will deliver cutting edge research and development projects with and for companies in Scotland."

The National Manufacturing Institute for Scotland will equip manufacturers to compete in future international markets and support the transformation



FM Nicola Sturgeon meeting with AFRC staff members.

of Scotland's manufacturing industry in terms of innovation and digital opportunities, creating sustainable, high-value and highly skilled jobs.

Executive Chairman of the AFRC, Professor Keith Ridgway, said: "We are delighted to be in a position to be able to use the capability and knowledge here at the AFRC and within the wider Strathclyde community to drive the development of the Lightweight Manufacturing Centre alongside the Scottish Government and Scottish Enterprise.

"Since opening in 2009 the AFRC has developed a track-record for world-class research and innovation in manufacturing and materials science, working with companies from across the manufacturing sector. We are very much at the heart of the manufacturing research and development in Scotland and look forward to helping more companies, big and small, boost their competitiveness and strengthen their businesses through the Lightweight Manufacturing Centre."

Delta Sigma develops an augmented reality display for live metrology data

More and more, the value of making in-process measurements to ensure first-time quality is becoming evident as the practitioners of these rapid verification techniques are reducing time on the production line and adding profits to the bottom line.

A recent addition to this measurement capability is Delta Sigma's ability to provide an instantaneous augmented reality (AR) view of the data from almost any metrology software. For some

years now, people have collected data with a CMM, laser tracker, scanner arm, laser radar, ultrasonic scanner, x-ray, or other device and then viewed the data on their computer screen. When the results are all in tolerance, all is well, but when remedial action must be taken, the difficulty in determining the exact location of the trouble spot on the assembly while looking at a computer screen can sometimes be problematic. With an AR view, the measurement information is superimposed directly on

the part (physical reality is augmented with virtual reality). The person responsible for taking the corrective action can see precisely where to work and what is to be done. Sub-surface measurements from devices like an ultrasonic scanner or x-ray are presented in a way that makes surface penetrations much more reliably positioned.

The system can also be used for part presence, placement, and orientation as well as FOD detection.

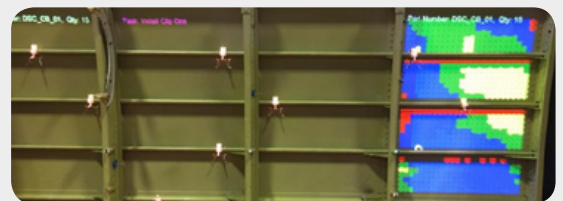


Image above: Delta Sigma's augmented reality display for live metrology data superimposes measurement information directly onto a part.



MetLase joins the AMRC to develop the fixtures of the future

MetLase, a joint venture between Rolls-Royce and Unipart Group, has become the latest member of the AMRC, bringing its world leading technology to the partnership.

The company has joined AMRC following a recent collaboration in which it developed a set of 14 fixtures for the assembly of complex parts.

Since its formation in 2015, MetLase has doubled in size and is growing rapidly. Using highly skilled and creative engineers, MetLase is able to deliver engineering solutions to complex issues by using high precision laser-cutting technology, combined with patented assembly and joining systems.

MetLase will work as a partner with the Integrated Manufacturing Group (IMG)

at the AMRC's Factory 2050 facility, drawing on its skills and modular fixturing to develop "smart enabled tooling".

IMG Theme Lead in Automated Assembly, James Illingworth, said: "Developing "smart" fixturing, or fixturing that is intelligent by using sensors to collect data, provides valuable benefits for in-process control and monitoring, and improvements in part quality. The data collected can be used in real-time for process adjustment or later in the manufacturing process for review."

Managing Director of MetLase, Steve Dunn said: "We are pleased to join the AMRC, which has a global reputation as a centre of excellence for manufacturing



Managing Director of MetLase, Steve Dunn at AMRC Factory 2050 with IMG Theme Lead in Automated Assembly, James Illingworth.

research and innovative engineering. As partners of the Integrated Manufacturing Group, we can combine our expertise to develop our fixtures to interact with autonomous technologies such as those involved with robotic assembly."

MetLase supports Sheffield University's Formula Student Racing team

MetLase is supporting the University of Sheffield's Formula Student racing team to help with their aspiration to be one of the top 10 UK teams in the competition.

The race is the world's largest student engineering competition, run by the Institution of Mechanical Engineers and provides a development platform for aspiring young talent.

MetLase, which is based at the Advanced Manufacturing Park in Sheffield, has supported the students by showing them how to use their patented technology to build the tools to develop the vehicle.

By working with MetLase, the students

were able to learn new engineering skills and put together a chassis with speed and to accuracy normally only seen in the aerospace sector.

Fourth year Mechanical Engineering Student - Team Principal, Isabel Brown said: "We really want to be one of the top 10 UK teams in the Formula Student Race this year, so we have placed a major focus on designing and ensuring parts are manufactured right first time. Our partnership with MetLase this year has been a significant help towards this as it has enabled us to manufacture the chassis within extremely tight tolerances to the design. This has not only allowed us to assemble the car in record time

it has also improved handling of the vehicle."

Managing Director of MetLase, Steve Dunn said: "The event is a fantastic opportunity for students to get hands-on experience of engineering in the real-world and it also gives UK engineering a chance to nurture talent and get industry ready graduates to work in our companies."

The Sheffield University team will be up against 128 universities from 25 countries and takes place at Silverstone on 21 July 2017. The teams will be judged on a number of factors including design, build and race time.

The car out on the race track.





Sandvik Coromant unveils the biggest innovation in turning... since turning

Sandvik Coromant has unveiled a revolutionary new turning concept that offers improved machining flexibility and the potential for significant productivity gains. The PrimeTurning™ methodology and supporting tools provide manufacturers, particularly in aerospace and automotive sectors, with the industry's first true 'all directional turning' solution.

Unlike conventional turning operations – which have remained largely unchanged for decades – PrimeTurning allows machine shops to complete longitudinal (forward and back), facing and profiling operations with a single tool. The methodology is based on the tool entering the component at

the chuck and removing material as it travels towards the end of the component. This allows for the application of a small entering angle, higher lead angle and the possibility of machining with higher cutting parameters. Furthermore, conventional turning (from part-end to chuck) can be performed using the same tools.

Some applications could see productivity increases in excess of 50 per cent through the deployment of PrimeTurning rather than conventional techniques. Some of these improvements are due to the small entering angle and higher lead angle, which creates thinner, wider chips that



spread the load and heat away from the nose radius. The result is both increased cutting data and extended tool life. In addition, as cutting is performed in the direction moving away from the shoulder, there is no danger of chip jamming. Higher machine utilisation due to reduced set-up time and fewer production stops for tool changes also enhances overall productivity.

Images above: New tools from Sandvik Coromant enable turning in all directions for the first time.

Evenort Ltd acquire Alexander Comley



Evenort Ltd, the Sheffield based precision engineering company announced it has acquired Alexander Comley, the almost 100 year-old, midlands based manufacturer of large flanged products. The purchase will better serve the existing customer base across the UK and internationally by allowing the newly formed group to offer a single source for all products.

In recent years Evenort's continued success culminated with CEO Craig McKay installed as Sheffield's 2015-2016, Master Cutler. Sheffield has a long held tradition for metallurgy and steel making, with the Cutler Company founded in 1624. At 45, Mr. McKay was one of the youngest to hold such an illustrious posting, representing the City's wider technology and manufacturing interests.

Alexander Comley's diversification into tubesheets for heat exchanges, filter plates for the filtration/separation industries with £500,000 investments in machinery provides a synergy for both companies that mean they are similar, yet different enough to complement one another.

Evenort CEO, Craig McKay commented: "Continuing the values on which Evenort



is ran, the opportunity to acquire such a historic name from the British steel industry is one we feel will be of benefit to both existing and future customers. Alexander Comley and Evenort will, over the coming months, form a group which will continue to evolve the "can do – will do" approach our customers have come to expect. Very exciting times lie ahead for us all."



All the winners from the 2017 Boeing Supplier of the Year Awards, Professor Keith Ridgway, Commercial Director Adrian Allen and Projects Director John Baragwanath, fourth, fifth and sixth from right, front row.

AMRC named Boeing Supplier of the Year at global awards ceremony

The AMRC received international recognition for its outstanding research and development as it was named a Supplier of the Year by The Boeing Company at an awards ceremony in the USA.

The AMRC, which was co-founded with Boeing 16 years ago, was honoured in the Innovation category of the company's annual Supplier of the Year awards in April of this year, acknowledging its instrumental role in the introduction of new products that meet Boeing's current and future business needs.

The AMRC was honoured alongside 12 other companies at an awards ceremony in Dallas, Texas, which recognised the distinguished performance of the winners and the value they create amongst Boeing's thousands of suppliers from around the world.

The AMRC has a global reputation as a centre of excellence for manufacturing research and leading the way in innovative engineering. This award is a testament to the strong performance of the AMRC and its long-standing collaboration with Boeing.

It is the second time the AMRC has received global recognition from Boeing since becoming the first British company to win the accolade in the

International (Technology) category in 2011. That award celebrated the AMRC's role in allowing Boeing to exceed the expectations of its customers by developing new technologies and processes for machining high-performance metal alloys used in aerospace.

Executive Dean of the AMRC, Professor Keith Ridgway said: "It is a great honour for the AMRC to be recognised for a second time under Boeing's Supplier of the Year Award scheme.

"The award is a tribute to the hard work and talent of the AMRC engineers who develop and introduce the manufacturing technologies and processes that keep companies like Boeing – and the UK manufacturing sector – competitive in a global market."

President and Vice-Chancellor of the University of Sheffield, Professor Sir Keith Burnett added: "It is a great honour for the University of Sheffield AMRC with Boeing to once again be named Boeing Supplier of the Year.

"We are deeply proud of the vision

and talent of our engineers who have a global reputation for advanced manufacturing research which works directly with industry in ways which transform business, create jobs and strengthen our economy.

"It is increasingly clear that what has been achieved here in Sheffield and Rotherham is unique, not only in the UK but globally. This work was the reason Boeing decided to open its first production facility in Europe to work with us and we will be working with the company in the US too, creating wealth and opportunity in both nations.

"Truly it is an inspirational partnership going from strength to strength."

Boeing's Leader for Enterprise Supplier Management, Kent Fisher, said:

"Boeing's success is a testament to the partnerships we hold with the finest aerospace suppliers in the world such as the AMRC. Together we will continue to deliver affordable, technologically advanced products and services that give our customers a competitive edge."



AMRC role model for Oman

One of the world's leading oil and gas exporters is working closely with the AMRC to establish its own version of the research centre in a bid to diversify its economy and attract major foreign investment.

AMRC Oman, known in-country as Intaj-Suhar, will be the first of its kind in the Gulf and is a clear example of how the collaborative approach pioneered by the University of Sheffield is being seen across the world as a role model for harnessing the power of engineering research to drive high value manufacturing and improve productivity.

Over the last two years, senior figures in Sohar University, Oman's first private university, have been working closely with their counterparts at the AMRC in the UK to develop the "clustering of university research with industrial design and production."

The project will be developed in two phases. The first phase will focus on "advanced manufacturing" to support industrial innovations and "manufacturing tools" to support SMEs and introducing new products. While Phase two is expected to be developed by private sector investments and will represent an added industrial hub to the region.

His Excellency Engineer Ahmed Al-Dheeb, the Undersecretary of the Ministry of Commerce and Industry in Oman, said the project will establish a manufacturing research centre of excellence to drive industrial innovation to help Oman build a more diversified economy.

Vice Chancellor of Sohar University, Professor Barry Winn, who is also the Chair of the project steering committee, said. "Our vision is to support the development of the manufacturing sector and enable provision of technology capability in advanced manufacturing through world-class facilities in design, machining, prototyping and proving pre-production.

Director of Research and Industry Collaboration at Sohar University, Professor Ghassan al Kindi said: "We believe the new centre, which opens next year, will also stimulate foreign direct investment by international manufacturers and support the downstream development of high-technology, small and medium enterprises that produce high value products under the 'Designed and Made in Oman' brand."

AMRC Executive Director, John Baragwanath, paid tribute to the Omani government and the team at Sohar University for having the vision and drive to create a world-class centre focused on high-value added manufacturing. "It has been a privilege to work with Oman in this remarkable venture," he said.

AMRC Oman will focus on advanced machining, specialist assembly, material development, optimised design, rapid prototyping and engineering testing. It will draw these together to support the strategic development in the supply chains of the aluminum, steel, composites and polymer industries.

"As the originators of the AMRC model we have been able to show them how world-class research can help manufacturers of any size add value to their business by introducing advanced techniques, technologies and processes. What we are doing chimes perfectly with Suhar's vision of helping Oman become 'a knowledge nation.'"

Professor Winn said: "It has been great working with John and his team at the AMRC. We have learned so much from them.

Like the AMRC in South Yorkshire, the Oman model will also provide an advanced apprentice training facility and a hub for the delivery of improved manufacturing engineering training programmes up to PhD. "Oman is keen to develop the technological skills that are essential to diversification."





HRH Duke of York opens Factory 2050

HRH The Duke of York has visited the Sheffield City Region to officially open Factory 2050 at the AMRC.

Factory 2050 is the UK's first state of the art factory entirely dedicated to conducting collaborative research into reconfigurable digitally assisted assembly, component manufacturing and machining technologies.

As part of his visit on 10 April 2017, The Duke of York unveiled a plaque commemorating the opening and was given a tour of the factory by the Head of the AMRC's Integrated Manufacturing Group, Ben Morgan.

Executive Dean of the AMRC, Professor Keith Ridgway, said: "Factory 2050 is an important part in the future

development of the AMRC which is hugely significant for both the Sheffield City Region and the UK.

"It will keep us at the forefront of manufacturing technology and is a beacon for the region - hopefully attracting young people to careers in manufacturing.

"It is an absolute honour to welcome HRH The Duke of York to officially open this exceptional facility."

During his visit, HRH The Duke of York said: "The AMRC is a very important part of the UK's industrial landscape. It has developed over the last 15-20 years from a gleam in the eye and is now at



the forefront of research in a whole range of areas.

"I would like to congratulate everyone who has done such a lot to build what is a world-class establishment doing some fantastic research. I've watched the AMRC grow over the years - I've even opened one or two of its buildings - so it's a great pleasure to be officially opening Factory 2050."

Multiple awards for AMRC project that saved BAE Systems millions of pounds

The AMRC has been presented with a national award from BAE Systems to recognise the impact of a project that matured into a full production system, and is on track to help the company achieve its affordability targets over the coming years.

The project 'Robotic Countersinking, The Future Today', involved the development and implementation of an automated production system enabling robotic countersinking technology to accurately machine holes in composite aircraft components.

The project was awarded a BAE Systems 'Business Leader Award' in 2016 and thanks to its success, has now also been presented with an 'Executive Committee Award'; a national award under the BAE Systems Chairman's Awards Scheme.

The prestigious scheme recognises excellence and acknowledges the efforts and achievements of employees, partners and customers in delivering benchmark performance for BAE Systems.

Head of the AMRC's Integrated Manufacturing Group (IMG), Ben Morgan, said: "The system is installed at BAE Systems in the UK, where it is being used to process a wide range of composite components for military aircraft, saving the company millions of pounds in capital and operational costs over the coming years.

"These awards are fantastic recognition of the research IMG conducts into developing robotic machining processes; by upgrading our robotic machining capabilities and harnessing the benefits of industry 4.0 technologies to mature new digital manufacturing techniques."

Assembly & Systems Technology Lead for Manufacturing Technology at BAE Systems, Austin Cook, said: "Winning both the Business Leader and Executive Committee awards for the robotic countersinking technology reflects the outstanding efforts made by the entire collaborative team. This technology sets a new benchmark for BAE Systems

manufacturing capability and the expertise within the AMRC was core to delivering this to production."



Austin Cook from BAE Systems (right) presents Ben Morgan (left) with a commemorative plaque celebrating the BAE Systems Executive Committee Award.



AMRC and Sheffield Digital announce partnership to boost links between digital and manufacturing

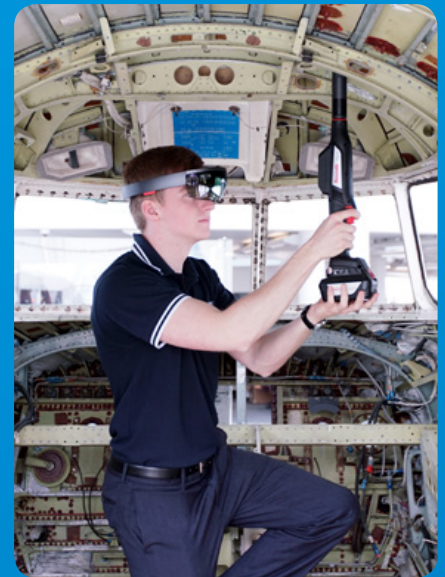
The AMRC is the latest organisation to become a regional partner of digital industries organisation Sheffield Digital.

The partnership will enable the AMRC to work with Sheffield Digital on activities that will help to bring the region's advanced manufacturing and digital businesses closer together. Over the coming months, Sheffield Digital will be collaborating with the AMRC to create opportunities for digital and manufacturing companies to meet, share information, identify challenges and collaborate on solutions.

The AMRC's Head of Digital, Rab Scott, explains, "We want to be the place where people come to see and interact with the technology, explore the pros

and cons and understand where to invest in order to achieve value. The Fourth Industrial Revolution (aka Industry 4.0) is being driven by digital technology, so it makes absolute sense to build closer links between local digital companies and the region's manufacturers. The digital sector needs to know about the needs of manufacturing and manufacturers need to understand the capabilities of digital technologies. The AMRC is the obvious place to bring people together to learn and collaborate and Sheffield Digital is the right partner to help us make that happen."

Mel Kanarek, one of the directors and founders of Sheffield Digital, adds, "We're delighted to have this



relationship with the AMRC in place. Sheffield Digital's community includes many digital businesses that have the ideas and skills that manufacturing needs. This partnership will help feed that expertise into the supply chain and increase opportunities for innovation and the development of new businesses."

Technical Lead at the AMRC Composite Centre named as Membership Director at Composites UK

Clara Frias, technical lead for the Composite Centre of the AMRC, has been named as the Membership Director of Composites UK.

Composites UK are a non-profit trade association for the composites industry in the UK, with over 300 members including the AMRC.

The association encourages continuous growth and development of the composites industry, promoting the best practice use of composites materials, so that UK industry can fully participate in the increasingly competitive world of global composite production.

Its role is to bring companies throughout the supply chain together creating partnerships and drive the industry forward, benefiting all of those involved.

Clara will serve a two-year term as a Director of Composites UK after being elected by Composites UK members at their Annual General Meeting.



Clara Frias (third from left) with the Board of Directors, who meet quarterly to plan the actions and direction of the work of the association.

The Board consists of 11 Directors who meet quarterly to plan the actions and direction of the work of the association. She said: "I look forward to working for the association to assess the validity of new technologies through collaborative trade studies, identifying supply chains through national hubs and creating new opportunities for members within the

composites industry. "Being a member of Composites UK, the association supports the AMRC with networking opportunities to create research partnerships, supporting SME engagement and further exposing Composites UK members to the work of the AMRC."



AMRC composites experts help luxury car maker to reduce weight

The Composite Centre at the AMRC is installing a unique, high pressure press as part of a project to help luxury car manufacturer Bentley reduce weight and greenhouse gas emissions.

The AMRC is working with Bentley, Sigmatec, Expert Tooling & Automation, Granta Design, Cranfield University and Wakefield-based production equipment specialist Group Rhodes as part of the Lightweighting Excellence (LX) programme, backed by the Government's Advanced Manufacturing Supply Chain Initiative.

Today, industry uses simple 'preforms' of composite material which are impregnated with polymer resin and cured to create composite material. These preforms are designed for low tack-time and production speed, but the resulting part uses more material than necessary structurally.

In order to capitalise on weight-savings offered by carbon fibre reinforced plastic (CFRP), the process strategy must be redefined. The project will look at the

precision and tailored production of the preform material to achieve reductions in weight of component by up to 20 per cent.

This project seeks to find the middle-ground between automotive and aerospace, where the need for customisation meets high volume production, by the integration of flexible, automated material and manufacturing processes.

The AMRC will turn the optimised preforms of composite material into finished components in a new composite press. The press is currently being installed adjacent to the AMRC's Factory 2050 facility on Sheffield Business Park, with production set to begin in 2017.

As part of the LX programme, the press will be completed by the development of an automated robotic cell by the AMRC and Expert Tooling & Automation. The cell will be used alongside the press for

further industrial research into carbon fibre weaving and robotic placement technology used to make the preforms of composite material.

The press will be a world first in terms of its size, capabilities and the level of monitoring and control it will provide the AMRC Composite Centre. It stands at six metres high by seven metres wide, allowing it to make several components at a time and could take no more than five minutes to produce a finished component, using a process known as High Pressure Resin Transfer Moulding – or HP-RTM.

"This will be a unique facility that will improve our capabilities and also benefit the UK," said Clara Frias, who is heading the project at the AMRC.

"The technology will allow us to collect data to optimise the most appropriate preforming technologies, scaling them up for industrial use and allowing programme partners to share benchmarking data with the automotive sector and wider industries."

For more information about the Lightweighting Excellence Programme, visit: www.sigmatec.com/lx/

Members of the LX programme including the AMRC Composite Centre, Sigmatec, Expert Tooling & Automation, Granta Design, Cranfield University, Engenuity, LMAT, Surface Generation and Liberty Advanced Composites visit the construction site of the composite press.



New apprenticeship levy will help raise the profile of apprenticeship training

Following the introduction of the apprenticeship levy in April of this year, apprentices are a hot topic.

Kerry Thompson, Director of Training at the AMRC Training Centre.

The Government wants to create three million new apprenticeships by 2020 and so to ensure investment in training, they are introducing a new way of paying for it. Large companies now have to pay 0.5 per cent of their annual bill which will be ring-fenced for training.

I believe this is a positive move. For too long this country has not held apprenticeships in high enough regard, and they have not been given the profile they deserve.

One of the huge benefits of the apprenticeship levy is that it has removed age restrictions away from funding of apprenticeships. Business can now use the levy for training purposes among employees at all ages and all levels of the organisation.

The levy provides businesses an opportunity to look at their current workforce and look at how they can upskill employees to benefit the company and even diversify into new areas. If used in line with organisation resource planning, I think the apprenticeship levy can create capacity for companies to grow.

Companies paying-in receive the money back in the form of apprenticeship training, along with a

10 per cent "top-up" bonus from the government, and I do think there will be a feeling from firms that if they are paying in, they may as well get something out of it.

But the quality of the training has to be right. The University of Sheffield is an approved apprenticeship training provider and we hope to work with organisations to offer training and skills in areas to address skills shortages and make it an opportunity for economic growth in the region.

We already provide highly skilled training for apprenticeships at our AMRC Training Centre where we have some of the brightest, talented young people from across the Sheffield City Region employed by local businesses.

They are learning the engineering skills for the future in partnership with industry, where many areas are suffering from an ageing workforce and are facing a skills shortage. By providing a new highly skilled workforce, we can help boost the region's economy.

Apprenticeships can also mean better staff retention for businesses. 90 per cent of apprentices remain employed after completion of their apprenticeship and

a quarter go on to be promoted within their first year.

For young people, as well as increasing employability, an apprenticeship increases earning power. Individuals with an advanced or degree apprenticeship will also earn more over their lifetime than those who have similar level qualification.

It is four years since our training centre first opened its doors and welcomed our first cohort of apprentices. We now have delivered training to more than 810 young people and as they progress to the next level, we are providing it, with routes through to a degree, and will be developing masters and even PhD qualifications.

It is vital that as a Russell Group University we are offering these alternative routes to a successful career in engineering. And I think the levy will only help strengthen the message of the benefit of an apprenticeship.

Apprenticeship Levy at a glance

The levy came into force on 6 April 2017.

All employers in England with a pay bill over £3 million per year pay 0.5 per cent of its annual bill to help fund investment in apprenticeships.

The government applies a 10 per cent top-up to the funds for spending on apprenticeship training in England.

The new tax aims to fund three million new apprenticeships in England by 2020.





AMRC Training Centre apprentice Leigh Worsdale wins 'Apprentice of the Year' award

Eighteen-year-old Leigh Worsdale became the first female apprentice to win the 'Apprentice of the Year' award supported by Boeing at the AMRC Training Centre's 'Apprentice of the Year' awards held at the University of Sheffield in March this year.

Leigh, who works as an apprentice Heavy Duty Diesel Engine Builder for Foxwood Diesel in Chesterfield, was awarded a trip to Boeing's factory in Washington State, outside Seattle to see first-hand how the global aerospace company designs, tests and builds its 737 aircraft.

The Apprentice of the Year award, uses nominations from apprentice employers and trainers and is judged

by a panel of members of the AMRC Training Centre staff and award sponsors.

Judges were 'overwhelmingly' impressed by Leigh's confidence and spoke about how she continuously seeks ways to improve her workplace and its processes. Leigh has been responsible for introducing a number of incentives at Foxwood Diesel that have helped to improve the business. Speaking at the awards, she said: "I'm shocked to win but it's amazing and the prize is so good!"

Foxwood Diesel Managing Director, Ken Worsdale said she was enthusiastic, dedicated to the company and well in advance of her training plan.

Leigh, who is from Chesterfield, applied for an apprenticeship after her GCSEs because she wanted to gain experience while getting paid. She was inspired by the facilities at the AMRC Training Centre after attending one of the centre's open days with her school.

She was awarded an apprenticeship under the Close Brothers SME Apprentice Programme, which contributes to the cost of apprentices to help SMEs recruit and train a new generation of advanced engineers.

Leigh said her highlights from the Training Centre were meeting new people with the same interests and learning about maintenance and the tech support in engineering.

Other winners at the AMRC Training Centre Apprentice of the Year Awards were:

**Fabrication and Welding
Apprentice of the Year –
Joshua Foxton** of ACS Stainless
Sponsored by Sheffield International Venues

**Maintenance Apprentice of the
Year – Joshua Corton** of Printaply
Sponsored by Hexagon Manufacturing Intelligence

**Machining Apprentice of the Year –
Ben Middleton** of Polypipe
Sponsored by Sandvick Coromant

**Technical Support Apprentice of the
Year – James Buddle** of Carrs Silver
Sponsored by Close Brothers

**Academic Achiever of the Year –
Dylan Shaw** of Ancon
Sponsored by Barnsley College

**Higher Achiever Apprentice of
the Year – Sam Ferguson** of Evenort
Sponsored by The University of Sheffield

**First Year Apprentice of the Year –
Leigh Worsdale** of Foxwood Diesel,
highly commended **Sam Johnson** of
Vulcan Engineering
Sponsored by the AMRC with Boeing

Mentor of the Year – as voted by the
AMRC Training Centre apprentices,
John Dobinson.
Sponsored by the Apprentice Employment Agency

Special recognition awards
(sponsored by the Manufacturing Technologies
Association, Huvema and Close Brothers)
were also given to **Cosmin Dragan**,
a plastic fabricator at Rotherham
Industrial Plastics, **Adrian Salatowski**
from Hallam Castings and Rolls Royce
apprentice **Alexandra Smith.**



Director of AMRC Training Centre, Kerry Thompson, said: "This is a significant event in the AMRC Training Centre calendar. Our job on the judging panel was not easy, they have all done such a wonderful job. All the nominees were a credit to themselves and their organisations during the presentations."

Professor Sir Keith Burnett, President and Vice-Chancellor of the University of Sheffield, said: "My warmest congratulations to Leigh for her milestone and well-deserved success. I am extremely proud of the achievements of our talented apprentices and of those who train and mentor them at our AMRC Training Centre."

"The UK desperately needs skilled engineers to help boost productivity and growth in our economy and our apprentices really are the future of skilled manufacturing workers, and of course this crucially includes our talented women engineers."

"The numbers of young people choosing an apprenticeship are increasing but we need to do much more to ensure these are of the very highest quality and so change the stigma around these qualifications."

"Our apprentices are an important part of our University and prized to the companies who sponsor and employ them. They are a magnet to inward investors seeking skills and a crucial

part of the U.K's future economy. We are delighted that in Sheffield, our University has seen and invested in the highest quality education of all kinds. We are providing opportunities for future development of degree apprentices, postgraduate apprentices and even routes to PhDs. We will not limit talent in any form."



House of Commons visit for the University of Sheffield's AMRC apprentices

Apprentices from the AMRC and Nuclear AMRC were invited to the Houses of Commons (Wednesday 21 June 2017) to celebrate the two centres' work bridging the gap between innovation in industry and academia.

The event, organised by the High Value Manufacturing Catapult (HVM Catapult), showcased the University of Sheffield's impressive growth and performance of working with industry.

Open to all MPs, the reception also highlighted how Catapult organisations like the AMRC and Nuclear AMRC are helping to shape the UK manufacturing innovation landscape that will deliver the UK's Industrial Strategy.

This year's AMRC Training Centre 'Apprentice of the Year' winner, Leigh Worsdale, McLaren apprentice Ian Hutchinson and Nuclear AMRC apprentice Jordan Wagstaff attended the event. They were joined by AMRC's Chief Executive Officer, Colin Sirett, Head of Digital for the AMRC, Professor Rab Scott, Nuclear AMRC Business Development Director, Jay Shaw, and Events Manager Jo Byron.

A number of technical demonstrations and exhibitions were on display from the AMRC and Nuclear AMRC including: a VR model of a new nuclear power plant, showing potential UK contribution; a 3D-printed model of the Westinghouse Small Modular Reactor; metal composite hybrid anti-roll bars for trucks and trains designed to reduce fuel costs and emissions and orthopaedic screws, created for use in surgical procedures such as cruciate ligament surgery.



The AMRC Training Centre's, McLaren apprentice, Ian Hutchinson demonstrates the capabilities of augmented reality at the event.

Lord Prior of Brampton, Parliamentary Under-Secretary of State for the Department for Business Energy and Industrial Strategy was guest speaker at the event. MPs were given the opportunity to view the technology exhibits and speak to apprentices and businesses working with the Catapult. The HVM Catapult combines the strength of seven existing centres – including the AMRC and Nuclear AMRC – across key manufacturing processes. The Catapult enables innovation to cut across sectors by bringing together businesses from diverse industries and giving access to a pool of world-class expertise, equipment and processes invested and supported by UK government. The HVM Catapult worked with more than 3,300 business customers in 2016-2017 and trained more than 860 engineering apprentices.

Major investments like McLaren Automotive's plans to open a new Composites Technology Centre next to the AMRC and aerospace company Boeing's decision to open a brand new manufacturing facility alongside the AMRC have helped contribute to an extremely successful year for HVM Catapult.

Heavy Duty Diesel Engine Builder apprentice with Foxwood Diesel, Leigh Worsdale, said: "The event was a great opportunity to talk to MPs about apprenticeships and the importance of them. It was also fascinating to see the various technology exhibits on display."





The AMRC invents game-changing hybrid 3D printing process

The Design and Prototyping Group of the AMRC has developed a unique hybrid 3D printing process that allows electrical, optical and structural elements to be introduced throughout an additively manufactured component during the build process.

'THREAD' is a patent-pending process, which means components can now be manufactured with in-built, continuous connectivity and additional functionality passing through the X, Y and Z axes.

The fully automated THREAD process is suited to a variety of additive manufacturing (AM) platforms. It has so far been successfully demonstrated on machines used for 3D printing polymer components.

AMRC Development Engineer and AM specialist Mark Cocking said: "THREAD has scope to simultaneously add multiple industry-recognised threads of differing materials into one component, giving the component additional functions. This will open AM up to a greater variety of uses.

"The development of this process is a potential game-changer. It could be used across many sectors such as medical, aerospace and automotive;

where weight and size of components is critical or where components would benefit from integrated data transfer and the protection of sealed connective tracks."

THREAD will be an advantage in the manufacture of components requiring encapsulated electronics. Components such as those used in medical prosthetics, consumer electronics or structural components that require electrical connections and until now, would have been secured externally to the component.

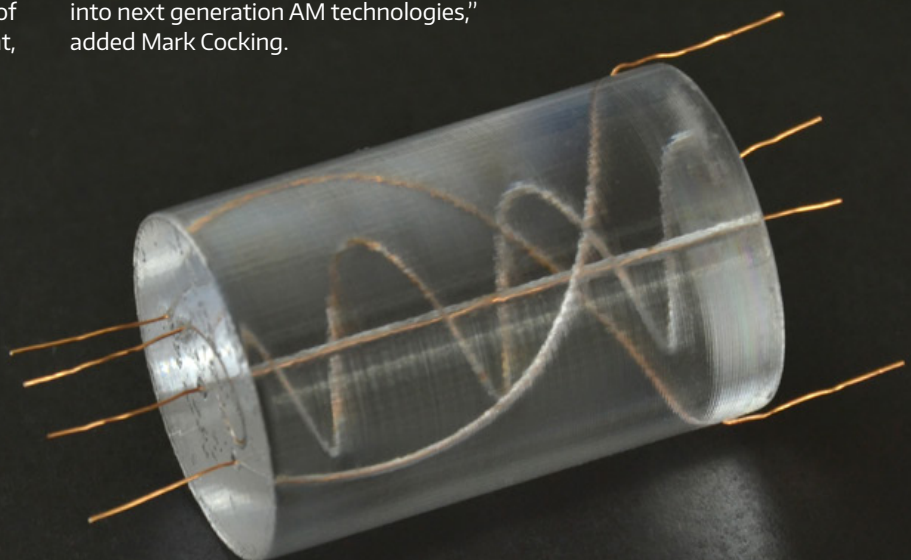
The nature of the 'sealed' conductive tracks could also be of benefit for components which may be sensitive to contamination from debris, corrosion or impact.

"THREAD has potential to be developed as an add-on technology for existing AM platforms and also incorporated into next generation AM technologies," added Mark Cocking.

Chris Iveson, who is driving the commercialisation of the technology, said: "We see THREAD transforming the functionality of additively manufactured components. Feedback from our contacts in various industries indicates a real need for this capability, with new potential applications being discussed daily. This is a great example of the AMRC using its unique expertise to solve real industry problems."

The AMRC are further developing the THREAD process and technology for various commercial markets. Manufacturers of 3D printers and industrial users of 3D printing processes are encouraged to contact the AMRC Design and Prototyping Group.

Please direct enquiries to Mark Cocking at m.cocking@amrc.co.uk or 0114 222 6244.



UK Patent Application GB1703137.8

“ We see THREAD transforming the functionality of additively manufactured components. ”

Chris Iveson, design and development engineer at the AMRC



Access to world-class facilities at AMRC Factory 2050 made even easier for SMEs with opening of new 'reconfigurable factory' research cell

Ease of access to the world-class research and development facilities on offer at AMRC Factory 2050, is being made even easier for small or medium-sized enterprises (SME).

The Integrated Manufacturing Group (IMG) based at Factory 2050, is unveiling a new opportunity for smaller companies to more easily conduct research into machining and assembly technologies on a new 'reconfigurable factory' research cell; in a safe and cost-effective environment.

SMEs will be able to work with IMG engineers on manufacturing projects designed to take the risk out of trialling new technologies and processes before putting them into production.

Operations Manager for IMG, Chris Greaves, said the cell will be able to accommodate projects spanning the trialling of new robotic assembly techniques for mass customisation or even small batch manufacturing techniques, small component assembly, and finish machining and polishing operations: "The cell will be able to be reconfigured to the specific requirements of an SME with a shorter lead time. This will allow easier, quicker and more affordable engagement for SMEs.

"Our aim is to create more effective engagement and greater open access

for SMEs; businesses who may not have the resources to join the AMRC as a member, but still want to take advantage of our state of the art capabilities and world-class research to improve their processes and outputs."

As a member of the High Value Manufacturing Catapult, the AMRC is open to work with any business, big or small. IMG want small businesses to think of the AMRC as a sandpit, where they can prove-out automation or robotics, or new manufacturing processes at low-cost and with low-risk to achieve the best value and productivity.

"Projects don't have to be long running or expensive to make big changes in short amounts of time," added Greaves. "Even small projects requiring a short-lead time can be cost-effective and contribute to the improving productivity of a company.

Greaves said businesses that invest in new technologies and processes keep ahead of the game when it comes to competition: "They think about the future, what they want to sell and how they will manufacture it. The technology to achieve these goals already exists, improving not only production, but enabling flexibility, cost effectiveness and improvements in health and safety."

Head of IMG, Ben Morgan, said:

"There is a common misconception that automation and robotics cause unemployment. What we are seeing in the market is that companies who are implementing automation are re-distributing jobs within their business and as productivity increases, so do profits and re-investment. More competitive manufacturing will mean more orders and ultimately more jobs for the region. It is imperative that the Sheffield City Region embraces automation in order that work is not lost to lower cost economies.

"Simply put, the UK relies heavily on the success of SMEs. The AMRC want to help SMEs invest in the future and explore how new technologies can help improve production, helping UK businesses remain competitive on national and international markets."

The new research cell will be up and running towards the end of autumn in 2017 and IMG are encouraging any smaller manufacturing businesses who is interested working with them to get in contact.

Any SME interested in working with IMG at Factory 2050 should contact Shirley Harrison at s.harrison@amrc.co.uk



Bespoke packaging SME collaborates with the AMRC to develop low-cost robotic manufacturing solution

An autonomous robotic solution for improving process time and health and safety during the manufacture of cardboard boxes has been developed by the Integrated Manufacturing Group (IMG) of the AMRC.

The system was developed for The Cardboard Box Company, an SME based in Accrington that designs, prints and manufactures bespoke corrugated packaging solutions for industrial, retail or promotional displays.

The Cardboard Box Company 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 SMEs fund research projects. The initiative match-funds the costs involved in conducting research and development projects for SMEs and is funded by HVM Catapult.

Managing Director of The Cardboard Box Company, Ken Shackleton, said: "The AMRC came to visit us in Accrington to look at our operation and how they might improve upon any of our manufacturing processes.

"It was decided that exploring the possibility of installing some form of robotics at the end of one of our production lines would help with our palletisation process. With potential benefits of maintaining consistent production speeds, whilst reducing manual labour and the health and safety issues related to the process."

The company produces 22,000 cardboard boxes per hour, with operators loading and unloading cardboard bales which weigh between 15-20kg manually, an incredibly labour intensive process.

To address this, IMG successfully developed a cost-effective automated system which uses a robotic arm palletising bundles of boxes. The prototype system was used to demonstrate to The Cardboard Box Company how they would be able to halve the time operators spend manually handling the cardboard materials during production.

IMG Project Manager, Ben Fisher, said: "This kind of development is valuable for an SME such as The Cardboard Box Company, as it allows them to redeploy employees to production processes requiring higher skill levels and therefore a greater need of manual intervention, creating valuable efficiencies.

"Alongside this benefit, this kind of automated technology brings consistency and speed to the production process and has valuable applications in safeguarding the health and safety of employees; reducing the need for physically demanding manual operations."

Ken Shackleton, said: "For the amount of expenditure incurred, the result was remarkable! We have subsequently received from the AMRC a number of companies to approach who can build a full industrial version of this robot with indicative costs which we are about to pursue."

Projects of this nature are valuable to demonstrate to SMEs the access they have to work with research institutions such as the AMRC; to develop and integrate state-of-the-art automated production processes and technologies at low-cost, on any scale.

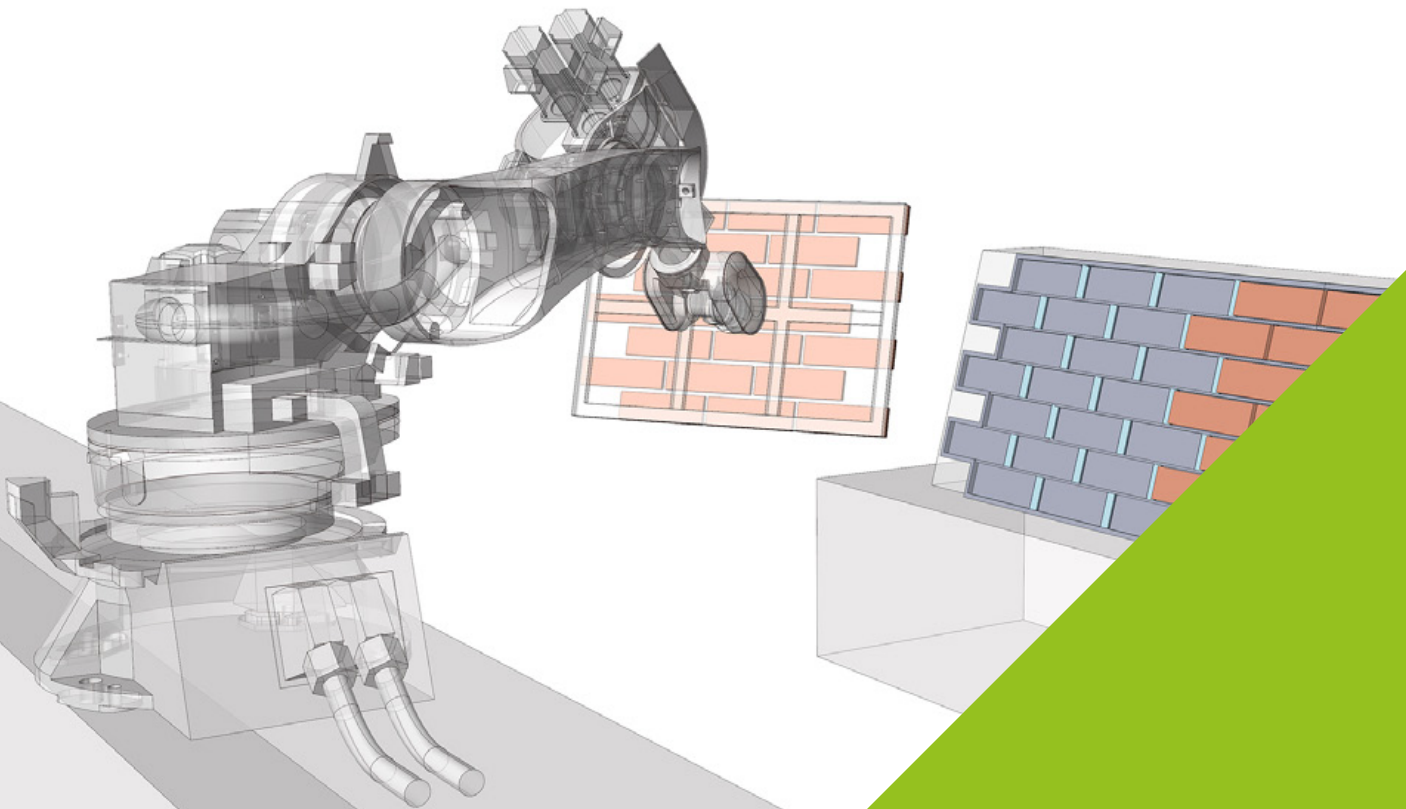
Ken Shackleton said: "This would not have been possible without the help of AMRC. For an SME to be able to access this technical level of knowledge to develop a project or resolve manufacturing issues is incredible.

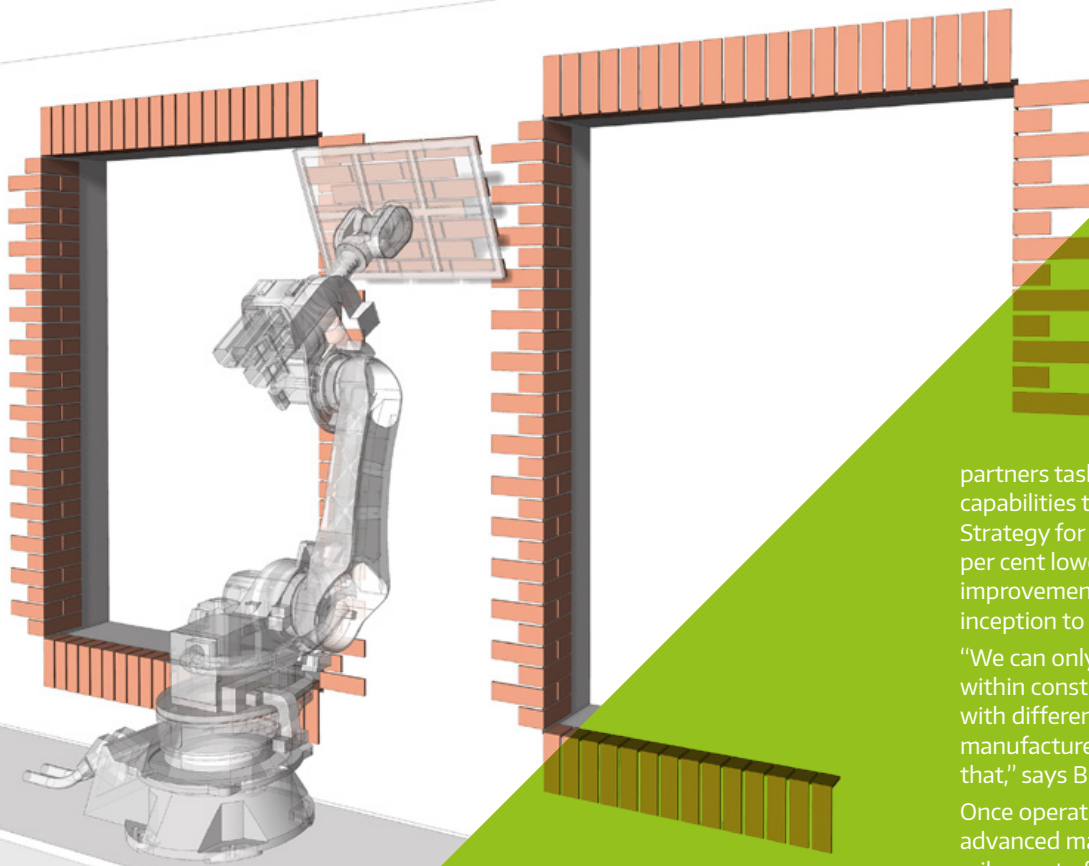
"To have access to an organisation that is currently developing the ideas and processes for some of the most advanced technical businesses in the world is a privilege. If we are to build and promote manufacturing in the UK, then the services of AMRC need to be taken advantage of."



A NEW REALITY FOR THE CONSTRUCTION INDUSTRY

When the Farmer Report into the state of the UK's construction industry was published last year its title alone sent a chilling message to the sector: Modernise or Die. Here the AMRC Journal shows how the Integrated Manufacturing Group is bringing digital manufacturing approaches to an industry hungry to harness best practice from the aerospace and automotive sectors.





David Brass,
Laing O'Rourke



Laing O'Rourke is no slouch when it comes to innovation. A front runner in the off-site manufacture and fabrication of building elements, this global construction company knows the industry is at a crossroads. And it is determined to take the right turning.

"We have been investing heavily in combining engineering excellence with digital platforms and off-site manufacturing," says David Brass, the general manager of the company's next generation, advanced manufacturing facility in Steetley, Worksop.

The facility will be able to supply at full capacity up to 10,000 high quality homes a year. "This will enable us to directly deliver smarter and more

efficient products that generate economic, social and environmental benefits," says Brass.

Known as Design for Manufacture and Assembly (DfMA), this approach unlocks opportunities for firms such as Laing O'Rourke to substantially reduce the time and risk associated with more traditional construction methods.

"It results in higher quality and more reliable delivery of buildings and infrastructure, providing greater value and certainty for clients," adds Brass.

To achieve this Brass knows he has to embed digital and advanced manufacturing technologies and processes into their off-site facility, if the company is to keep ahead of the pack. "We are proud of the way we innovate but we know we can learn from others, especially in the aerospace and automotive industries, where automation is much more the norm," he says.

In 2015, the government announced £22.1m of funding through its Advanced Manufacturing Supply Chain Initiative (AMSCI). This was to support R&D, capital investment and training in advanced manufacturing capability for the construction industry supply chain.

Backed by this funding, Laing O'Rourke joined forces with the AMRC and a wider consortium of industry and research

partners tasked with creating new capabilities to support the UK Industrial Strategy for Construction targeting 33 per cent lower costs and 50 per cent improvements in delivery times from inception to completion.

"We can only meet the challenges within construction in productivity with different thinking and off-site manufacture plays a vital part within that," says Brass.

Once operational, Laing O'Rourke's new advanced manufacturing facility just 20 miles east of Sheffield will employ up to 1000 people when at full capacity, but in very different roles to today's offsite factories.

"Our focus will be on controlling, monitoring and maintaining state-of-the-art robotic and electronics systems, resulting in greatly enhanced workforce productivity," Brass added.

Which is where the AMRC's Factory 2050 and its Integrated Manufacturing Group come in.

"Laing O'Rourke are trailblazers when it comes to off-site production," says Chris Freeman, who leads the Digital Manufacturing work-stream at Factory 2050. "But they are keen to raise their game. Our role is to help identify and develop a range of technologies and processes to help make their new factory truly advanced. We are looking at everything from relatively simple quick fixes to the de-risking key of investments in digital technologies such as augmented reality, visualisation robotics and big data, that will drive productivity, performance and quality."

One such quick win was identified on the semi-automated production line of Laing O'Rourke's Smartwall. This pre-fabricated element includes fire protection, sound proofing and insulation, along with Mechanical and Electrical services.

"It was clear there was a bottle neck on the line where the process involved

continues...

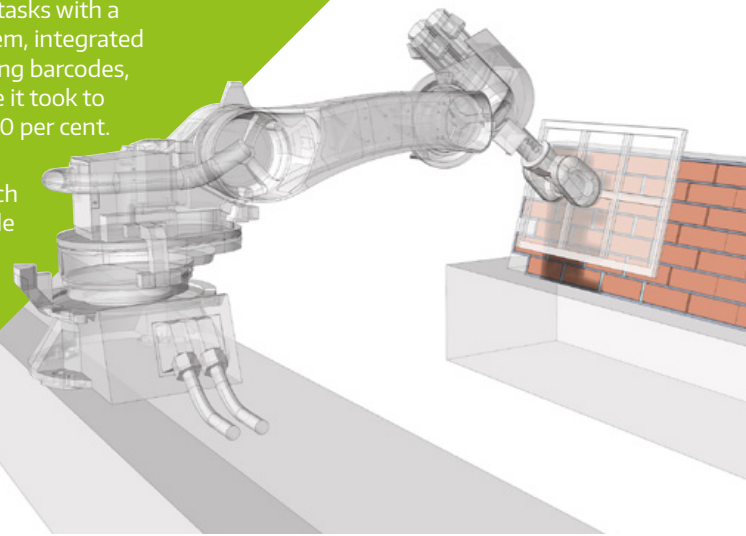


the manual mark-up of switch box locations from the drawing of the wall," says, AMRC Project Engineer, Arthur Kershaw, part of the AMRC team who implemented a solution that exploited the factory's existing CAD data.

"After translating the data, we took two laser line projectors, paired with a barcode scanner, which we linked up to the Laing O'Rourke server to accurately project the required positions at the touch of a button," said Kershaw's colleague, Diego Aranda, the team's systems and controls engineer at Factory 2050.

By replacing the manual tasks with a laser line projection system, integrated into existing systems using barcodes, the IMG reduced the time it took to perform these tasks by 60 per cent.

"The digital process was not only quicker, but much more accurate and reliable by removing the risk of human error," says Kershaw.



Augmenting worker performance

Britain's leading construction companies could achieve 25 per cent reductions in costs and waste, alongside 30 per cent increases in productivity, with virtual and augmented reality technologies being pioneered by the AMRC.

Researchers at the AMRC's Factory 2050, who are at the forefront of bringing digital technologies to the construction sector, are part of a consortium of high tech companies formed to develop an Augmented Worker System (AWE) for the construction industry.

"Activities such as AWE are central to the digitalisation of construction and infrastructure," said AMRC Augmented Reality Technical Fellow, Chris Freeman. "The integration of

cutting-edge technologies into a data rich platform such as AWE will help drive UK productivity by enabling better communication and more effective decision making."

Freeman and his AMRC colleagues are an integral part of private-public sector consortium led by Soluis, a leading construction visualisation company that has pioneered the application of realities technology, including the development of an augmented reality asset management tool, In-Site, that was piloted at Crossrail's Liverpool Street station with Laing O'Rourke.

Chairman of Soluis Group, Martin McDonnell, said: "The proof of concept project with Crossrail showed how this technology could be applied and add incredible value to the industry. Our

vision is to develop this concept much further and create a set of tools that would form the augmented worker of the future."

Other members of the consortium include Pinnacle Business Solutions, an information systems consultancy comprising of highly experienced software developers, consultants and engineers; Carbon Dynamic, an innovative modular timber building construction company; and another High Value Manufacturing Catapult – the Advanced Forming Research Centre.

The consortium will be supported by key industry organisations that will comprise a steering group. These include AECOM, Doosan Babcock, Laing O'Rourke, Autodesk and Microsoft.



AMRC project targets a step change in the capabilities of robots used in aerospace

Work has completed on a £850,000 project to give the UK aerospace sector a unique capability for high accuracy robotic machining.

The Flexible Robotic Machining in High Accuracy Applications project was launched by the AMRC, with backing from the Aerospace Technology Institute to develop an Accurate Robotic Milling System.

The AMRC identified the need for the project after carrying out three years of robot machining research for aerospace original equipment manufacturers (OEMs) and high-end automotive manufacturers.

"We believe there is great potential to achieve a step change in high accuracy robotic machining on the back of our previous research and our understanding of the fundamental mechanics," says Ben Morgan, who heads the AMRC's Integrated Manufacturing Group at Factory 2050.

The AMRC is combining an existing

accurate robotic solution with world-leading expertise in CNC machine tool dynamics in a bid to enhance the robot's accuracy and overcome its lack of stiffness and dynamic stability.

The organisation has had the latest accurate Renishaw rotary encoders incorporated into its KUKA 'Titan' robot and linked to the robot's Siemens 840D controller.

The technology has been developed by Electroimpact, one of the world's leading aerospace automation companies, with UK offices in Deeside; which has experience in creating accurate robots and has sold systems for drilling in aerospace.

"This will create the most accurate large volume machining robot in the world," say Morgan.

"The modifications that have been carried out will ensure the robot will be at the heart of our automation research in collaboration with UK aerospace OEMs and Tier One companies.

"The project has the potential to develop accurate and stiff robotic machining for both metallic and composite structures, offering manufacturers increased flexibility and greater efficiency, when it comes to producing higher quality components.

"It would reduce the need for expensive specialised multi-axis machine tools and would have applications in both current and future commercial aircraft programmes as well as in a wide range of other high value UK industries including the defence, automotive and marine sectors."



The newly upgraded KUKA Titan robot at the AMRC's Factory 2050.



SMART WINGS offer a composite solution to the threat posed by icing in flight

A £1 million-plus project to develop “smart” composite leading edges for aircraft wings with embedded heaters to protect the wings against ice build-up, while reducing weight and boosting efficiency compared to existing systems, has concluded successfully after crucial wind tunnel tests.

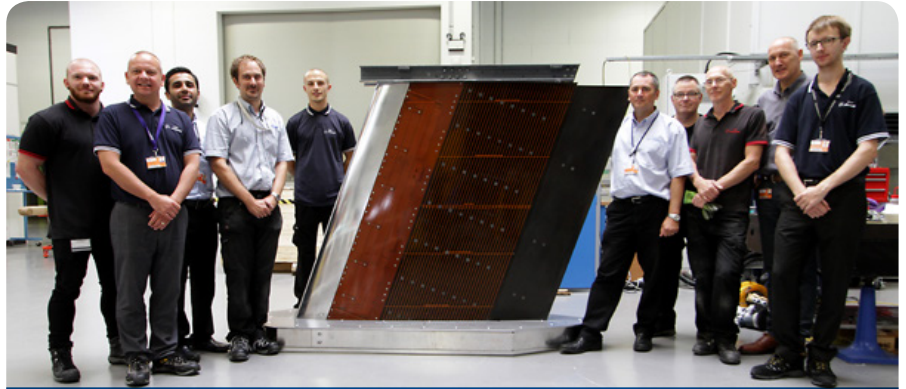
The European Union-funded ELWIPS programme brought together researchers from the AMRC and aerospace companies Meggitt PLC and AeroTex UK.

ELWIPS - the Electro-thermal Laminar Wing Ice Protection System Demonstrator - is a programme managed by aircraft manufacturer Dassault Aviation. ELWIPS, along with other innovative research programmes aim to develop technologies which will feed into their next generation of aircraft.

The AMRC designed and built a composite wing structure which incorporates innovative electric heating technology and power control systems developed by Meggitt subsidiaries in the UK and France, while world leaders in icing prevention and prediction, AeroTex, determined the sizing, zoning, power rating and control strategy for the heaters.

A section of wing incorporating the technology was sent to the United States, where it recently completed tests in a special wind tunnel operated by the US air and space agency, NASA, which can cause icing and measure its effect on the wing’s aerodynamics.

“The whole development process has taught us a tremendous amount and generated a lot of data that will be



Members of the AMRC who collaborated on the ELWIPS project with the composite wing structure demonstrator.

very useful in future projects,” said Technical Lead at the AMRC Composite Centre, Dr Tim Swait.

“The heating technology developed by Meggitt is very impressive and has great commercial potential. Tests in the NASA wind tunnel showed it could prevent ice from forming in the first place and would also shed ice if it was allowed to form on the wing.

“If the system is developed commercially it will be a major step forward for lighter aircraft and could have implications for the construction of greener large commercial aircraft.”

A number of different systems are currently used to protect aircraft against icing, which can drastically affect wing aerodynamics and has led to crashes in the past.

One common system for jet airliners bleeds hot air from the aircraft engine

and routes it along ducts in the leading edges, while another, seen on turboprop regional airliners and utility aircraft, uses rubber “boots” on the leading edges which can be inflated to force ice off. Both systems add weight and complexity to aircraft.

“You only actually need icing protection on a limited number of flights and for typically short periods of time, so you are carrying all that extra weight for no reason. Aircraft of the future won’t be able to use bleed air, since manufacturers are optimising their engines to extract every last bit of performance,” says Dr Swait.

Electric heating has been difficult to implement on smaller aircraft because systems currently require substantial amounts of power.

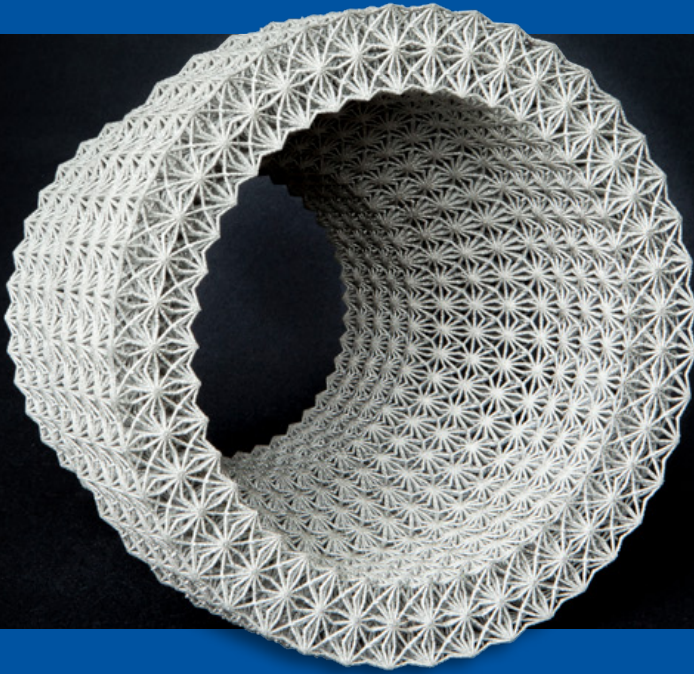
The ELWIPS project solves that problem by only using power when and where it is needed, instead of heating the leading edge of the whole wing.

“A pure electrical system will save weight and allow the wing’s leading edge to be composite rather than metallic, removing the need for ribs, spars and fasteners and reducing weight further. The system will be more reliable, allow the engines to run more efficiently and allow designers to improve laminar airflow over the wing, increasing efficiency even further,” adds Dr Swait.





AMRC Additive Manufacturing Forum



Additive technologies have been heavily discussed over the last few years, but how established are they as a manufacturing technology for real parts?

The AMRC Additive Manufacturing (AM) Forum brought together industry partners to discuss the current challenges manufacturers face when introducing AM technologies into their businesses and how optimise component design to maximise the commercial value.

Additive manufacturing at the AMRC

James Hughes, director of AMRC NAMTEC

Speaking at the AMRC Forum, AMRC NAMTEC's Director James Hughes told delegates that NAMTEC is conducting research that will provide the tools for business to take advantage of AM, by addressing some of the constraints of the technology.



James told delegates that tackling challenges such as how to design components that have self-supporting structures, accommodating laser parameters into method of manufacture, characterising the right powders for the right application and optimising topology of a component ready for manufacture are vital for manufacturers to take advantages of the benefits of AM.

AMRC NAMTEC is looking at a range of these challenges in-depth, including how to analyse and understand powder feedstocks and how this affects component validation.

One of their main focuses involves conducting research into reducing the cost and improving production time of using gamma titanium aluminide (γ -TiAl). The four-year Horizon 2020

project aims to develop the laser deposition process for γ -TiAl parts using powder produced by a novel high energy ball milling process (HEBM) compared to gas atomisation.

James said: "It's a difficult material to work with, as it has low ductility so suffers from cracking; but it is attractive to aerospace due to its low density ($\sim 3.76 \text{ g/cm}^3$) and relatively high operating temperature of up to 800°C .

"This makes it a competitor of nickel-based super alloys and opens up opportunities to use it for hybrid machining processes for repair of components with high-value geometry, such as turbine blisks in aerospace engines; or impellers in turbo chargers."

James commented on the fact that gas atomised powders are expensive

to produce, but in γ -TiAl produced by HEBM, the presence of non-spherical powder affects flow on machine. James said removing those deviations significantly improved flow.

James advised that in the future the AMRC would look at what benefit can be gained from using a heated build area, giving manufacturers the ability to control thermal history of a component and higher powered lasers to provide more control of material properties.

"The overall aim is to build a bank of data that can inform manufacturers, contrasting AM alongside comparable technologies such as forging or machining, so they can assess which technology is the most appropriate for the manufacture of a component."

Event review continues...





Great opportunities for UK plc in a continually growing aerospace market

Denzil Lawrence, UK supplier development at Boeing

Denzil Lawrence works in supplier development for Boeing Commercial Airplanes, he told delegates at the AMRC Forum that the aerospace industry is a thriving sector for UK plc to target; with long term growth forecast for new aircraft as well as increased opportunities for maintenance, repair and overhaul as airline fleets grow.

He said that manufacturers need to ask how AM and other technologies can

help in the manufacturing process to save time and resources. To do this, they need to look across the value chain - from powder to part - not just focus on the optimisation of the build process; to exploit growth and to create valuable opportunities.

Lawrence said that Boeing are encouraged by the developments being seen in AM within the supply chain, which may provide opportunities for more structural additively

manufactured components to be introduced into aerospace systems as well as in propulsion, interiors and other commodities.

He stressed that collaboration across the whole value chain is vital to ensure that these technologies can succeed in the aerospace sector. Therefore, UK suppliers must work together to create viable businesses cases to ensure they are well placed to deliver that success.

Design with additive manufacture to add value to the whole manufacturing process

Dan Fleetcroft, engineering director of Performance Engineering Solutions Ltd

Performance Engineered Solutions (PES) Ltd works across a number of high-value manufacturing sectors, offering design, engineering and data capture services. One of their specialisms is using additive manufacturing (AM) to improve product performance, reduce time to market and minimise development costs for their clients.

PES Engineering Director, Dan Fleetcroft, encouraged businesses to look carefully at the technology to identify what value can be added to their products and processes by considering AM as a potential solution from the outset of a project.

He said: "There are many benefits to utilising AM technologies, for instance we use AM to produce prototypes or limited runs of components. This

approach helps to reduce the associated risks of product evaluation and testing as there is no requirement to invest in expensive tooling which may have to be modified or remanufactured.

"It allows us to check the geometry of a product before committing to the tooling necessary for volume production and manufacturing."

PES manufacture AM parts directly from CAD and scan data, which means as well as new designs for prototypes or functional components, AM is well suited to the reverse engineering of legacy parts. Fleetcroft encouraged manufacturers to take advantage of opportunities in new sectors:

"There are the many opportunities to introduce the use of AM, but the lack of knowledge about AM in

the manufacturing industry means people are unaware that AM parts are already being used in sectors such as aerospace."

He said new areas to consider include elite sports, as the high level of customisation and small batch production required can be delivered through high performance bespoke AM parts, at costs not achievable through more traditional subtractive techniques or moulding.

Fleetcroft added: "AM allows you to create components that are impossible or impractical to produce by conventional manufacturing methods. Developing knowledge and understanding of the increasing range of AM processes will get you ahead of the market."





The time is now for AM to be integrated into mainstream manufacturing processes

Stephen Crownshaw, AM business development manager at Renishaw plc

Stephen Crownshaw, AM Business Manager, UK & Rest of World Sales at Renishaw plc, told the AMRC Forum that the benefits of AM can be integrated into mainstream manufacturing processes, but process control across the sector is needed to ensure the build of viable components.

Crownshaw said to integrate AM into their manufacturing processes means businesses should consider a paradigm shift in how AM parts that require high tolerances are manufactured:

“The proliferation of AM products across many sectors should coincide with cost and resource savings thanks to the flexibility of the design process.

“Use simulation to reduce errors and stresses in components, use AM for prototyping and remember that even though AM has the ability to produce components to very high tolerance - for

use in the aerospace sector for example - this isn't always necessary.

“For an efficient build, use AM's flexibility and only machine surfaces to high-tolerance that actually require them.”

Crownshaw said optimising the AM build process improves ability to meet manufacturing requirements, adding value to the whole supply chain. However industry data needed to be collected on the AM process, as conventional ISO standards no longer fit these new processes and technologies.

Crownshaw said that remote and in-line process monitoring will assist the industry to evaluate what makes a viable AM component and eliminate post-production testing to save time and cost of production. It will also provide evidence based knowledge and valid techniques that can be set as industry standards:



“So integrating metrology processes in the manufacturing chain will be vital to understanding the process, if you understand the process, you can control the process.”

Adding value to additive manufacturing

Rob Deffley, principal engineer at LPW Technology Ltd

LPW Technology Ltd produces metal powders for additive manufacturing (AM) alongside processing high temperature materials and titanium powders for emerging markets.

Principal Engineer for LPW, Rob Deffley, told delegates that the powder quality used for AM is vital for the validity of a component, so there is an urgent industry need to characterise powders and specify their use within AM.

Deffley said that LPW is capturing data from closed loop monitoring to provide certainty of conformance in storage, environment and transportation of powders to give manufacturers confidence in using powder products.

Research carried out by LPW showed that for components to retain the high density required for maintaining quality, powder characteristics such as; particle

size, degradation of materials, powder flow and the composition of powder an AM machine can accommodate need to be monitored closely.

Deffley said that cross-contamination of powder affects component integrity, so the segregation of powders and thorough cleaning of AM machines is vital to avoid this:

“Contamination can cause stress concentrations or crack initiation in a component and lead to in-process failure or loss of integrity of the parts produced. Sieving after use will remove

oversized and irregular particles, but oxygen rich particles still build up in the powder over time, which translates to the part and influences material characteristics.

“LPW produce atomised powders via several methods to provide the most appropriate spherical powder particles for the best flow rate and part density.”

Deffley told delegates consistency in powder characteristics depends on continued research to build up industry knowledge and help to set universal standards for powder quality.



“ There is an urgent industry need to characterise powders and specify their use within AM ”

Rob Deffley



idc Machining Science.

Conference May 2017



The annual conference for the Industrial Doctorate Centre (IDC) for Machining Science is the opportunity for PhD and EngD students with a machining, manufacturing and materials science background to present their research and exchange ideas with their peers and industry representatives.



The IDC students at the 2017 annual conference.



Using structural health monitoring to reduce the cost of ownership of engineering structures

Keynote speaker – Professor Keith Worden, Head of Dynamics Research Group at the University of Sheffield

Professor Keith Worden, Head of Dynamics Research Group at the University of Sheffield, was one of the keynote speakers at the conference. He gave the delegates an introduction to Structural Health Monitoring (SHM), a modern development in Damage Identification (DI) techniques.

Used to detect damage or poor performance using a permanent sensor network, SHM systems can be interrogated for health information about an engineered structure or system, such as a bridge.

Prof. Worden stated: "SHM is essentially pattern recognition, extending

traditional in-line process monitoring and control. Sensors alone can't tell you if you have damage, but they produce data which can be interpreted by SHM systems for a diagnosis, using advanced methods to accommodate uncertainty and variability."

Prof. Worden told delegates that to implement SHM effectively, questions need to be asked about what data should be gathered from a structure, what damage needs to be detected and, if present, how fast will it grow?

"SHM is already being implemented in aerospace, civil and mechanical engineering. A permanent sensor network can provide Big Data for

analysis and machine learning, potentially without human intervention," he added.

"This all means that vibration-based or ultrasonic wave-based analysis can be used by SHM to go beyond detection of possible damage or changes to the material and the geometry of a structure, to isolate, manage and possibly repair a structure before it fails."

Prof. Worden finished by telling delegates that implementing SHM will improve the safety and efficiency of a structure: "It can be used to aid revenue generation as part of a model of servitisation, reducing the cost of ownership of high-integrity structures."



Developing metal injection moulded titanium foams for biomedical applications

Mohammed Shbeh.

Titanium is prized in manufacturing as a metal for its properties associated with high-strength, low density and excellent corrosion resistance.

It is also bioinert, which is not ideal when used in certain orthopaedic implants and bioactive behaviour would be preferred for more effective integration.

Mohammed Shbeh, a PhD student in Materials Science and Engineering, is working on the development of porous, biologically active titanium (Ti) foams for orthopaedic implants to address this, and the stress shielding effect of implants upon bone density.

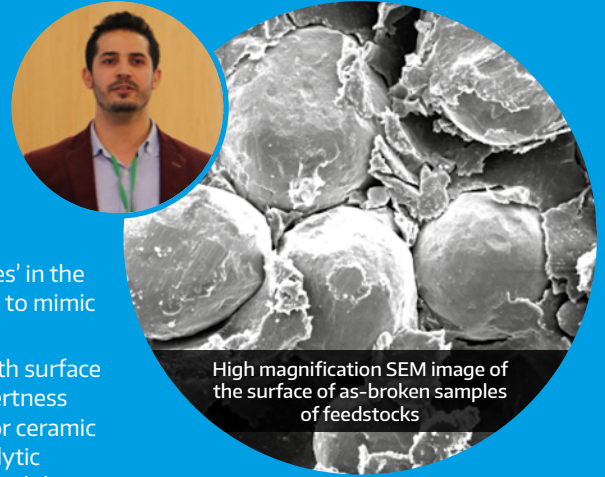
Ti foams are produced using metal injection moulding (MIM), due to the method offering the possibility of manufacturing near net shape components. MIM can produce complex components with graded density and is

adapted for use to create 'pores' in the structure that can be adjusted to mimic the structure of bone.

It is subsequently modified with surface additives to combat the bioinertness such as Hydroxyapatite (HA) or ceramic coatings using Plasma Electrolytic Oxidation (PEO) which in turn aid the chemical integration of the implant.

"This structure with its compact outer layer for strength and porous inner layer replicates the structure of the natural bone and enables bone in-growth, nutrient exchange, cell migration and attachment," said Shbeh.

"Trials produced components with 62 per cent porosity and a thick biologically active coating, with comparable mechanical properties to that of an actual bone, and surface area 22 times larger than that of dense Ti orthopaedic implants with the same dimensions.



High magnification SEM image of the surface of as-broken samples of feedstocks

"These structures could potentially integrate more effectively with bone, alleviating the problem of stress-shielding onto the biological bone material."

Shbeh found that introducing HA to the structure of the foams can induce brittleness and reduce the load bearing ability of the Ti foams. While PEO treatment results in a thick, rough and biologically active coating that penetrates the surface forming an interconnected network of surface and subsurface coatings.

The case for introducing natural fibres to reinforce biodegradable composites

Stella Manoli

Natural fibre composites are gaining ground in the composites industry today, due to natural reinforcing fibres having high mechanical performance and biodegradability properties.

Stella Manoli, a PhD student in Mechanical Engineering, has been comparing naturally processed flax and nettle fibres to evaluate their mechanical properties in tensile strength, stiffness and young modulus against the currently used industrially processed natural fibres.

Manoli conducted tensile tests on nettle and flax, single and fibre bundles. "The natural nettle fibres have higher tensile strength, up to 1200MPa and are 50-60 per cent stiffer than the corresponding industrial nettle fibres," she said.

The composite material was manufactured by injection moulding technique combining the natural flax and nettle fibres with a Floreon modified PLA matrix. Then the mechanical properties of the natural flax and nettle Floreon composites were evaluated by tensile and flexural tests.

"The tensile strength of natural nettle fibre composite is up to 88MPa compared to 76MPa for the industrial nettle fibre composite," said Manoli. The tests were performed under atmospheric conditions at 23±2°C and 55±5% humidity level.

The natural fibres were found to have higher tensile strength and performed better than current industrially derived fibres used in composite material. An environmental analysis of fibres related

to CO₂ emissions was performed using a life-cycle assessment technique.

Manoli suggested that: "Natural nettle fibres should be introduced as reinforcing fibres to create greener, cleaner, biodegradable composites. The incorporation of natural nettle fibres with biodegradable polymers as Floreon leads to the manufacture of a high strength and high stiffness composite with reduced environmental emissions."



Nettle fibres

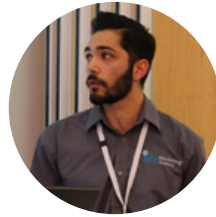
Event review continues...



Optimising Cartesian stiffness of serial manipulators

Huseyin Celikag

Robotic machining is an option to respond to changing customer demands, PhD student Huseyin Celikag told delegates at IDC Conference: "Industrial manipulators are relatively cheap, more dexterous and can be reconfigured to a facility easily compared to standard CNC machines; however, they are still rarely used in milling, turning or grinding operations."

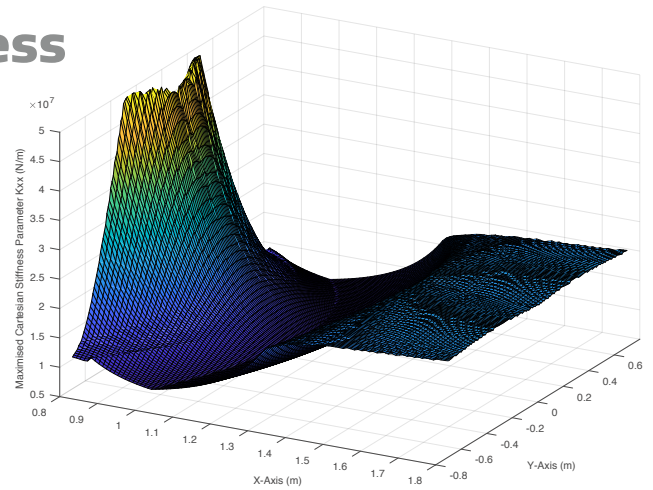


"As manipulators have traditionally been designed for repetitive tasks, compared to a standard CNC machine, they have relatively low end-effector accuracy and Cartesian stiffness; resulting in dimensional inaccuracies on a workpiece".

Celikag told delegates this means manipulators are not prolific for machining high performance materials, so he was looking at how to optimise the dynamics of robotic machining operations.

In his work, by utilising the redundant degree of freedom around the tool axis, Celikag said that many poses can be achieved for a single point in a cutting tool path and all have different Cartesian stiffness properties. His methodology relies on selecting the pose having the maximum Cartesian stiffness parameter and assigning it back to the tool path point for optimising stiffness of the manipulator.

By analysing the optimised Cartesian stiffness parameter kxx map of



ABBIR6660 on the machining table, Celikag found that the stiffness parameter is improved as the manipulator aligns its joints in the considered direction. The improvement was found to be larger when the end-effector is closer to its base.

"Up to 8.5 times the minimum stiffness parameter kxx of the manipulator is achievable" he said. "Using simulation, stiffer areas can be visualised and utilised for optimised robotic machining processes."

Machinability method development for advanced aerospace powder materials

Kyle Marshall

Powder metallurgy derived, nickel based super alloys are being used increasingly as temperatures and efficiencies in gas turbine engines increase. Its corrosion resistance, low thermal conductivity and retention of strength at high temperatures make it ideal for use in components like powder metallurgy derived turbine disks.

However its mechanical resistance to high temperatures means machining nickel super alloys is difficult and costly due to high abrasive tool wear.

Joint Engineering Doctorate student Kyla Marshall, is developing methodologies to assess implications and deformation involved during turning of nickel super alloys, accounting for variations in production.

"We need to look at whether the powder process can be manipulated to produce machinable material without any detriment to the material properties," said Marshall.

He performed small scale forging trials and found a range of microstructures could be produced within a single billet, these trials have been repeated on a large scale to produce material to examine the effect of these differential microstructures on the machinability of the material:

"Conducting an examination of the machined surfaces, it can be seen that local microstructural features affect how the material accommodates subsurface deformation induced by the machining process."

Data collected from this analysis provided information on how grain boundaries affect material properties of machined components. Marshall found that when the billets were machined, the grain rotated to accommodate the process.

The next step for Marshall is to perform full scale machinability trials; this will allow links to be made between the local grain size and precipitate morphology, and the resultant subsurface damage.

This will allow a greater understanding between the machining process and material response, and inferences can be made with regards to the post machined material behaviour; in particular fatigue life which is key property of the material type being studied.





Breaking the land speed record – engineering kids’ interest in science



Keynote speaker – Mark Chapman, Engineering Director at Bloodhound SSC

The Bloodhound Supersonic Car (SSC) – the unique UK project to design and build a car that can break the 1000mph barrier and set a new world land speed record – is first and foremost, an educational project.

Engineering Director of the Bloodhound SSC, Mark Chapman, the second keynote speaker of the day, told delegates that the project is an exciting tool in motivating young people’s interest in science, technology, engineering and mathematics (STEM) and transform STEM teaching, “Its purpose is to get kids enthusiastic about science and nurture the curious problem solvers of the next generation.”

Chapman said that achieving the 1000mph speed will be a challenge, but an exciting one that can be used to inspire the young, and reach a global audience to give companies the opportunity to sponsor the project, or contribute to engineering components for the car.

Mark was keen to share with the IDC

Conference delegates that engineering and STEM subjects can be exciting, and to remember that technology sometimes doesn’t need to out-engineer the simplest solutions.

He told the delegates about how a redesign of the hand controls of the car had been solved through a competition where an entrant had used a simple £6.99 electric drill trigger: “It’s amazing how being resourceful with funds can foster creativity and open the eyes of young people of what can be achieved.”

Bloodhound SSC has so far involved 6000 primary and secondary schools, running global competitions where school children design, build and race their own scale model rocket cars.

The Bloodhound SSC will begin the first



Image: Flock and Siemens



of two record breaking campaigns in South Africa in 2018, its EJ200 jet engine and hybrid rockets will propel it at the rate of 4.5 football pitches laid end to end per second.

Mark said: “The attempt itself may break the sound barrier, but its educational legacy will live on much longer in a new generation of engineers, scientists and mathematicians inspired by such a unique project.”

Real-time monitoring systems for multi-robot cells

Mateo Leco

Robotic machining emerged as a manufacturing process to take advantage of a robot’s dexterity and flexibility, but it is still rarely using in aerospace manufacturing, Mateo Leco, a PhD student in Advanced Robotics and Automation told conference delegates.

He said that this was mainly down to robots having limited stiffness and lower positioning accuracy compared to more commonly utilised CNC counterparts, and current robotic solutions not including a dedicated monitoring system.

Leco is developing an intelligent monitoring system for a robotic countersinking cell experiment. The system will sense real-time data about

process variables such as spindle power and cutting tool vibration, for the prediction of actual countersink depth-of-cut during machining of pre-drilled holes in aircraft panels and identify when a depth-of-cut was within tolerance.

The countersinking cell consisted of a master robot with a countersinking end effector and a slave robot to assist with alignment. Data collected from multiple sensors identified 53 signal features from the process variables, which was used to build process models.

“Using machine learning techniques, the models were able to learn any underlying relationship with the process variables of interest, i.e. the depth-of-cut. Repeat trials used for

training also incorporated process errors due to the limited stiffness of robots into the models” said Leco. “The results from three classification tests showed the system could correctly classify all the holes that had over-depth values.”

Leco is now developing the system so it can identify all the holes that do not fall within the tolerance limits and improve its performance by applying feature selection methods to reduce the number of features monitored by the system. He is also exploring probabilistic regression methods for accurate predictions and maximum control over the machining process.



New partners at the AMRC with Boeing



A science-based technology company creating products to improve lives.



Engineering firm offering automation, machine vision, and robotics solutions.



Independent industrial group specialising in composite materials and technical textiles.



Global software solutions company focused on providing wearable technology for evolution in human processes.



Mechanical engineering consultancy, designing and manufacturing bespoke engineering solutions with speed and precision.



Machine tool company serving precision component manufacturers across all manufacturing sectors.



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Leading global engineering and technology services company, focusing on the areas of electrification, automation and digitalisation.



Provide support to the consumer optics, meditec and microscopy businesses in the UK and precision industrial metrology solutions for automotive and aerospace.

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