quarterly journal

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The University Of Sheffield.

AMRC
ADVANCED MANUFACTURING RESEARCH CENTRE

Engineering **the next generation**

Apprenticeship
AMRC announce new degree-level apprenticeship

Future Factories
Opportunities for aerospace companies who embrace new technologies

Grinding and Gears
AMRC embarks on new grinding and gear manufacture research programmes

CATAPULT High Value Manufacturing

European Union
European Regional Development Fund

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AMRC
ADVANCED MANUFACTURING RESEARCH CENTRE

Welcome to our

quarterly journal

Pushing manufacturing's boundaries forward is vital for a balanced UK economy

We have to keep pushing the boundaries of manufacturing if the UK is to reap the benefits of a more balanced economy and there are plenty of examples of how we can do that in this latest edition of the AMRC Quarterly Journal.

One way is to take the knowledge and expertise we have gained in the field of machining and apply it to other fields.

Components that have been machined still require finishing and that often involves grinding – seen by many as a bit of a 'dark art.'

We set up our Grinding Centre of Excellence to cast some light on that dark art, by investigating the physics behind the process and the properties of the consumables involved, so that manufacturers will be able to configure their machines, introduce more competitive strategies and choose consumables with confidence.

You will see in this edition how we have invested in state of the art equipment and are developing our research programme to achieve those aims, in addition to engaging with leading companies in the field.

You will also see how we continue to push the boundaries of the tasks robots can carry out, working with BAE Systems to develop a robotic cell for countersinking holes in composite aircraft components and searching for ways to further improve robots' capabilities to carry out more exacting tasks, including working collaboratively with humans.

We are also taking the lessons we have learnt about making things faster, greener, leaner and with less need for human intervention into the field of construction, demonstrating how aerospace technologies can have a beneficial impact on that industry.

And we are collaborating with other organisations at home and abroad to make road and rail transport more sustainable by reducing weight and, as a result, fuel consumption.

At the same time, our Castings group has increased its capabilities to produce large scale, near net shape castings with a high quality surface finish as it moves towards installing a facility which will develop the expertise required to make the largest titanium aerospace castings in Europe.

We have also created the capability for testing the airworthiness of light aircraft in the UK after a break of around 30 years.

At the same time, we haven't forgotten that you can only keep pushing the boundaries if there is a supply of talented and skilled young men and women entering manufacturing.

In addition to celebrating the successes of the apprentices going through the AMRC's Training Centre, we are looking to the future by offering them a route into Higher Education, through the pioneering launch of a Foundation Degree that paves the way for them to study further, whilst being sponsored and paid by their employers.

Last, but not least, we want to encourage the next generation of engineers, which is why we were delighted to see four leading engineering institutions stage an Engineering Extravaganza for pupils from local schools at our Knowledge Transfer Centre.

We are also delighted to receive the generous donation from First Group of a bus which will be maintained by Training Centre apprentices and used to take the message out to schools that engineering and manufacturing offer exciting, challenging and highly rewarding careers, building our future.

Prof Keith Ridgway, CBE.

Executive Dean of the University of Sheffield Advanced Manufacturing Research Centre

AMRC Advanced Structural Testing Centre completes historic airworthiness test
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AMRC design and build new generation of blast-proof vehicle
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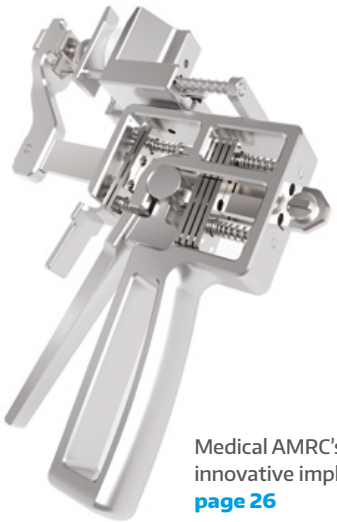

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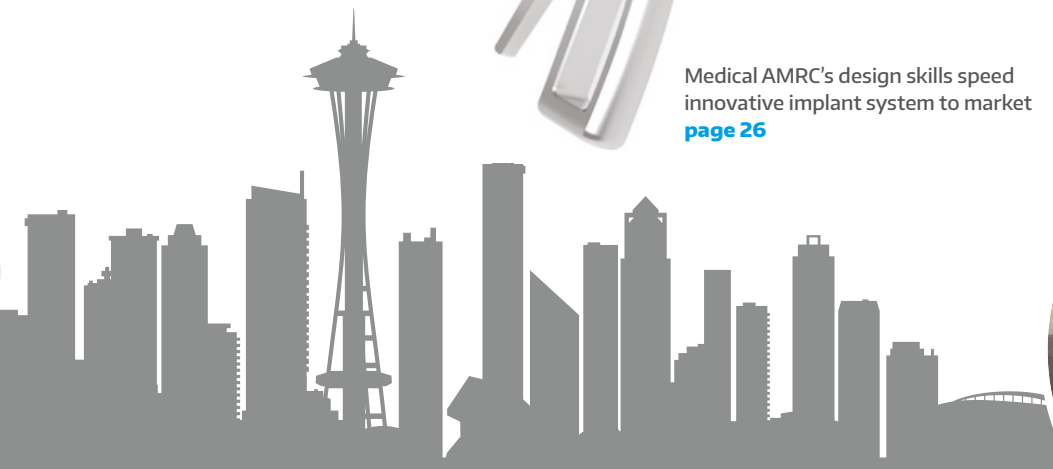

Russell buzzing with ideas after the trip of a lifetime

Award-winning engineering apprentice Russell Fox has the 'trip of a lifetime' to Seattle and aerospace giant Boeing's commercial aeroplanes sites.

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Alicona Supplies 3D InfiniteFocus system at AMRC

Alicona have been awarded an order for a third InfiniteFocus system at the AMRC in Sheffield.

AMRC have been an Alicona user for four years with both an SL system and a G4 system, the latest system supplied is a G5 version; this is not to replace the G4 but to be used alongside it due to the workload with the current instruments.

The InfiniteFocus is a 3D optical measuring system that allows the measurement of both form and surface finish on a wide variety of products, and on a wide variety of different materials. The key area that AMRC have been involved in with the Alicona systems is the measurement, wear rates and characterisation of cutting tools. This new model is supplied with an advanced real3D option allowing the full 360 degree measurement of shaft tools.

The InfiniteFocus is uniquely optimised for this type of measurement as it allows measurement of steep slopes and small radii on both smooth and textured surfaces; in addition the system is used for quantifying the effectiveness of the cutting tools on various materials including composites and carbon fibre.

AMRC Metrology Group Manager, Richard James, said: "Additionally the Alicona systems can be used in many manufacturing areas, providing unique and flexible measuring solutions both in the production line and in the measurement room. The Alicona G5 enhances the AMRC capability with regards to micro 3D scanning. Due to its reduced scanning times, it makes full 3D tool inspection a practical option."

Region's design and manufacturing skills on display in new trophy

Five Sheffield companies joined forces to ensure the region's most prestigious manufacturing awards combine the latest technologies, materials and design, while paying homage to the achievements that make Made in Sheffield a hallmark for quality.

Castings Technology International (Cti), Fripp Design and Research, The Laser Cutting Company, Stainless Finishing Services and Durham-Duplex teamed up to produce the 2016 trophies for the awards presented by Made In Sheffield, which showcases the skills of local companies committed to producing high-quality products.

Meanwhile, a sixth local organisation, Sheffield Assay Office, employed its laser marking technology to etch the names of the winners onto the awards.

Cti is a recent addition to the ranks of Made in Sheffield and when commercial manager, Richard Gould, heard it wanted someone to make the base for its trophies, he offered Cti's services.

"It was a great chance to use ground breaking technologies we have developed to show how this region excels in working with challenging aerospace materials, which are part of the future for metals processing expertise," said Richard.

Cti employed two technologies that demonstrated its ability to make bespoke, production quality castings without the need to spend time making expensive patterns and tooling, to make part of the base from titanium, and an insert made from aerospace grade aluminium that creates the impression of molten metal pouring over the lip of a melting shop ladle.

Tom Fripp, from Fripp Design and Research, said using castings for the base had presented challenges and opportunities for his company, which has designed every Made in Sheffield Award.

"Every manufacturing process has its own challenges. Cast parts can need more post production machining and we didn't want to do anything in the design that would make that more tricky, but there are some interesting things you are able to do with castings," said Tom.

Made in Sheffield's Charles Turner added: "The Sheffield region has got some fantastic companies and fantastic technologies that continue to keep it at the forefront of design and manufacture of high quality products made from advanced materials.

"The Made in Sheffield Award is a physical representation of that success in just the same way that the award winners are its standard bearers."

Demand for novel casting process fuelled by drive for **improved performance and focus on total cost**

Increasing pressure to improve the performance of critical pumping equipment and reduce costly down time is creating opportunities for a novel method for making one of a pump's key components.

Impellers play a crucial part in a pump's overall efficiency, but ensuring their blades are perfectly balanced and of a suitable surface quality, thickness and geometry to ensure a long service life, delivering maximum flow rates, is difficult to achieve using traditional casting processes.

It is not unusual for blade thicknesses to vary, when impellers are made using sand moulds and, although they can be dynamically balanced in air; that does not guarantee they will remain hydraulically balanced when pumping fluid.

Improving the surface quality of the impeller's blades is also difficult and expensive because protective shrouds severely restrict access.

Castings Technology International (Cti), based at the Advanced Manufacturing Park at Catcliffe, near Sheffield, realised its Replicast® process could offer an alternative solution.

The organisation, which specialises in helping castings companies to solve problems and improve production, has now further developed the process so that it can produce impellers which have inherently challenging and sometimes narrow passageways.

As a result, Replicast® can now be used to produce impellers with much improved hydraulic performance up to a metre in diameter with high dimensional accuracy and superior surface finish.

At first, it seemed that the lower cost of impellers made using traditional processes limited demand for Replicast® impellers. However, that is changing following further optimisation of the Replicast® process, reducing the cost premium by around 30 per cent, and a shift of focus among pump users and manufacturers towards the total cost of pump ownership and 'up time'.

At least one manufacturer has moved from focusing on a casting's 'ticket price' to how much it costs them to buy the raw casting, process it and install it in a pump. The switch makes Cti's impellers far more attractive since they have significantly lower, to zero, non-conformance costs, require little or no "detailing" and far less finish machining, thanks to the company's near-net-shape process.

Replicast® uses ceramic shells formed around sacrificial replica patterns, made directly from CAD designs using additive manufacturing technologies or machined from polystyrene.

Tests have shown that pumps using Replicast® impellers are 10 per cent more efficient than impellers made by traditional methods, which means pumps can be smaller, saving valuable floorspace whilst further reducing material and manufacturing costs.

New designs can be produced in half the time it would take if a conventional wooden pattern had to be made, modifications can be made just as rapidly and it is far easier to reverse engineer a product, using a coordinate measuring machine to collect the data to produce a CAD design from which the sacrificial pattern can be made.

"The oil and gas, chemical process, power and water purification industries are all beginning to focus on total cost and realising how financially damaging it can be to suffer any down time because of pump failures," says Cti's Richard Gould.

"We are also responding to demands for greener, more efficient pumps and rapid maintenance solutions by being prepared to hold strategic stock thereby providing a replacement service that will exchange new and refurbished impellers for routine maintenance."

Replicast® reduces the cost premium by around **30%**

Adhesive workholding allows turbine blades to be ground in one hit instead of four

A new method for securing a turbine blade prior to machining by gluing one side of its aerofoil to a fixture, rather than using mechanical clamping, allows the blade's root and tip to be ground in one operation instead of four.

The one-hit manufacturing process is not only faster, but also eliminates work-in-progress and the risk of introducing inaccuracy due to repeated refixturing.

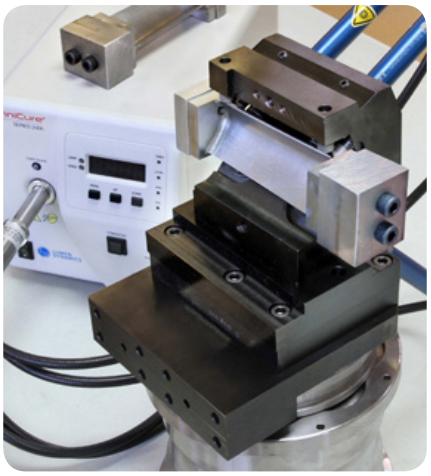
The technique is being developed in the UK by NCMT, the European agent for the patented Blue Photon photo-activated adhesive workholding system from the USA.

Developed at The Pennsylvania State University, it involves applying spots of adhesive between 0.5 mm and 3.0 mm thick that are cured for 30 to 60 seconds by ultraviolet light via fibre optic cables.

NCMT's research department has exploited Blue Photon's versatility by designing a novel turbine blade fixture. It incorporates four gripper inserts that, once adhesive has been applied and cured, hold the blade securely by one side of the aerofoil.

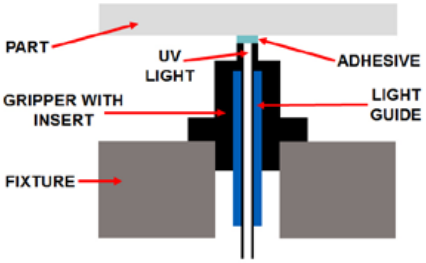
In tests, it was confirmed that the clamping force produced by the fixture could easily withstand the requirements of machining. The material removal rate actually exceeded that achievable when the blade was mechanically clamped, as the pressure had to be limited to avoid component distortion and loss of accuracy.

Use of the Blue Photon technique has grown rapidly in the aerospace industry in the USA and is ideal for clamping gamma titanium aluminide to produce low-pressure turbine blades for the latest generation of high-efficiency jet engines. The technique can be used to secure not only ferrous metals but also non-ferrous metallic parts as well as ceramics and composites.



Left: The fixture designed by NCMT for securing a turbine blade on one aerofoil surface using four adhesive grippers so that the root and shroud features can be VIPER-ground in a single cycle.

Below: Schematic showing the Blue Photon principle of adhesive workholding.



Iron foundry expert joins Castings Technology International as a consultant

Graham Jagger

A foundry expert, whose technical capabilities include producing complex components with a cast weight of up to 40 tonnes, has joined Castings Technology International (Cti).

Graham Jagger becomes iron castings consultant at the leading European centre of excellence dedicated to providing independent R&D, technical support and consultancy services to the castings and metal related industries.

Graham started his career in the foundry industry as an apprentice pattern maker in 1965, becoming a shop floor technician and technical and development engineer before moving into management 35 years ago.

He has spent more than 20 years as a foundries manager and helped a medium-sized iron foundry to expand into new markets and increase its manufacturing capabilities as technical manager, before becoming the joint owner and technical director of an iron foundry in West Yorkshire.

Graham says: "My experience has been gained on the ground, on a day to day business, producing castings, managing foundries and managing people.

"My role at Cti will be to support iron foundries in whatever way I can.

"These are challenging times for UK iron foundries, but there are opportunities for them to thrive if they are prepared to target low volume, niche markets, versatile technologies and supply the full spectrum of iron based materials including compacted graphite iron and austempered ductile iron, which engineers are increasingly utilising, the latter of which can replace steel in some applications."

Graham believes adopting technologies like Cti's Patternless® and Replicast® processes, more often used for stainless and special steel alloys and reactive metals, could give UK iron foundries the versatility and ability to react rapidly which they need to succeed in modern markets.

The Patternless® Process does away with the need to make permanent patterns for components which have to be stored. Instead, data from CAD drawings is fed into CNC machines which directly produce moulds from blocks of sand.

Replicast® creates a replica pattern, either by machining it from polystyrene or building it up using additive manufacturing (AM) technology.

Research project aims to give UK a lead in **heavy duty suspension technology**

Top vehicle suspension specialists, a high performance engineering design solutions business and advanced manufacturing technology experts are bidding to develop a revolutionary system to cut transport emissions and costs while boosting reliability and durability.

Tinsley Bridge, the Sheffield-based SME that is one of the world's leading suppliers of anti-roll bars, has joined forces with Performance Engineered Solutions (PES) and the University of Sheffield Advanced Manufacturing Research Centre (AMRC).

The trio has launched a project, co-funded by the UK's innovation agency, Innovate UK, to develop unique, high performance, metal composite hybrid anti-roll bars for trucks and trains.

The bars are safety critical suspension components that are currently made from metal and the project aims to significantly reduce their weight by developing a composite alternative with metal end pieces.

Reducing weight will cut fuel costs and emissions. Using composites could also mean the bars will never need replacing – unlike their metal counterparts – and will increase the dynamic loads the bars can cope with.

One of the major challenges will be achieving a sufficiently strong bond between the metal and composite and researchers will be investigating a number of innovative solutions.

The potential market for high performance composite anti-roll bars for use in road and rail applications runs into millions of pounds.

Tinsley Bridge is already the fourth largest supplier of anti-roll bars to global OEM truck manufacturers and a key development partner for stabiliser and torsion bars to vehicle manufacturers.

Successful development of metal composite hybrid bars through innovation and research would create an advanced version of the product to counter the threat of low cost foreign competition and open up new opportunities, but the potential benefits don't end there.

"There could be multiple spin-offs, including opportunities in the aerospace sector, if the work we are doing comes to fruition," said Mike Maddock from PES, which has worked with the AMRC on a number of projects, including developing a rear wing for a Porsche racing car and body parts for a Subaru made from eco-friendly bio-composites, partly funded by the Niche Vehicle Network.

"This project also highlights the value of strong collaboration to drive innovation which delivers technical advances, enabling UK PLC to take the lead in multiple sectors," said Maddock.

"Bringing together the knowledge and expertise of SMEs like Tinsley Bridge and PES, working in partnership with the AMRC raises the profile of local businesses and the region in the global market place as an important part of the Northern Powerhouse."

PES is heading up the engineering and design side of the project, using its lightweight and composite expertise, while the AMRC's Composite Centre will use finite element analysis to check the designs will resist the loads the bar undergoes before automatically producing the bar using its MF Tech filament winding system, unique to the UK.

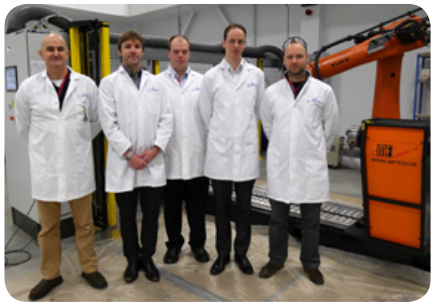
The AMRC will also use its CT scanner to 'see' inside the bar, checking its structural integrity and verifying the build quality.

Tinsley Bridge Engineering Development Manager Russell Crow said: "If we are successful, we will have created a unique process and high value manufacturing capability which will provide future job security and potential for significant expansion.

"It will also create a novel manufacturing capability for the wider benefit of the UK."

Matt Smith, from the AMRC Composite Centre, added: "Although composite materials are used in a range of industrial applications, they have not been developed as a hybrid component to meet the challenges of heavy vehicle stabiliser and torsion bars.

"The strong technical and environmental benefits, increased durability, improved fuel efficiency and reduction in carbon emissions means we have the potential to develop a leading place for the UK with a disruptive technology that has global implications."



Pictured with the MF Tech filament winding system are (l-r) Mike Maddock, PES; Matthew Smith, AMRC; Daniel Tunnicliff, Tinsley Bridge; Russell Crow, Tinsley Bridge; Dan Fleetcroft, PES.

Engineering Extravaganza excites youngsters about the possibilities of a career in manufacturing

School students have risen to the challenge to show whether they have the skills to engineer tomorrow's world.

Around 120 youngsters, aged 12 to 14, took part in an Engineering Extravaganza, organised by four professional engineering institutions as part of British Science Week and staged at the University of Sheffield Advanced Manufacturing Research Centre's Knowledge Transfer Centre.

The interactive event was designed to inspire young teenagers and their teachers about STEM – Science, Technology, Engineering and Maths – subjects and demonstrate the varied careers that can be followed in engineering.

The professional institutions, working together as Tomorrows Engineers, set a series of challenges designed to give the youngsters hands on experience of different fields of engineering by using problem solving skills.

The Institution of Civil Engineers (ICE) asked teams to build the tallest tower using as few Lego bricks as possible, while taking into account the forces that act in large towers and how they affect their stability.

The Institution of Mechanical Engineers (IMechE) challenged teams to build an air-powered model of the Bloodhound supersonic car and compete against each other to see whose car would go the furthest and fastest.

The Institution of Engineering and Technology (IET) got the youngsters to engineer their own small scale versions of "vacuum tube trains" – a new technology which could be a reduced cost alternative to air travel by transporting people at speeds of around 1,000 miles an hour.

Meanwhile, the Institute of Materials, Minerals and Mining (IOM3) got the youngsters to explore how materials play a central role in our lives and have helped to change and improve the technology we rely on.

Rolls-Royce Manufacturing Engineering Programme Manager Ian Crowston, who led the team organising the event, said: "We wanted to give young people a chance to spend time with engineers, technologists and scientists and show them how exciting a career in engineering could be.

"Engineering is at the heart of everything that can make the world a better place. The solution to most, if not all, of our problems can be found in engineering and we need these young people to become the engineers and innovators of the future if we are to survive and thrive."

Pictured left to right, Harry McNeill, Jack Vernon and Winko Kyawoo from Aston Academy, in South Yorkshire, get ready to test their air-powered car, as part of the IMechE challenge.

Rolls-Royce manufacturing engineering programme manager and Engineering Extravaganza lead organiser Ian Crowston talks with students about one of the event's challenges.

Electron Beam Welding offers a chance to reduce the cost of offshore wind energy

Alternative manufacturing technologies could help control the rising cost of the main structures used for offshore windfarms and reduce the price of the energy they generate, according to the AMRC's Ben Kitcher.

Moves to install fewer, larger turbines in deeper water have meant a shift from monopole turbine supports to fixed platforms on steel jackets similar to oil rigs – vertical, tubular sections piled into the sea bed and braced by cross members.

Manufacturers tend to come from the oil and gas sector and use technologies suited to bespoke oil rigs, including submerged arc welding, where the weld pool is shielded from the air by a blanket of molten flux.

Kitcher argues the number of identical jackets required for a deep water wind farm means a technology like electron beam (EB) welding could be more appropriate and reduce costs.

He says submerged arc welding is highly labour intensive and very slow, compared to EB welding, where the manufacturing process can be automatically tracked and generate quality data, reducing the cost of non-destructive testing by a quarter. Meanwhile, robots could be used to replace finishing and painting by hand.

"You could build kits of standard parts, and weld them together to construct jackets on land close to where they are going to be deployed," says Kitcher.

However, there are still challenges to overcome if EB welding is to be introduced, according to Bernd Baufeld from the Nuclear Advanced Manufacturing Research Centre.

EB welding has to be carried out in a vacuum or the weld site has to be encased in a 'local' vacuum chamber. Chambers large enough to get the whole component inside are very expensive and costs are really only justified for high value manufacturing.

"Some work has been done by the likes of TWI and CVE on local vacuum chambers and on chambers where the electron gun moves along a sliding seal, but local vacuum technology requires specific solutions for every geometry and highly accurate weld preparation," says Baufeld, adding that EB welding produces X-rays which raises health and safety issues.

New AMRC centres aim to replicate machining successes for grinding and gear making

Two new AMRC centres have embarked on research programmes to radically improve the understanding, flexibility and competitiveness of grinding and gear manufacturing processes.

The AMRC's Grinding Centre of Excellence aims to turn grinding from being a "dark art," based on trial and error and past experience, into a straight forward process, whose results can be predicted, based on scientific principles, and to accelerate the practical application of university level research.

Meanwhile, the new **AMRC Gear Engineering and Research (GEAR) Centre** plans to radically enhance the competitiveness and capabilities of UK gear manufacturers by creating flexible and novel machining methods and investigating surface finishing, treatment and characterisation.

The Grinding Centre of Excellence has the capability to develop new processing strategies for grinding aerospace components, including turbine blades, vanes and shafts, which require fewer machines and manual interventions.

Earlier work by the AMRC significantly improved aero-engine shaft machining operations and the new centre is targeting similar improvements in grinding operations.

The GEAR Centre is adapting AMRC techniques which have significantly improved aero engine disc and shaft production to improve production of gear box components.

The centre is also developing the capabilities of five axis flexible machining centres to make gears, to create a versatile alternative to existing methods using bespoke machines and tooling, which limit the scope to innovate, develop new designs and make a wider range of products.

It has also introduced a dedicated gear grinding platform to investigate processes which aren't easily transferrable to machining centres and is collaborating with other experts in:

- Novel gear design and testing at the Newcastle University's Design Unit
- Gear forging techniques from the Advanced Forging Research Centre at the University of Strathclyde
- Coating technologies from the University of Sheffield's Leonardo Tribology Centre

The AMRC has invested in a range of equipment to enable the two new Centres to carry out their work, including a Studer S41, Blohm Profimat MC 607, Makino iGrinder G7 with state of the art filtration systems from Fluid Maintenance Solutions, a Makino A100 and a Mori-Seiki NT 4250 1500 SZ.

In addition they have acquired dedicated gear grinding capability in the form of a Höfler RAPID 1250XL. Hybrid manufacturing capability is also being expanded from current vibration assisted machining on a DMG Sauer Ultrasonic 10 through to a new addition in the form of a DMG MORI LASERTEC 65 3D ULTRASONIC for additive and subtractive machining.

The AMRC has also invested in enhanced measuring capabilities for the two centres, by acquiring a Talyrond 565XL, capable of measuring large capacity roundness for large diameter bearings and non-rotationally symmetric components and a Leitz PMM-C 12.10.07 co-ordinate measuring machine.

AMRC grinding and gear manufacturing capabilities expand

The AMRC's Studer S41 cylindrical grinding machine is the biggest machine Studer has ever made and is being used to carry out fundamental research into detecting thermal damage during the grinding process by measuring a range of process outputs.

Researchers are also investigating ways of improving process accuracy and control by automating operations which currently rely heavily on manual inputs. Their work aims to replicate the successes the AMRC has achieved with milling and turning processes but for far tighter tolerances, which can be as low as a micron on some features.

The Blohm Profimat MC 607 is the AMRC Grinding Group's main research platform and is being employed to develop methods for testing and comparing the performance of grinding wheels and coolants, when processing a range of materials, so that manufacturers can benchmark their products and customers can be confident that they have chosen the right consumable and parameter window for the material and task.

The Makino iGrinder G7 is a 5-Axis VIPER grinding platform which is being used to investigate and develop more efficient processes for grinding aero engine blades and vanes, building on grindability investigations carried out on the Blohm Profimat.

The Makino A100 is a bigger version of the G7 and is based in the AMRC's Knowledge Transfer Centre, where it is being used for a number of Engineering Doctorate (EngD) projects.

Research being carried out on the Mori-Seiki NT 4250 1500 SZ aims to add grinding capabilities to what is a conventional mill-turn platform to create flexible manufacturing methods that allow components to be milled, turned and ground on a single machine and could have implications for the work the AMRC is doing on developing flexible platforms for producing gears.

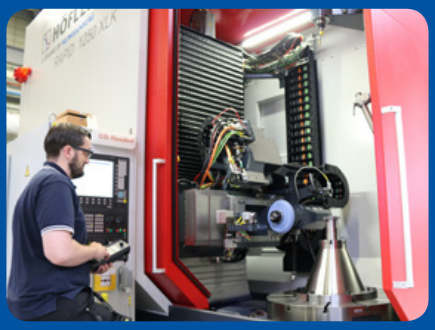
Although much of the focus of the AMRC GEAR Centre's work is on creating flexible platforms for manufacturing gears, researchers are using the Höfler RAPID 1250XL gear grinder to investigate ways of optimising conventional gear grinding approaches and improving the process to make it easier to introduce new gear designs and designs incorporating novel gear architectures.

The AMRC's DMG Sauer Ultrasonic 10 machine is being used to investigate the benefits ultrasonic-assisted machining can bring in terms of improved tool life and surface finish for components machined from conventional materials as well as potential applications when machining advanced, novel materials that are very hard and brittle.

Those capabilities will be enhanced by the arrival of the DMG MORI LASERTEC 65 3D ULTRASONIC machine, which can process far larger components and has additive, in addition to ultrasonically assisted subtractive capabilities.

The Talyrond 565XL's capabilities for measuring roundness, surface finish and contour make it ideal for verifying the results of research carried out with the Studer S41, while the Leitz PMM-C 12.10.07 enhances the AMRC's capabilities to verify that the new gear manufacturing techniques researchers are developing are achieving the desired accuracies.

Grinding Technology forum event report on pages 28 to 30.



Images top to bottom:
Studer S41,
Blohm Profimat MC 607,
Makino A100,
Höfler RAPID 1250XL.

Factory 2050

filling up with equipment and projects

Factory 2050, the AMRC's £43 million reconfigurable, digital factory for collaborative research, is beginning to fill up with cutting edge research projects.

The development on Sheffield Business Park, close to the AMRC's Advanced Manufacturing Park headquarters, is home to the AMRC's Integrated Manufacturing Group, whose current complement of 40 people is continuing to grow.

IMG's research focuses on robotics and automation, integrated large volume metrology, digitally assisted assembly and manufacturing informatics.

Using those technologies, it is developing ways for industry to meet rising demand for mass customisation and high variation down to a batch size of one, if required, and 'intelligent' machines and processes that can monitor and optimise their operations.

IMG is investigating ways of creating new production line configurations, tailored to specific products and sectors by allowing machines to be moved easily around the factory floor.

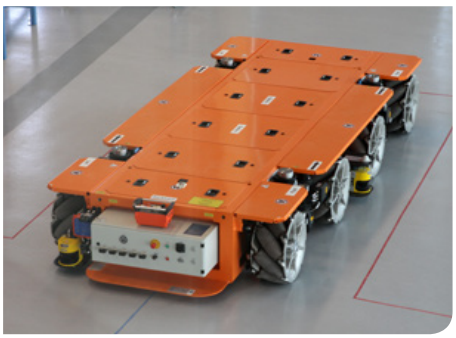
Rapid reconfiguration is facilitated by routing single and three phase power, data, air and other services through ducts that go around the circumference and hub of Factory 2050's glass-walled rotunda and are also along spokes between the centre and circumference.

Factory 2050 also incorporates wireless technologies that include industrial Wifi, low power Bluetooth and Radio Frequency Identification (RFID).

IMG's work spans techniques for shortening lead times and rapidly ramping production up and down, the development of intelligent work benches and instruction systems using virtual and augmented reality to deliver the right information to the right person at the right time, in the right format and using the device that suits them best.

The group is also leading the AMRC's work on 'Internet of Things' technologies that are driving Industry 4.0 by allowing different devices and human operators to communicate, including developing the best ways of handling and making sense of 'Big Data' – the masses of data generated by Internet enabled equipment and products.

Current projects include improving the accuracy of robots by incorporating additional encoders in joints and end effectors, so that they can carry out machining operations and developing versatile, adaptive fixturing for large scale aerospace structures.



Clockwise top left: IMG's new Mazak VTC800/30SR machining centre, Factory 2050 filling up with projects, KUKA OmniMove Robot, Factory 2050 external view.

The KUKA KR1000 L750 Titan is the only KUKA Titan used for research in a UK Catapult Centre.

The group is also leading the AMRC's work on 'Internet of Things' technologies that are driving Industry 4.0

IMG is working on the digitally assisted assembly of prefabricated "Smartwall" panels designed to be used in modular assemblies that could radically reduce the time it takes to construct homes and commercial buildings and has already achieved double the targeted time reduction for making the panels.

Other projects underway in Factory 2050 include a technology demonstrator using a robot to assist a human with manual tasks and a system to eliminate waste by creating a re-useable metal alternative to the millions of tonnes of plywood shuttering used on construction sites when concrete is poured.

Work is continuing at Factory 2050 on several projects which had already achieved successes before the Group relocated.

These include developing a self-clamping and feeding drill for drilling cleats used to fix stringers and ribs to aircraft wings, a prototype applicator for sealants used in aero structures and a robotic system for countersinking holes in composite aircraft components, detailed in another article in this issue of the AMRC Quarterly Journal.

Around 2,000 cleats have to be secured to each wing of a short to medium range aircraft and each cleat has to have four holes drilled in it which currently have to be up-sized four times.

Having developed a one shot system that offers better hole quality in confined spaces, there are now possibilities for developing the system further for larger aircraft.

Meanwhile, the prototype sealant applicator has already been shown to reduce sealant use and the time taken to apply it, in addition to reducing the amount of masking required and the potential for debris getting into the sealant.

Castings researchers expand capabilities for rapid manufacture of large-scale components

Opportunities are opening up to radically reduce the time it takes to produce large scale, highly accurate castings with a high quality surface finish that does not need machining.

Thanks to backing from the UK's innovation agency, Innovate UK, and the Aerospace Technology Institute, AMRC Castings has been able to significantly increase the size of replica patterns and moulds it can produce using CNC technology.

In the past, the maximum size of a single mould component AMRC Castings could make has been limited to 2600x1500x850 millimetres.

That has now been radically increased to 2600x4000x2000 millimetres, following the installation of a bespoke CMS Poseidon five axis CNC machine.

The specifications of the CMS Poseidon have been tailored to machining dimensionally accurate replicas from polystyrene which are coated in ceramic to create the moulds used in AMRC Castings' Replicast® and MEGAshell® Process.

It has also been designed to machine sand moulds for AMRC Castings' Patternless® Process , which makes mould and cores by using CNC technology to mill them out of blocks of bonded sand.

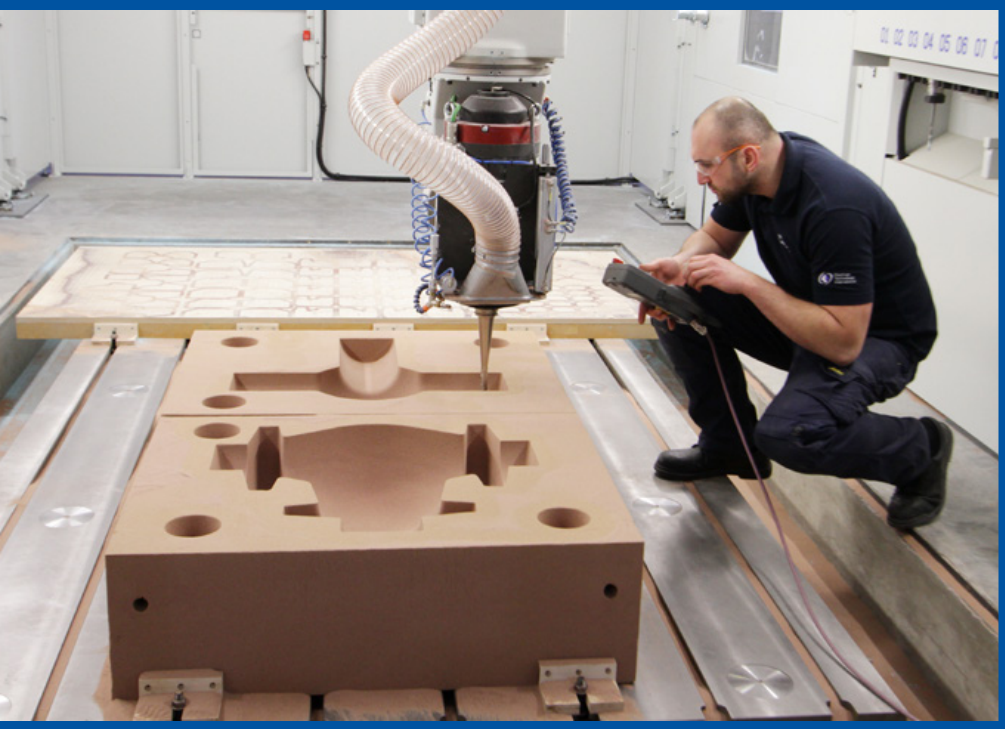
The new machine will come into its own when the biggest furnace for casting titanium aerospace components in Western Europe is installed at AMRC Castings' headquarters later this year.

The facility, which has also received support from the High Value Manufacturing Catapult, is designed to enable UK companies to break into global markets for near net shape large-scale titanium aerospace engine and structural components weighing up to 500kg.

AMRC Castings' Richard Gould said: "Any UK company wanting to break into the market would have to develop the know-how themselves, but we aim to build up the know-how for the benefit of the UK.

"The new CMS Poseidon machine is very fast, while retaining a very high degree of accuracy and will be ideally suited to making moulds for marine propellers, large scale valves and other critical components for the oil and gas, renewables and wider energy markets, as well as aerospace."

When not being used for research, the CMS Poseidon could be used to make moulds for castings producers, provide them with the knowledge transfer services they need to introduce the process themselves, or produce complete castings for users.



The new CMS Poseidon being set up.

A sand mould being machined from a block of bonded sand.

Leading cast steel engineering group becomes latest AMRC partner

WILLIAM COOK CAST PRODUCTS

William Cook, the UK's largest steel casting group, has joined the University of Sheffield Advanced Manufacturing Research Centre (AMRC) as a partner.

With factories in Sheffield, Leeds and Co. Durham, William Cook can trace its history back over nearly 175 years.

The group manufactures sophisticated components, assemblies and systems for a wide range of applications, has substantial research, development and design resources and includes global energy, transport and defence groups among its clients.

The group has just won a major £30m contract with General Dynamics to supply parts for the British Army's future fleet of fighting vehicles.

The decision to join the AMRC follows the University of Sheffield's acquisition of Castings Technology International, which led last year to the creation of AMRC Castings.

William Cook Group chairman, Andrew Cook CBE, great great grandson of the founder and architect of the successful consolidation of the UK steel castings industry in the 1980s and 1990s, says the group is keen to make use of the additional research and development facilities the AMRC provides.

Mr Cook said: "I was surprised and encouraged to see the level of practical help the AMRC can give companies that are keen to explore the possibilities of working with new materials, in new sectors and with new technologies.

"I'm looking forward greatly to William Cook playing a part in the AMRC's world class centre. We are keen to utilise AMRC Castings' research facilities and also the AMRC Training Centre."

Prof Keith Ridgway CBE, Executive Dean of the AMRC, said: "We are delighted to welcome one of the UK's most successful steel founders and engineers as a partner.

"In the recent past William Cook has invested substantially in research and technology that has allowed it to move into more challenging, higher value markets. By mobilising AMRC Castings' expertise, we hope to help the group build on that achievement by further increasing its competitiveness and expanding into even more technically advanced areas."

> "I'm looking forward greatly to William Cook playing a part in the AMRC's world class Centre"
>
> Andrew Cook, CBE

William Cook supplies extreme specification, heavy duty safety critical components to the energy sector, including wellhead and down-hole equipment for the oil and gas industry, and nuclear reactor and steam turbine components.

It is also global leader in the design and manufacture of track and running gear for armoured vehicles and the main supplier of armoured vehicle track to the British Army; it also supplies cast armour and structural parts for military platforms and components for military aircraft and submarines.

The £30 million contract with General Dynamics means Cook Defence Systems will supply the track system for AJAX, which will be the most advanced armoured vehicle in the world when it comes into service in 2019.

The AJAX success is the second coup for Cook Defence Systems in recent months. In November 2015 Defence Secretary Michael Fallon visited the company to announce a £70m, four-year deal to support the Army's existing armoured vehicles.

General manager, William Cook, said: "We won this contract despite stiff international competition. I am pleased that a global defence giant like General Dynamics can still rely on a British manufacturer to get the very best for the British Army's armoured vehicles."

Other sectors supplied by the group include the rail industry, for which it has developed innovative designs of bogie frames and couplers.

Professor Keith Ridgway CBE, executive dean of the AMRC (left), with William Cook, great great great grandson of the William Cook Group's founder (centre) and Will Jeffs, from AMRC Castings, pictured at the AMRC.

AMRC Castings' expertise and technologies span titanium and other reactive metals and alloys, as well as super-alloys, in addition to steel and other metals.

The organisation is currently constructing a unique facility, designed to enable UK companies to break into global markets for large-scale titanium aerospace engine and structural components weighing up to 500kg, with backing from the Aerospace Technology Initiative and the High Value Manufacturing Catapult.

The AMRC Training Centre provides advanced apprenticeship and higher-level training, which enables apprentices to go on to study for higher-level qualifications up to doctorate and MBA level. The centre also offers a range of courses for continuing professional development.

Above: AMRC apprentices, trainers and employers gather round Apprentice of the Year, Sam Brookfield, after his win at the awards ceremony.
Right: Sam Brookfield, AMRC Training Centre 'Apprentice of the Year' 2016.

AMRC Training Centre apprentice jetting off to Brazil after **Apprentice of the Year win**

A 17 year old manufacturing apprentice from Sheffield-based industrial fastening manufacturers, Cooper & Turner, has won the amazing prize of a once in a lifetime trip to Brazil in South America.

Sam Brookfield, from Sheffield, won the trip for being awarded the prestigious title of 'Apprentice of the Year' at the AMRC Training Centre's second-annual apprentice awards ceremony.

Automation and control specialists WEG, who jointly sponsored the Award with Boeing, have invited Sam to their Brazilian headquarters in Jaraguá do Sul, Santa Catarina where he will tour WEG's manufacturing facilities, meet and work with their local apprentices and see sites such as the Camboriu beach resort and the spectacular Brazilian capital Rio.

Sam won overall Apprentice of the Year after picking up the title of 'Academic Achiever of the Year', an award sponsored by Barnsley College for his "enthusiasm, commitment to his apprenticeship and the impact he made on the judging panel."

Sam said he was "buzzing" about winning the trip to Brazil: "I'm extremely shocked, I really didn't expect to win. I'm really excited to see new ways of engineering and also see some sun!

"I am very grateful to my parents for giving me something to look up to and everyone who has supported me throughout my short time as an apprentice."

Nominated by their employers and trainers for showing outstanding achievement, the nominated apprentices were invited to present to a panel of judges made up of apprentice trainers and award sponsors.

The judging panel decided immediately that Sam was a young person with the ability to inspire: "There was a noticeable silence amongst the panel when he left the room. To achieve what he has achieved required an amazing effort from someone with a great personality and infectious enthusiasm."

Other winners on the night were: Leggett & Platt Electrical Engineering Maintenance Engineer, Thomas Hesling, P.Clay Fabrications Welding and Fabricator Apprentice, Kieran Ferry, Gripple Multiskill Maintenance Apprentice, Jake Cawthorne, Atkins Apprentice Draughtsman, Joe Martin, AMRC Machinist, Bethany Cousins, Cooper & Turner Office Administrator, Amy Flannery and AMRC Training Centre Trainer, David Wood received a 'Mentor of the Year' award as an overwhelming number of apprentices felt as a new trainer, David had already made an incredibly positive impact during his short time training at the Training Centre.

Special Recognition Awards were also awarded to Rolls-Royce Apprentice Manufacturing Engineer, Jack Smith, AESSEAL CNC Lathe Operative, Nathan Wall and AESSEAL CNC Machinist and 6S Co-ordinator Rob Hobson for their individual contributions to the Training Centre and employers; such as becoming STEM ambassadors, supporting extra-curricular activities, for progress made or professionalism displayed whilst on site at their jobs and at the Training Centre.

AMRC Training Centre Head of Operations, Kerry Featherstone, told apprentices and guests: "The awards ceremony is about recognising our apprentices and their incredible achievements. Sitting on the judging panel I saw some incredible examples from the workplace and how all the nominees had grown as individuals."

AMRC Training Centre announces new degree-level apprenticeship

In September 2016, engineering apprentices will be able to study for a new Foundation Degree available exclusively through the University of Sheffield AMRC Training Centre.

The Level 5 Foundation Degree (FD) in Manufacturing Technology will allow apprentices the opportunity to study for a University of Sheffield certified degree-level qualification as an apprentice, without the burden of student debt.

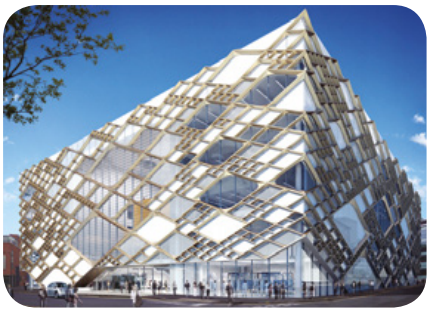
The FD will be taught at the AMRC Training Centre and University of Sheffield's new Diamond Building. It will provide apprentices with the academic qualifications of a foundation degree with the benefit of professional skills and experience.

Head of Operations for the AMRC Training Centre, Kerry Featherstone, said: "The practical elements of the course allow apprentices to translate the academic knowledge they gain into the particular skill-set required by the manufacturing sector, combining both the needs of the learners and the sector."

Professor Keith Ridgway, Executive Dean of the University of Sheffield Advanced Manufacturing Research Centre (AMRC) said: "To compete in a global economy it is essential that our engineers of the future have a wide range of generic skills in addition to core engineering competencies.

"This course ensures students gain a balanced knowledge and understanding in the context of engineering manufacture with the right mix of academic and vocational learning."

The course has been developed with funding provided by the Higher Education Funding Council for England, which has also contributed to the development of the AMRC Training Centre's first employed-status BEng in Manufacturing Technology.



The University of Sheffield's new Diamond Building which has specialist teaching facilities for engineering.

Taking its first students in September 2017, the yearlong 'top-up' degree will provide apprentices who have completed the FD with a valuable alternative route to gaining a BEng qualification all without the burden of student debt.

Go to **www.amrctraining.co.uk/foundation-degree** for more information, employers can contact the business development team on **0114 225 8035**.

Demand for apprenticeships at AMRC Training Centre soars

Since taking on its first 140 apprentices in autumn 2013, the AMRC Training Centre has grown rapidly into an award-winning centre of excellence with over 400 employed-status apprentices.

This figure is expected to rise to 650 during the next academic year, as demand for apprenticeships continues to grow and young people realise their dreams to pursue an exciting career in engineering.

AMRC Training Centre Programme Manager, Dan Swift, said: "More and more young people are choosing to earn and learn, seeing the value in getting real hands on experience alongside their qualifications, free from the burden of student-debt."

In preparation for the September 2016 start dates, the Training Centre is holding extra 'assessment centre' dates throughout the year to manage the amount of new applicants interested in taking advantage of the new apprenticeship and degree level opportunities.

After putting in an application, potential apprentices are put through the assessment centre day, which includes a job style interview and series of tasks to determine suitability. Successful applicants then go onto employer-matching events, where they speak to the various employers to find a role which suits them.

Local employers advertising their vacancies with the Training Centre vary from major global businesses to local small and medium-sized enterprises, such as Rolls-Royce, Nikken, AESSEAL, Gripple, Cooper and Turner and Technicut.

Dan Swift, said: "We encourage any final year GCSE, AS or A Level students thinking about studying engineering, or who have an interest in subjects such as science, technology, engineering and mathematics to come to an open day at the Training Centre to discuss their options."

The shop floor of the AMRC Training Centre.

"Engineering and manufacturing apprenticeships open doors to a wide range of exciting careers in mechanical manufacturing, fabrication and welding, technical support, design, electronics and maintenance; and our new degree and masters level apprenticeships means there are more career options than ever for young people," he added.

For anyone interested in applying for an apprenticeship at the Training Centre, more information can be found at **www.amrctraining.co.uk.**

RUSSELL BUZZING WITH IDEAS AFTER

the trip of a lifetime

Award-winning engineering apprentice Russell Fox came back buzzing with ideas for improving efficiency, picked up during his 'trip of a lifetime' to Seattle and aerospace giant Boeing's commercial aeroplanes sites there.

Russell Fox, 18, from Atherton Road, Arbourthorne, works for Sheffield-based automotive tools specialist Eldon Tools.

He won the trip to Seattle in the state of Washington after being named the AMRC Training Centre's Boeing Apprentice of the Year in 2015.

"It really was the opportunity of a lifetime because the experience I had is not open to the general public," said Russell.

"You can do Boeing factory tours, but you wouldn't get access to all the places I was able to see and all the amazing Boeing staff I met – and to be the first AMRC Training Centre apprentice to go to Boeing made it even better."

Russell was most impressed with Boeing's Renton factory, where production of 737s has been more than trebled to 42 a month in response to customer demand by using lean manufacturing techniques and without changing the factory lay out.

One innovation which has saved man-hours on the shop floor was to provide a full range of required tools by each machine, instead of expecting staff to walk to a central store to collect them.

Russell says he is going to make a similar suggestion to managers at Eldon, where he is currently learning to program a new CNC machine that Eldon plans to use to create bespoke trays for the special tool kits it makes for customers.

"In one section of my workplace we have enough tools for each machine, but they are all locked in a couple of tool cabinets," says Russell.

"We could use our new CNC machine to make holders for the sets of tools for each machine, so that, instead of having to go and look for tools, operators would have all the tools with the machine.

"Boeing showed me that saving minutes can save hours overall. Being more efficient means increased production rate and customer satisfaction."

Russell was also impressed by the way Boeing saved time on setting up workpieces by getting materials suppliers to deliver products with a pre-machined dovetail that fits a slot in the tables of their machine tools.

"Everything has the dovetail, which is removed when the last profile is machined. It results in a dramatic time saving when changing workpieces," says Russell, who also learnt how crucial

> **You can do Boeing factory tours, but you wouldn't get access to all the places I was able to see**
>
> Russell Fox

delivery and despatch times were for a company like Boeing where delays could have a massive ripple effect throughout the supply chain.

Russell was fascinated by the range of aircraft in Seattle's Future of Flight Museum and the 'Red Barn' – the original Boeing factory set up by Bill Boeing in 1916, which forms part of the Museum and has some of the company's first machines in their original layout.

But what impressed him most of all, apart from Boeing's huge modern factories, was its Dreamliner gallery, where 787 airline customers can select everything from the cockpit to the galley and see full size mock-ups of seating and lighting arrangements.

"There was some really clever technology," said Russell, who was also intrigued to find out that psychologists had been used to create bespoke Dynamic LED Lighting that is fully adjustable during flight to complement passenger's sensory experience, right down to the way the food tastes. Together with the extra-large windows and the fact that the 787's cabin is pressurised to a new maximum level of 6,000 feet - 2,000 feet lower than most other aircraft, giving passengers fewer headaches and less dizziness and fatigue, demonstrate how the 787 Dreamliner is the most innovative aeroplane on the market.

Russell was also impressed by the city of Seattle, which sits on Puget Sound an inlet of the Pacific Ocean.

"They call Seattle the Emerald City, because of all the greenery. It's so colourful and everyone is so happy," he said.

"Seattle was where Starbucks started– and it's great to be able to say I have been to the original Starbucks coffee shop. I also went sailing for the first time in my life and that was a beautiful experience," says Russell.

While Russell also got the chance to see a panoramic view of the city from the Seattle Eye and the viewing platform 520 feet up its Space Needle, it was the underground tour that particularly stands out in his memory.

After the Great Seattle Fire in 1889, which destroyed 31 city blocks, the city fathers decided to raise the street level to what had previously been the first or second storey level.

The decision improved drainage and sewage disposal and means it is still possible for visitors to get down to some of the former streets, see original shop fronts and even visit a restored 1890s saloon.

"It's really weird," says Russell. "You start in an old pub and you can see shop doors. It's crazy to think that as you walk around 'ground level' is really 12 to 30 feet beneath you."

AMRC Training Centre apprentices to take show on the road thanks to generous donation by First Group plc

First Group in Sheffield have generously donated a bus to the University of Sheffield AMRC Training Centre for apprentices to refurbish and use for engagement activities with the region's local schools.

The AMRC approached First Group looking for a bus that could be used as a hands-on project for their engineering apprentices to strip out, refit and restore to full working order.

First Group donated the bus, which had been retired from their fleet in running condition, to the Training Centre free of charge; along with a full set of tyres kindly donated by Bridgestone, who provide tyres for the First Group fleet

The bus will be fitted out with displays, demonstrations and used to engage with local school children at open days and events.

Alan Barstow, engineering manager for First Bus Sheffield, said: "We were happy to donate a bus that would have usually gone on to be scrapped; a programme like this can ensure the apprentices get great experience.

"I am extremely proud that First Bus Sheffield can be part of what is happening here at the AMRC and the AMRC Training Centre, as they are both adding real value to the Sheffield City Region."

The new bus will complement MANTRA, the AMRC's 14m HGV trailer packed with the latest state of the art machinery and simulators for use at educational STEM events across the country.

However the lorry can be too big or heavy to visit smaller local schools. So the new bus will allow the apprentices to show their work to more local school children.

Co-founder of the AMRC, Professor Keith Ridgway CBE, said: "The bus will contain a range of AMRC and Nuclear AMRC technologies, demonstrations of work completed by the apprentices and show life as an apprentice at the AMRC Training Centre.

"The hope is that the demonstrations will encourage young people to consider engineering as a career and assist the wider population to understand the work, the impact of the AMRC."

Former Manchester United manager Sir Alex Ferguson revisits the AMRC Training Centre

Footballing legend Sir Alex Ferguson returned to see the work being done by the University of Sheffield AMRC Training Centre and urged its young apprentices to seize the opportunities they are being offered.

Sir Alex, who was manager of Manchester United Football Club for 26 years, was speaking after touring the Training Centre, which was established in response to industry needs and has become a centre of excellence for engineering and manufacturing training.

Sir Alex launched construction of the Training Centre during a visit to the AMRC in 2013, urging businesses to show their confidence in young people by recruiting them as apprentices.

He told the apprentices, Training Centre staff and guests from industry: "Until recently there were no opportunities for apprenticeships, but I know from my own experience how valuable they are, that's why I am so impressed with the venture here."

Sir Alex told the apprentices that he knows the value of grasping life changing opportunities: "The centre is unbelievably impressive, the opportunities you have here are fantastic and you should seize them, to improve and build your skills wherever possible."

Sir Alex was taken around the 5,500 sq m Centre by some of the apprentices, all of whom are in paid employment with advanced manufacturing companies ranging from large, blue chip organisations to micro businesses.

The apprentices also presented Sir Alex with a memento of his visit – a miniature cannon which they made, using the CNC machine tool skills they have learnt at the Centre.

AMRC Training Centre Head of Operations, Kerry Featherstone, said: "We were delighted when Sir Alex asked if he could come back and see around the completed Centre.

"When he was last here, Sir Alex spoke movingly about how important an apprenticeship had been to him and how important it was for businesses to have new generations of skilled workers.

"Under his leadership, Manchester United developed a long standing tradition of guiding youngsters through their youth ranks into the first team, and on to international honours. I'm sure his words will inspire our apprentices to strive for similar success in their careers."

AMRC help create a lasting legacy for the iconic Vulcan bomber

Engineers from the AMRC are helping to preserve the legacy of the iconic Vulcan XH558 bomber by creating a 'virtual tour' of the aircraft that will be used in a new educational programme.

The Vulcan, an iconic example of British aerospace innovation, was restored by the Vulcan to the Sky Trust, returning the aircraft to flight in 2007, 14 years after it was retired from RAF service.

Having completed its last flying season in 2015, witnessed by thousands in the UK and abroad, the aircraft is now permanently on display at Doncaster's Robin Hood Airport, where it will become the centrepiece of a new educational programme planned by the Trust.

The programme has been designed to show young people what can be achieved with a career in engineering and inspire a new generation of scientists, designers, engineers and aviators.

AMRC metrology engineers approached the Trust to offer their state of the art scanning and measurement capabilities to capture the aircraft in a 3D model that they then used to create a 'virtual tour' of the legendary bomber.

Richard James, Metrology Group Manager for the AMRC, said: "Vulcan to the Sky want the virtual tour to form an integral part of their educational initiative.

"It will help the Trust enhance their public outreach, allowing unprecedented access to the aircraft, with the public being able to see all around and inside the aircraft in great detail."

The team scanned the aircraft using a spherical scanner (Surphaser) to capture multiple point clouds, from which data can be used for reverse engineering projects such as 3D printing a model.

They then use a 360° NCtech iStar panoramic camera supplied by MD 3D, a UK company who provide metrology devices, to create the related virtual tour imagery, and also allowing for colourisation of the point cloud for ease of use when viewing.

The technology and process used to scan the aircraft is commonly utilised in the manufacturing sector to create factory layout simulations, for large volume scanning and processing of large amounts of scan data.

The metrology team have applied this technology to projects outside the manufacturing sector as a way to preserve historical data, recently scanning a medieval ossuary at Rothwell Charnel Chapel and Ossuary Project in Nottinghamshire. The data has provided a virtual model to assist archaeologists in preserving the site for future generations.

Richard hopes the same will happen for the Vulcan: "Not only will the virtual model and tour maintain and promote the legacy of the Vulcan for educational purposes; it can also be used as a vital resource for maintaining and repairing legacy aircraft."

Robert Pleming, Chief Executive of the Vulcan to the Sky Trust, said: "The results of AMRC's work to produce a virtual tour are truly amazing. I'm sure that the virtual tour will become a significant contributor to our educational activities around the Vulcan. Thank you AMRC, most sincerely."

To view the virtual tour and information about visiting the Vulcan in Doncaster, visit the Vulcan to the Sky Trust website at: **tinyurl.com/xh558virtualtour**

Metrology engineers scan the iconic Vulcan XH558 bomber in Doncaster.

Advanced Structural Testing Centre completes historic airworthiness test

A bid to give Britain the capability to carry out full airworthiness tests on light aircraft after a break of 30 years has been completed successfully at the AMRC.

Top tier aerospace companies in the UK still can and do carry out the tests, but testing has become focused on their own aircraft and the capability for testing light aircraft made by independent designers has disappeared over the years.

That has all changed now that the AMRC's Advanced Structural Testing Centre (ASTC) has successfully completed tests on the Game Bird 1 (GB1), a two-seater aircraft developed by Lincolnshire-based Game Composites and designed to carry out complex manoeuvres in aerobatic competitions or simply be flown for fun.

Although GB1 has been designed and built in the UK, it looked as though Game would have to take the aircraft to the Czech Republic for full airworthiness testing until ASTC chief Phil Spiers became aware of the project.

"When I heard about the plans to design and build an aerobatic aircraft within 60 miles of the AMRC, I was determined that we should keep testing, as well as the production process, inside Britain," says Spiers.

"We believe no one has carried out an airworthiness test on a light aircraft in the UK for 30 years, but we knew we had the skills and experience in abundance to help Game get its aircraft approved as quickly as possible.

"The whole experience has helped us grow tremendously as a test team and it is something we have all really enjoyed. It wasn't hugely expensive, we learnt a lot and I think Game learnt a lot about what is involved in testing and the tremendous confidence it can give you in what an aircraft can do.

"It also demonstrates that we can test large, complex structures and meet the standards required by European certification agencies."

Engineers at the ASTC designed a bespoke test rig to apply forces up to 10 times those exerted by gravity, simulating the forces the aircraft will have to cope with as it carries out high speed manoeuvres.

They made some of the parts of the rig, while other components were made elsewhere within the University of Sheffield Advanced Manufacturing Research Centre (AMRC).

The ASTC called on the skills of welding specialists from the Nuclear AMRC and the abilities of the AMRC's own apprentices to construct a complete "whiffletree," which distributes test forces over the aircraft's fuselage and wings, causing them to twist and flex as they are designed to do in flight.

Mounting the plane on the whiffletree was a big challenge in itself. The fuselage, with wings fitted, had to be lifted four metres into the air and then flipped upside down.

Engineers had to position mounting points on the ASTC's 10 metre square 'Strong Floor' to within 1 millimetre, manufacture complicated loading brackets to similar accuracy and attach strain gauges precisely at 17 locations on the plane's surface.

"If we were a few millimetres out, it would make a big difference to where the loads go, which is why we have had to create quite a complicated load fixture," says Spiers.

The challenges didn't end there. The ASTC has also had to devise a way of heating the whole of the aircraft to 70°C while some of the tests were carried out.

The idea is to exceed the maximum temperature the airplane is likely to be subjected to – usually when it is on the tarmac in a hot country, rather than when it is flying.

Insulating the rig required the help of

The Whiffletree

More information about the aircraft and the ASTC's work can be found at:

thewhiffletree.co.uk and videos of the GB1 in flight can be viewed on YouTube, search **AMRC Gamebird**

SIG Technical Insulation and MacGregor & Moir, subsidiaries of Sheffield-based leading European supplier of specialist building products SIG.

SIG's technical specialists suggested using an in-house laminate insulation board, more normally used to prevent heat escaping from metal ducts that are at the heart of heating and ventilation systems in commercial buildings.

"We always try to use local suppliers, wherever possible and SIG's response more than justified our choice," says Spiers.

"The laminate insulation board was the perfect solution and the level of service SIG provided was among the best I have ever seen."

Part of the testing regime involved deliberately damaging the airframe and seeing if the damage got worse under strain.

"When traditional metal airframes get a crack it becomes very apparent, but, with carbon composite you can get what is known as BVID – Barely Visible Impact Damage - damage in the carbon fibre lay up that is impossible to detect," adds Spiers.

Even with some definitely visible damage, the airframe continued to soak up the pressure and testing went so well that there was time to do a second life test – a further 72,000 cycles at room and high temperatures and even higher loads of up to 15g.

GB1 passed the second set of tests under the watchful eye of the European Aviation Safety Agency, giving it a working life of 30 years.

The experienced gained during the first life test resulted in improvements to the rig, which meant the second life test went very smoothly.

"By that time we really understood the rig and how it worked so we could be confident about running it overnight with no one there, It took about four weeks to do," says Spiers.

The challenges didn't end there, however. Producing the final report involved processing the data recorded during the two life tests – enough to fill around 1,600 Excel spread sheets.

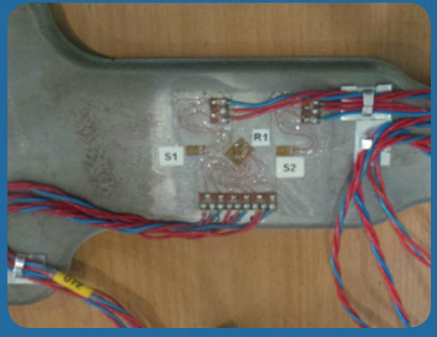
Having passed all the airworthiness tests, all that remains is for Game Composites to carry out a drop test , but orders are already coming in for the aircraft – including an order for a number of aircraft placed by one nation's aerobatic competition team.

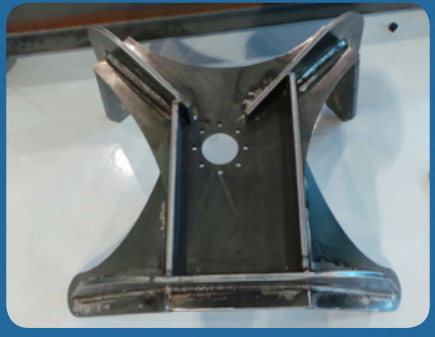
The Game Bird 1 (GB1) has been designed by former German National Freestyle Aerobatic Champion and aircraft designer Philipp Steinbach and is built by Lincolnshire-based Game Composites.

It is intended to be the world's most fun to fly two-seater aircraft, weighs only 575 kg and can cruise at more than 200 knots.

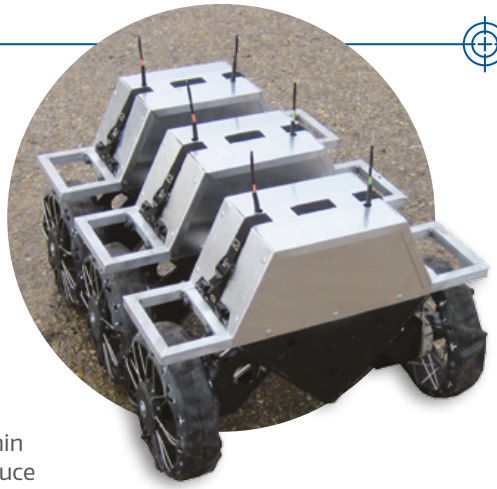
GB1 has a range of 1,000 Nautical Miles on 320 litres of fuel or can carry 95 litres for aerobatics.

The aircraft is designed to be used for unlimited aerobatics, training for all levels, as well as upset recovery training, flying cross country and for pure fun. It has a front and rear seat arrangement which is intended to expand the potential market beyond hardcore aerobatic competition pilots.





AMRC design and build new generation of blast-proof vehicle



The Design and Prototyping Group (DPG) at the AMRC has designed and built a prototype unmanned ground vehicle (UGV) designed to withstand the blast impact from a buried explosive charge.

The DPG was awarded funding as a result of its proposal in response to the Centre for Defence Enterprise's (CDE) competition to design a highly robust ground platform.

The CDE is part of the Defence Science and Technology Laboratory, which ensures that innovative science and technology can benefit UK security.

The aim of the competition was to identify design features which enhance survivability, by exploiting mechanisms and technology that limit the effects of high-intensity stress waves that propagate through structures, enabling the vehicle to maintain capability.

Senior Project Manager, John Spencer said: "The purpose of an unmanned vehicle such as this is typically to venture into areas where it would be too dangerous or difficult for a vehicle with an on-board crew. Our proposal was to develop a UGV that with further development could be capable of conducting search and rescue, reconnaissance and path finding operations".

The DPG designed and manufactured a prototype modular explosion resistant vehicle (MERV) and sensor platform. The vehicle's key features include replaceable modules with an armour steel 'v' shaped outer hull designed to direct a blast away from the drive and control systems, secondary armour comprising 3D printed lattice structures and suspended systems trays within the hull assembly, designed to reduce transferred shock loadings from an explosive charge.

Where possible, the design team tried to reduce exposure to the blast, rather than trying to absorb or deflect direct impacts; using innovative features details such as non-pneumatic wire wheels.

Tom Wood, design engineer on the project, said: "The wire wheels present a small area to the explosive charge to allow much of the blast to pass through.

"A conventional pneumatic tyre can deflate if the tyre or rim suffers localised damage, but the individual elements of the wire wheel are not dependent on each other, so localised damage does not cause complete failure of the wheel. This helps ensure that the vehicle remains mobile after a blast so that it can return itself to base."

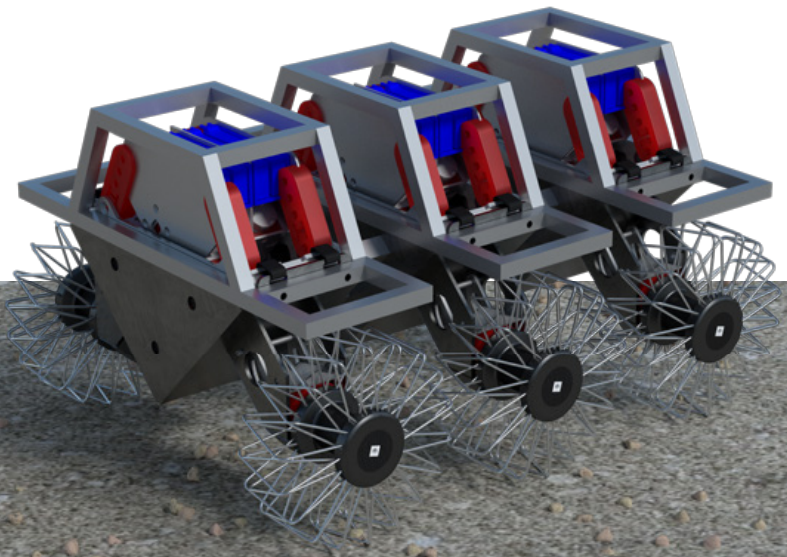
Another key area of the DPG's design was the modular segmented body. This enables the vehicle to be easily reconfigured from the six-wheel format to either a four or eight wheel vehicle, depending on its application, and the modules to be replaced quickly in the field.

The completed vehicle prototype was sent for live blast trials, where a series of buried explosive charges of varying weights were detonated beneath the vehicle in positions that were considered to be most vulnerable.

Throughout testing the vehicle exhibited no structural or internal failures and the electronics and drivetrains remained functional. Damage from the lowest charge weights was minimal and even though some damage was sustained to components during exposure to the highest charge weights, these were able to be replaced easily to restore full functionality with minimal repair time.

"The success of the live blast trials confirmed how robust the prototype is, but more importantly it has highlighted the areas that could be developed and improved further," added John Spencer.

"The potential uses of our UGV include driving ahead of a unit to investigate a suspicious object without putting personnel at risk. If some of the design features developed by the team can be scaled up and applied to a manned vehicle, the project has the potential to lead to protection systems that could ultimately save lives in high risk situations. We are now exploring the opportunities for follow-on projects".



Computer generated image of the MERV, shown without top covers.

AMRC's robot research cuts the cost of producing aircraft components for BAE Systems

A research project to enable robots to accurately machine holes in composite aircraft components, has matured into a production system and is on track to save BAE Systems millions of pounds in capital and operational costs over the coming years.

The robotic countersinking technology was developed through collaborative research, led by the AMRC and involving KUKA Systems UK.

The development technology de-risked the process enabling the design of a production system. This production system has now been installed at BAE Systems in the UK, where it will be used to processes a wide range of composite components for military aircraft.

Ben Morgan, head of the AMRC's Integrated Manufacturing Group, said: "We have been able to develop a cost effective solution with the latest state of the art control systems.

"The architecture of the system will allow the technology to evolve over time and embrace the ideas behind Industry 4.0. We're now advancing the development system further, enabling process monitoring and generating 'Big Data'. Analysis of this data, i.e. 'Data Mining' will provide an understanding of quality in process."

The robotic countersinking technology includes the use of multiple robots to automatically handle composite components and then countersink high tolerance pre-drilled fastener holes.

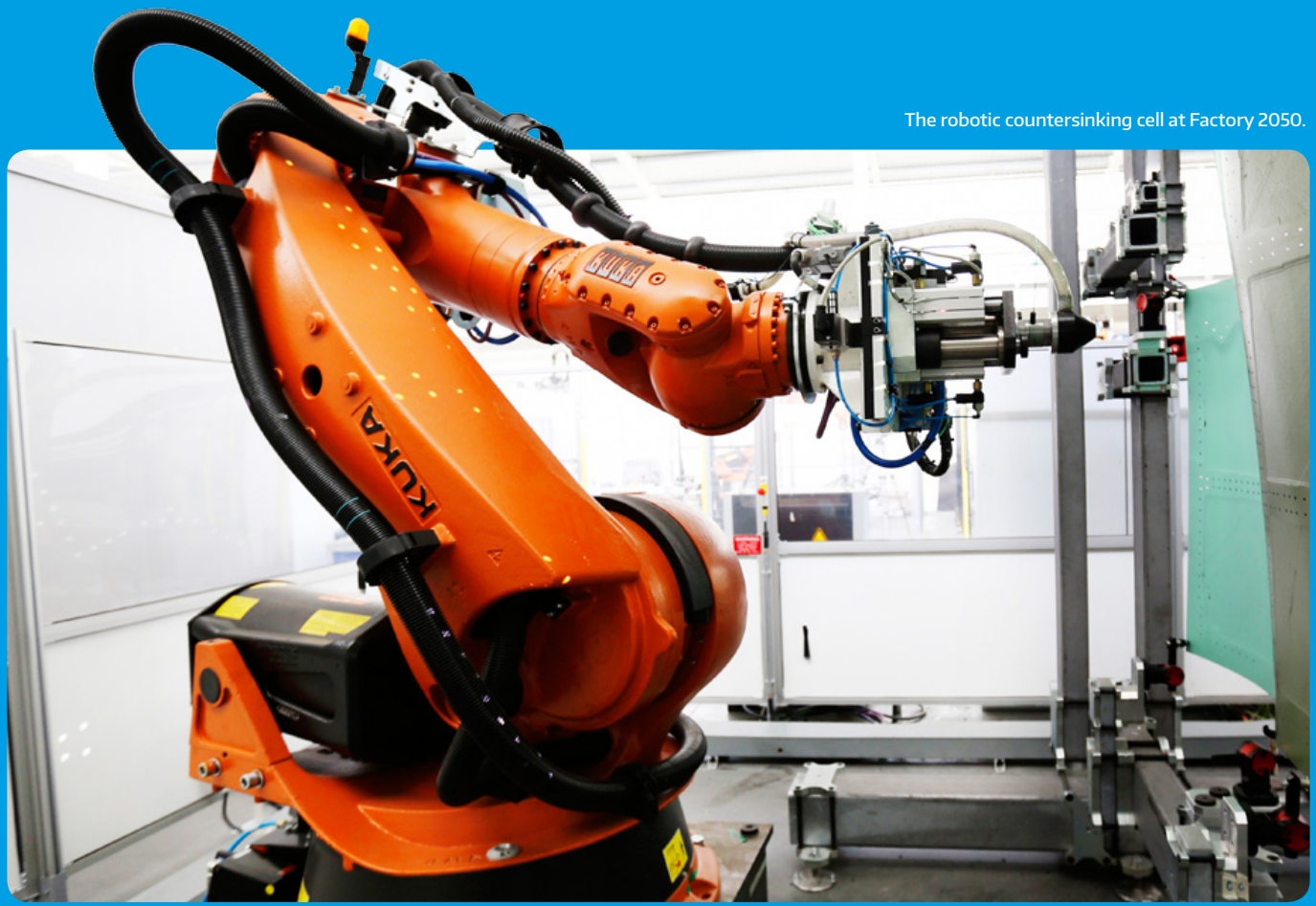
Non-contact metrology integrated with the machining robot locates predrilled holes and corrects the robot's position before countersinking.

A separate robot provides support to the component eliminating expensive holding fixtures. The system is controlled via the latest S7 Siemens programmable login controller (PLC) and includes the use of augmented reality to aid component fixturing.

Austin Cook, from BAE Systems, said: "Since we began working with the AMRC in 2006 it has supported the development of key manufacturing technologies ranging from high performance titanium machining to advanced automation for military components.

"We collaboratively research new innovative solutions at various maturity levels. The AMRC, and in particular the Integrated Manufacturing Group, has helped us mature the robotic countersinking technology from technology concept to full scale production demonstrator, de-risking along the way, and helping to catapult the capability into our business."

For more information about the AMRC Integrated Manufacturing Group, visit: **www.amrc.co.uk/research/assembly-img/**



The robotic countersinking cell at Factory 2050.

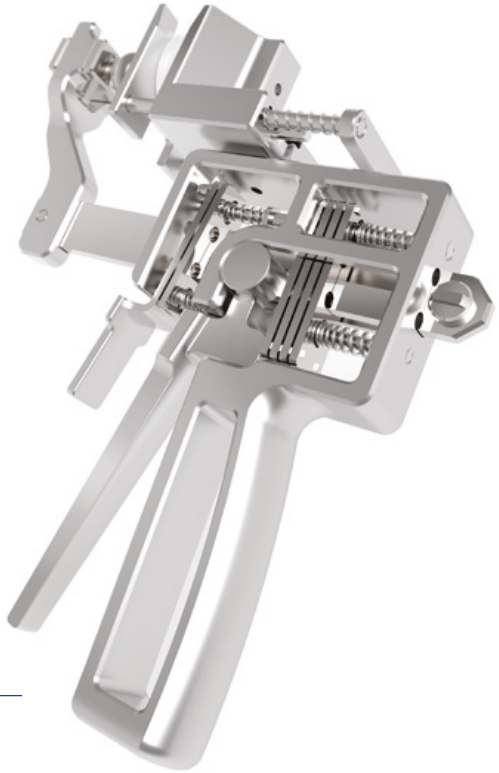
Medical AMRC's design skills speed innovative implant system to market

Orthopaedic implant and surgical instrument manufacturer JRI Orthopaedics approached the Medical AMRC for help developing a device that will allow surgeons to quickly construct implant assemblies for a new orthopaedic system during surgery.

Medical AMRC researchers used their skills to select suitable medical materials and design the device with JRI's manufacturing capabilities in mind, considering simple manufacturing approaches, such as designing components to be machined from only one side to reduce production set-up time. They also ensured the device was ergonomically designed to fit in the hand of the surgeon and exert high clamping forces which could be released easily, using one hand.

The Medical AMRC produced a concept prototype from parts made by SLA printing and machined from stainless steel, which JRI used during consultative meetings to give surgeons an extremely realistic feel for what it would be like to use the device without the need for expensive and time consuming manufacturing procedures.

JRI Orthopaedics Principal Project Engineer Joel Treen said: "The Medical AMRC team were great to work with. They listened in detail to our requirements and understood the issues quickly. Using their range of skills and experience, they delivered a design that fit the brief perfectly. We will be more than happy to work with them again on further projects, and look forward to it."



New surgical screwdriver makes life easier for surgeons while cutting health service costs

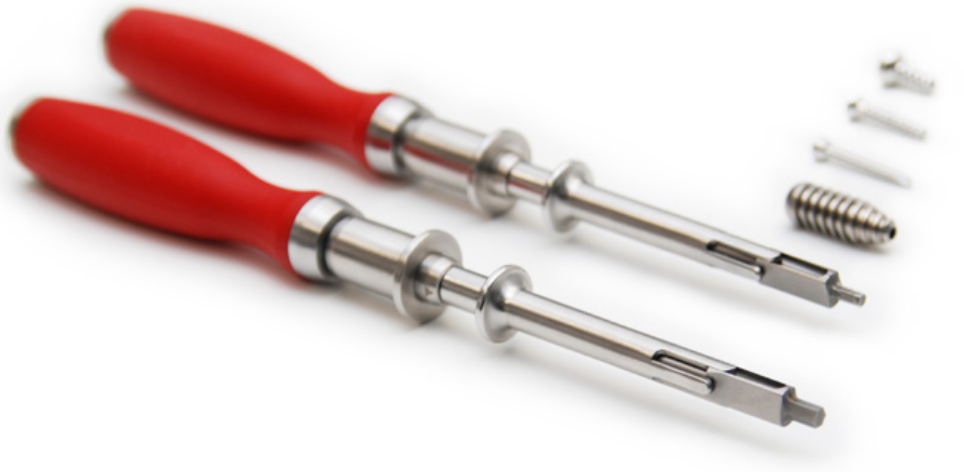
Sports injury, trauma and orthopaedic products specialist Harvard Healthcare commissioned the Medical AMRC to develop a range of innovative orthopaedic screwdrivers for operating theatres, which would retain screws securely until they were anchored in place.

The screwdrivers are designed to be an easy to use alternative for surgeons who currently employ a variety of devices to retain screws, which tend to be overly complex, difficult to use and hard to manufacture.

The Medical AMRC's pre-production prototype comprises only three components – a sleeve, shaft and handle - manufactured from different grades of stainless steel to ensure resistance to corrosion and ease of disassembly for sterilisation.

The Medical AMRC worked in collaboration with Sheffield Precision Medical to optimise the manufacturing process.

The resulting product works better than any competitor product, yet costs less to manufacture because it requires fewer parts and is far less complex. A patent application has been filed for the device and confidence is high that it will be extremely popular and find applications beyond the medical sector, in other industries.



Understanding **uncertainty** is a must for MEASURING SUCCESS

Anyone making decisions based on results and data, needs to have an appreciation of the associated measurement uncertainty, according to AMRC Metrology Engineer Adam Wiles.

Wiles was speaking at a Technology Update on 'Uncertainty in Measurement', at the AMRC's Knowledge Transfer Centre, during which volunteers took part in a series of measurement experiments using a variety of simple hand-held devices.

Using hand-held devices allowed the spread of results to approximate uncertainty – as the influence of human error was by far the biggest factor in the total error.

Digital Vernier callipers could produce readings to the nearest 10 microns (their resolution), but the spread of measurements, taken by different operators, using the same callipers to measure the same component, was over 0.5mm.

"Uncertainty is not just dependent upon the device, or the operator, or the part, but the uncertainty will even vary between different features on the same part," said Wiles.

For example, the spread of results when measuring the inside diameter of a turned ring, was larger than the outside, as the device did not easily 'centre' on the ring when measuring the internal surface.

Uncertainty is unavoidable, but it is manageable. However, uncertainty causes problems if it represents a significant fraction of the tolerance for a component, said Wiles, asking how pass/fail decisions could be made if the uncertainty range covered both conditions?

Devices that could be controlled like a Co-ordinate Measuring Machine (CMM) had much improved repeatability, which could be a fifth of the known error range of the equipment.

"Depending on the device you are using, the dominant 'form' of error changes. Different devices behave differently and produce different results," said Wiles.

Human error could be replaced by errors caused by temperature variations, device characteristics and device bias – the difference between the average result and the true value.

A lot of people took their measurements and sent out the results to the last decimal place produced by the equipment they were using, as if those results were perfect, which we know they were not.

"We need to treat our measurements with the respect – or maybe the disrespect – that they deserve," said Wiles.

Wiles suggested four guidelines for reducing the uncertainty in metrology:

1. Use a device that was suitable for the tolerances involved.
2. Check the accuracy of the device against a known artefact.
3. Repeat the measurement five times and use the average.
4. Record the conditions the measurement was made under, any calculations made and the identification number of the device.

AMRC metrology engineer, Adam Wiles.

GRINDING TECHNOLOGY FORUM

New grinding techniques and technologies

are key to vital aerospace performance improvements

Dr Jamie McGourlay, Rolls-Royce partnership manager at the AMRC

Pressure to develop new grinding techniques and technologies is increasing as leading aerospace companies introduce new materials, while seeking to improve manufacturing performance, AMRC Forum members have been told.

Dr Jamie McGourlay, Rolls-Royce partnership manager at the AMRC, told a Forum on the latest developments in grinding technology the challenges were creating a range of new opportunities in what was a key part of the aerospace high value manufacturing production process.

In the aerospace sector, grinding activities range from manual operations to highly integrated CNC processes, but all needed to deliver high performance and a superior finish, with potentially high levels of stock removal with materials that were difficult to machine, such as nickel and titanium

Grinding operations also had to be able to cope with new materials- an increasing trend, with more new materials now being introduced than had been in the last 15 years.

New materials included ceramic metal composites and intermetalics like gamma titanium aluminide, which offer benefits like reduced weight with increased strength at high temperatures, but are difficult to machine and can be brittle at a lower temperature.

Rolls-Royce had revolutionised the way it produced aero engine components like discs and blades by adopting modern, high performance machining techniques.

"We have achieved a step change in manufacturing performance for many conventional machining processes, including turning and milling. Now we need to do the same thing for grinding," said Dr McGourlay.

The company needs to significantly increase turbine blade production over the next three years and that meant a corresponding increase in related components like high pressure nozzle guide vanes.

Companies in the sector saw key opportunities for standardising methods and equipment, reducing manual interventions, introducing integrated systems, new platforms with more functions and hybrid processes, including ultrasonic machining.

"We are only starting to understand these processes, but they look promising," Dr McGourlay told the Forum.

There was a big drive to understand cost drivers across the process by becoming more informed about consumables and the technology, with the help of benchmarking projects at the AMRC.

"We want to get a clear understanding of where we are today, as well as where we want to be tomorrow," said Dr McGourlay.

"We are not just saying we want to be better – we want to know how much better we might be, but any improvement has to be cost effective. The AMRC is becoming a centre of focus for a lot of the decision making process."

Dr McGourlay said Rolls-Royce had a burgeoning interest in new research leading to new capabilities and was prepared to join with its suppliers to support collaborative research, adding: "We are not going to achieve any of what we want to achieve unless we consult with and bring our intelligence to bear with that of our partners."

Researchers seek new ways to select parameters for grinding performance and quality

Jim Kelsey, AMRC Grinding Group project engineer

Reducing process time and the consumption of consumables are among the key focuses for aerospace grinding research along with developing near net finishing techniques, exploring ways of grinding next generation materials and in-process damage assessment.

AMRC Grinding Group project engineer Jim Kelsey told the Forum on latest developments in grinding technology that information to help manufacturers choose the right grinding machines, operating parameters and consumables and assess the time, cost and quality of different process routes was very limited, when compared to what was available for milling and turning.

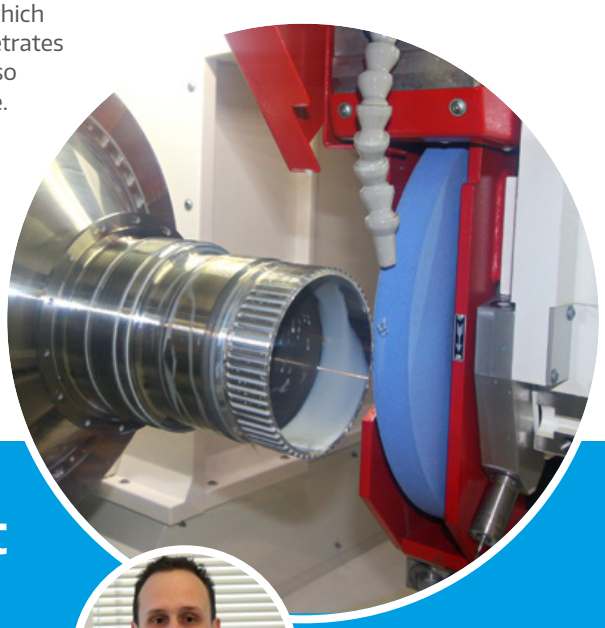
End users of grinding products had difficulty assessing new products quickly due to the holistic nature of the grinding process. Numerous inputs had to be considered and that could be time consuming and costly.

Models relating factors such as chip thickness to wheel topography, allowing for equivalent force and power outputs, existed to assist parameter calculation, but it was difficult to produce accurate and consistent values.

Simpler models, based on feed per cutting point, or the depth to which each piece of abrasive grit penetrates the surface of the workpiece also existed, but weren't as accurate.

Standardised, empirical Grindability tests could be used to characterise products such as coolants and tools, identify near optimal operating parameters and present them in format that could be understood by the end user.

Initial project work has followed this method but the large number of tests required makes it expensive and means it might only be justified for new product ranges. However, the AMRC was exploring ways to reduce the testing requirement and encourage better suppliers and end users engagement to share the cost of characterisation.



Quality and wheel wear count alongside removal rates in high performance grinding

Markus Weiss, head of the grinding technology department at Tyrolit

Manufacturers wanting to achieve high performance in grinding operations have to adopt a holistic approach that takes into account the grinding machine, dressing system, lubrication, wheel, workpiece and fixation.

That was the message from Markus Weiss, head of the grinding technology department at Tyrolit, one of the leading manufacturers of bonded grinding, cut-off, sawing, drilling and dressing tools and supplier of tool and machine systems.

High performance did not necessarily mean high removal rates, it could mean increased part quality, reduced grinding wheel wear or longer intervals between dressing the wheel, Weiss told the AMRC Forum.

New materials like ceramic metal composites and titanium aluminides, which were very difficult to machine, were also driving the requirement for higher performance.

Pressure for increased performance was also driving the development of new grinding tools with improved bonding systems to hold the grit more tightly.

"As a grinding wheel manufacturer, we are looking at the abrasive layer and the wheel body," said Weiss.

"We are looking at the grinding machine and process and we have a lot more to think about. A holistic view is necessary to achieve high performance grinding."

GRINDING **TECHNOLOGY FORUM**

...continued from previous page

Composites, 3D printing and wheel dressing innovations are improving production and quality

Daniel Mavro, chief technical officer with United Grinding Group

New innovations including carbon fibre wheel bodies, 3D printed coolant nozzles and machine integrated wheel dressing are helping to improve production speed and the quality of ground components, the Forum on latest developments in grinding technology heard.

Daniel Mavro, chief technical officer with United Grinding Group said carbon fibre wheel bodies, developed by United during the past five years offered high wheel speeds with improved damping, reduced weight and chatter and didn't expand, unlike steel and aluminium wheels.

Carbon fibre wheels could be recoated six to eight times and the bodies could be kept in service for up to three years.

Applications included grinding a number of bearings on a camshaft at the same time, reducing process time by 70 per cent and allowing all the bearings on a shaft to be ground in 90 seconds.

"BMW, Audi and Porsche shafts are ground this way, with waterproof robots doing the loading and unloading," Mavro told the Forum.

United had partnered with Swiss-based coolant nozzle specialist JCM Tooltec to develop different types of grinding machine coolant nozzles using 3D printing.

Nozzles included a plastic nozzle; a hybrid nozzle whose printed plastic core had a printed metal covering and a nozzle printed from stainless steel. Printing nozzles with different profiles to fit the wheel ensured coolant was directed where it was needed, avoided flooding the component and wheel with the coolant and cut grinding time, while reducing the risk of burning the component.

New machine-integrated electro-discharge wire dressing technology was helping to improve the performance and the high process stability of metal-bonded grinding wheels, used with difficult-to-machine materials.

The technology was eliminating the need to remove wheels so that they could be dressed on external equipment and then replaced and re-set, while opening the way for metal-bonded grinding wheels to replace electroplated wheels, by offering similar performance, with superior cooling and a longer life.

Tightening tolerances pose new challenges for measuring success

Mick Walters, Hexagon Manufacturing Intelligence's business development manager

Manufacturers striving to meet ever tighter tolerances for high performance grinding face a series of challenges measuring their success, Hexagon Manufacturing Intelligence's business development manager Mick Walters told the Forum.

Using traditional gauging tolerances of 10 per cent of the manufacturing tolerance, anyone grinding components to tolerances of +/- five micron would need a coordinate measuring machine (CMM) that was accurate to one micron.

At that level of accuracy, temperature, humidity, vibration and even the smallest speck of dust could affect the accuracy of measurements.

"If you are thinking of investing in ultra-high accuracy measurement, look at the small print in the brochures," said Walters.

"Most manufacturers specify a single probe type or diameter that matches the accuracy of the machine, however, a Leitz machine allows the use of multiple probes and guarantees the machine specification with all standard probes."

> **"If you are thinking of investing in ultra-high accuracy measurement, look at the small print in the brochures"**
>
> Mick Walers

FUTURE FACTORIES

AMRC and North West Aerospace Alliance joint forum

AMRC's new Factory 2050

Meeting aerospace challenges will open the way to major opportunities

Dr David Bailey, chief executive of the North West Aerospace Alliance

Major opportunities are opening up for aerospace companies in a high value manufacturing corridor stretching from Cumbria, through the Sheffield region and down to Derby.

But, if they are to seize the opportunities, those companies will have to meet a series of challenges, according to Dr David Bailey, chief executive of the North West Aerospace Alliance (NWAA).

Dr Bailey was speaking at a joint forum organised by the Alliance and the AMRC, held at the AMRC's new Factory 2050 development.

He told the forum growth in demand for aircraft had depended on the aspirations of a billion people in Western Europe and North America over the past 20 to 30 years. Future demand would be fuelled by the aspirations of six billion people in China and India.

Around 32,000 new aircraft worth more than $5 trillion aircraft would need to be built over the next 20 years, creating a major opportunity for the UK aerospace industry, which had grown by 27 per cent since 2010 and now had a £29 billion turnover and exports worth £26 billion.

There were lots of opportunities, but also lots of challenges, including ramping up production while overcoming capacity shortages, reducing costs in the supply chain, adapting to making components from new high performance materials and to tighter tolerances.

Aerospace companies would have to adopt new sourcing strategies and reduce the "buy to fly" ratio by finding ways of reducing the amount of metal that needed to be removed when components were made.

Increased use of robots, automation, new tooling and new technologies like additive manufacturing and friction stir welding all offered opportunities for aerospace companies.

"Technologies being developed here at the AMRC are going to have to replace what we have done traditionally in our industry," said Dr Bailey.

"The AMRC is globally respected and has the capability to develop new manufacturing technologies. There are definitely opportunities to be realised from bringing together that manufacturing technology capability and the manufacturing capacity in the North West."

Dr Bailey said it was very important that the North West, Lancashire and Sheffield came together to pool their capabilities, which was why the NWAA was supporting proposals from Lancashire Enterprise Partnership, Lancaster University and the AMRC for an AMRC development on the Samlesbury Enterprise Zone, near Preston.

The North West Aerospace Alliance was formed in 1994 to represent and support the Aerospace Industry across the North West of England. NWAA represents approximately 25 per cent of the UK aerospace industry with over 220 member companies and a combined turnover in excess of £7 billion.

Manufacturers urged to start the Industry 4.0 journey by focussing on process improvement

Ben Morgan, head of the AMRC's Integrated Manufacturing Group

Smart, connected devices, hybrid computing, more advanced data analytics and the ability to simulate what both manufacturing processes and products will do before they physically exist are combining together to change the way we look at manufacturing.

That was the message from Ben Morgan, head of the AMRC's Integrated Manufacturing Group, to delegates attending the NWAA/AMRC joint forum in Factory 2050.

Innovation, new technologies, processes and materials could all help companies meet the challenges to become leaner and far more agile, capable of mass producing greener products with a batch size of one, if necessary, for clients who all wanted it delivered yesterday.

But, all the hype about what might be achieved by Industry 4.0, the Internet of Things, Cloud Computing, Big Data and Real Time Data was causing excitement and confusion in equal measure.

"Data gains value as we get more of it and, as we get more and more data, we start to see trends and optimise what we are doing. We can use manufacturing data in just the same way, adapting the way we are manufacturing a part on a machine before mistakes are made," said Morgan.

"Sixty per cent of the manufacturing workforce is over 50 and thinking about retirement. They are going to take a lot of skills with them and we will have inexperienced engineers coming on to the shop floor.

"We need to target the information we have in the best way possible for those inexperienced engineers, giving it to them line by line, particularly in aerospace where traceability is the key.

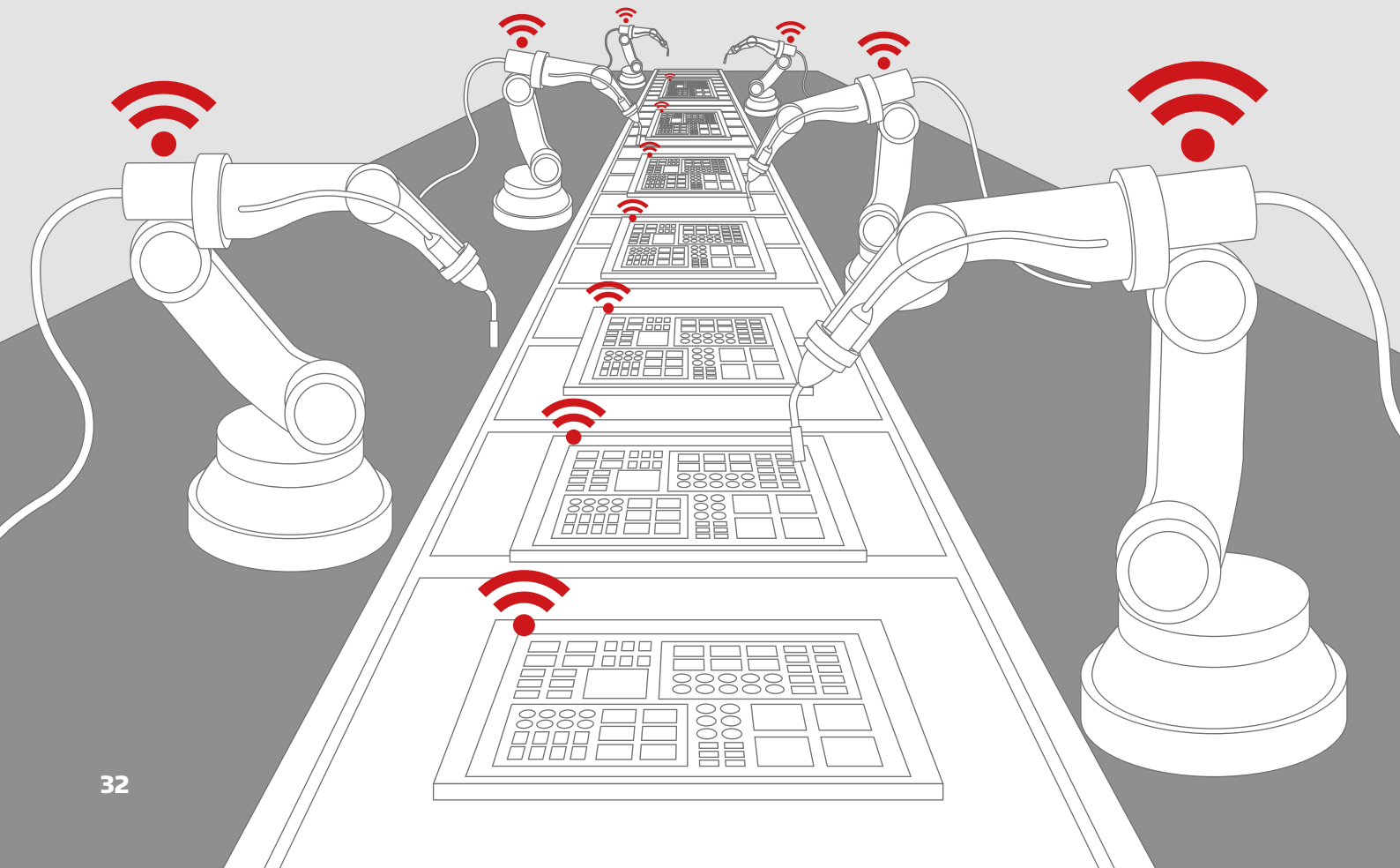
"Traditional machine tools, metrology and robots are generating a hell of a lot of data in the manufacturing environment and we are not capturing it or leveraging any benefit from it.

"If we can develop a factory information bus, and a system for tapping into that and carrying out analytics, we give operators and management the support they need when making decisions, including decisions on issues like how we integrate with the supply chain and factory systems."

Ben Morgan urged companies to focus on processes when considering how to make use of the opportunities offered by Industry 4.0.

"People can get carried away with different technologies, but there is no point in that. You need to be process focused.

"The way forward is to understand the processes, understand the technologies and start the journey."



Expertise exists to help risk-averse companies overcome their technology fears

Austin Cook, specialist engineer for manufacturing technologies at BAE Systems

The much predicted shift from high volume production of identical products towards lower volumes with significant variation and customisation is already affecting the defence sector, according to Austin Cook, specialist engineer for manufacturing technologies at BAE Systems.

"We are seeing demand for increased endurance, lower fuel consumption, increased reliability, lower observability, greater flexibility, lower through life costs and lower production volumes," Cook told the NWAA/AMRC joint forum.

"The market is demanding greater customer choice and there is a changing political landscape which is demanding a fast time to market with reduced funding."

Cook said that while the UK was good at innovation, it was also risk averse, which affected the speed with which new manufacturing philosophies, technologies and systems were being introduced.

Meanwhile, some organisations that had faced difficulties in getting new technologies like robotics to work in the past now saw them as a threat to success, rather than an aid.

"The general view is that if we, as a country, implemented more automation, our productivity would go through the roof," said Cook.

"While the UK isn't looking at automation in the same way as Germany, there is a lot of support for helping companies to understand what the technologies can do and what the limitations are."

Cook said benefits could be gained by companies encouraging their supply chains to help themselves and by working collaboratively with them and organisations like the AMRC on technology transfer.

He cited as an example a project to install a robot cell to countersink holes in composite aircraft parts, carried out by BAE with the AMRC.

Taking into account different variants, there were 90 composite parts, each of which had to have hundreds of holes countersunk in them.

Countersinking using conventional automation would have been prohibitively expensive and a large machine tool would not have been able to keep up with demand, so the holes had been countersunk manually. That required a lot of floor space and man hours, as well as posing a Hand and Arm Vibration Syndrome health and safety risk.

The robot cell developed with the AMRC had now been installed at BAE Systems and had improved productivity, reduced costs and eliminated the health and safety risk.

"It's not about trying to automate people out of the business, it is about applying automation where it is needed, for example those repetitive processes that risk health" said Cook.

"It has been a success, based on the help and support of the AMRC and the next step is to take the process further. We can also transfer the technology to other companies."

The robotic countersinking cell at the AMRC Factory 2050.

> **"The general view is that if we, as a country, implemented more automation, our productivity would go through the roof"**
>
> Austin Cook

Great opportunities for UK advanced manufacturers who embrace Industry 4.0

Professor Sam Turner, AMRC chief technical officer

The knowledge UK-based advanced manufacturers have and the place they hold in the global supply chain could be a threat as well as an opportunity, according to AMRC chief technical officer Professor Sam Turner.

"A strong skills base makes us think we are okay the way we are and there is no need to automate," Prof Turner warned the NWAA/AMRC joint forum.

On the other hand there were great opportunities in the UK, especially in aerospace and in the North West, which was home to one of aerospace's biggest clusters.

Even the threat posed by impending skills losses could be an opportunity if it encouraged companies to build robust processes.

Prof Turner outlined a future in which companies might use their expertise to build manufacturing systems that could be exported around the world instead of simply being used to make components at home.

"We need to embed our current knowledge into systems that can be distributed globally. Rather than just making certain products or sub assembly components, we need to recognise that value is added through developing and selling manufacturing systems.

"We ultimately want to build manufacturing systems that don't just make components but deliver the programme. Engineers and people build processes, and it's processes that build parts."

Industry 4.0 technology could be used to connect the manufacturing supply chain experience with in service performance, enhancing tolerances, increasing lifespan and enabling servitisation with upgrades to components, creating a business model reminiscent to software suppliers.

Linking manufacturing data and life cycle information with in service health monitoring and fault detection could be used to enhance the consumer experience, providing automated, optimised maintenance scheduling and hardware upgrades, using additive manufacturing.

The development of 'digital twin' technology, emulating the way machines, processes and whole factories work could be used to improve manufacturing performance, optimise processes, plan future factories, detect where processes fail and evolve self-learning systems.

"Building self-learning systems that combine knowledge, physics-based models and data analytics will achieve a step change, enabling us to build processes that are near to right first time, but also learn, allowing systems to improve and evolve," said Prof Turner.

Companies with shared interests might also be able to use real time data to create even greater value for all within a supply chain.

Capturing knowledge digitally and using it to automatically generate digitised instructions remained a significant challenge, but advanced manufacturers could benefit from the use of augmented reality technology developed by the gaming industry, which was a great way to create robust semi-automation and build the foundations for best practice.

Adopt a holistic approach and avoid automation's pitfalls

Eugene Smethurst, head of design, consulting, construction, and management services provider AECOM's process and automation business.

Automation is seen by many as the solution to poor productivity in parts of the UK's manufacturing industry, with some predicting that every £1 invested in manufacturing automation would create £49 in economic output.

However, it is not always the right way to go according to Eugene Smethurst, head of design, consulting, construction, and management services provider AECOM's process and automation business.

Smethurst told the NWAA/AMRC joint forum that investment in expensive equipment could be a mistake, if a company failed to optimise not just the process and equipment, but all the infrastructure that supports it and issues like project lifecycle management.

"Automation is a tricky subject," said Smethurst. "A very complex machine that looks like it is doing lots and lots of work can be less efficient than five machines that can be reconfigured very quickly. You have to be very careful about technology selection.

Process led design had to take into account buildings, business information and employees. There was no point installing automation if a company's design team was not designing for automation or the supply chain was not producing accurate parts that could go straight onto the production line.

Smethurst urged companies to break down their production facilities into individual cells and study it using digital twin technology to determine whether equipment they were planning to invest in would be fully utilised.

Companies implementing Industry 4.0 technologies needed to consider interoperability, the data they already had, the data they would need and how to analyse that data.

"One of the first things to talk about is interoperability. If you don't understand how you connect one thing to another and work out how they are going to talk to each other, Industry 4.0 will fall apart," said Smethurst.

"If you don't put in data analytics that can find patterns and is predictive, there is no point in having the data," he added.

Ocado, Amazon and Google cast new light on manufacturing's opportunities

Ben Morgan, head of the AMRC's Integrated Manufacturing Group

A grocery delivery business that has re-invented itself, the world's leading e-tailer and top search engine all offer important pointers for manufacturers getting to grips with the potential benefits of Industry 4.0

Ocado started out delivering groceries that had been ordered online, Ben Morgan, from the AMRC's Integrated Manufacturing Group told the NWAA/AMRC joint forum.

Huge expansion had driven it to look for ways to become more efficient. When Ocado found the technology it needed wasn't available, it had partnered with innovation specialists to develop a bespoke solution.

The result was the Ocado Smart Platform, a proprietary system for operating online retail businesses, that runs its distribution centres, schedules its deliveries and incorporates a 4G network communications system that can control more than 1000 robots.

The development had transformed Ocado from being a grocery logistics business to a software and technology company that was on the verge of selling its system to companies in the US and across the globe.

Amazon had developed the Dash Button, a small electronic device designed to make ordering products easier and faster. Each Wi-Fi enabled button could be configured to order a specific quantity of a specific product and could be placed close to where the product was regularly used.

"You could re-order washing powder at the press of an Amazon Dash Button on your washing machine," explained Morgan, adding: "The technology could have a significant impact on SMEs in the UK, linked to sophisticated Enterprise Resource Planning (ERP) systems, used to determine what items are running out and re-order them.

Google, meanwhile, had transformed the way people navigated their way around.

A quarter of a century ago, people used a paper-based map to plan a route in much the same way that present day companies used paper-based systems for the Standard Operating Instructions (SOIs) or Procedures (SOPs) their operatives have to follow.

Around the turn of the century, it was AA Route Planner and now Google Maps gives you the right information at the time you need it, based on your geographical location, traffic levels and any potential hazards along the route.

All three had lessons for manufacturers seeking new markets for their knowledge and expertise, getting maximum efficiency from their supply chain and realising the benefits of being able to collect, analyse and act on the large volumes of data generated from shop floor to sales, administration and purchasing.

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