quarterly journal

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The University Of Sheffield.

Advanced Manufacturing Research Centre

BOEING

The future is happening now

FACTORY 2050:
THE SMART FACTORY CONFERENCE

Pioneering Degree
AMRC Training Centre launches pioneering Foundation Degree

AMRC Korea
Official launch of AMRC Korea in Jeonju city

Titanium castings
Europe's biggest aerospace castings facility nears completion

CATAPULT High Value Manufacturing

European Union
European Regional Development Fund

The University Of Sheffield.

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Welcome to our

quarterly journal

Collaboration lays the foundation for new successes at the AMRC

The AMRC's success is built on collaboration and recent months have seen us set the seal on a series of new collaborative initiatives locally, nationally and internationally.

You will see from this latest edition of our Quarterly Journal how the AMRC is building ties with industry, research organisations and government in South Korea through the creation of AMRC Korea.

At the same time, we have signed an agreement with the Shanghai Academy of Spaceflight Technology (SAST) to work on technical issues linked to China's space programme.

The launch of AMRC Korea builds on the success of a series projects with the Korea Institute of Carbon Convergence Technology and other Korean high-value manufacturing R&D institutes and companies.

AMRC Korea will develop that collaboration in a number of fields, all focused on advanced manufacturing technologies.

Meanwhile, working with SAST involves us helping a key partner in China's space programme to find technical solutions to complex aerospace issues.

Nationally, expanding the capabilities of AMRC Castings and our Advanced Structural Testing Centre (ASTC) operations is paying dividends for British industry.

Our last journal reported on AMRC Castings' acquisition of a new machine to produce large scale, dimensionally accurate replica patterns from polystyrene.

In this Journal, you will see one of the first jobs it has undertaken will help radically reduce the cost of making containers for Britain's civil nuclear industry by replacing complex fabrications with a single casting.

ASTC's new capabilities are supporting one UK manufacturer's export successes in China, the development of new steels for aircraft landing gear and research into the quality of recycled metal powder.

Even closer to home, collaboration between the University of Sheffield School of Mathematics and Statistics and the AMRC's Machining Group is leading to the development of simulation tools for creating new, automated manufacturing processes.

One of the most exciting fruits of recent collaboration has been the launch of our pioneering Foundation Degree in Manufacturing Technology, designed to ensure bright, young people, who opt to start work straight from school, can still go on to secure a University qualification.

Industry and the University of Sheffield joined forces with the AMRC Training Centre to create the qualification, which provides advanced manufacturers with the higher skilled employees they desperately need.

It is gratifying to see these types of achievement gain the sort of recognition that led to our Factory 2050 development being asked to host a round of the Duke of York's prestigious technology contest, Pitch@Palace.

Factory 2050 is home to cutting edge research and innovation involving technologies essential for UK manufacturing's future, so it was an ideal location for a new generation of entrepreneurs to seek backing for their innovations – a fact highlighted by Prince Andrew at the event.

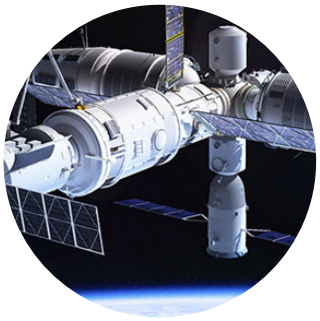
Prof Keith Ridgway, CBE.

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

The future is happening now –

AMRC Factory 2050 conference
page 12–19

Europe's biggest aerospace castings facility nears completion
page 9



Pioneering collaboration gives AMRC a role in China's space programme
page 10

New initiative targets a step change in the capabilities of robots used in aerospace
page 20

contents

> "...the most accurate large volume envelope robot in the world."
>
> Ben Morgan, head of the AMRC's Integrated Manufacturing Group

Solutions for the digital transformation

DMG MORI is promoting CELOS® and intelligent Software Solutions as an elementary basis of the transition to full digitisation of production process chains.

Industry 4.0 is dominating discussions of the future like nothing else, particularly in the machine tool design sector. As the world's leading manufacturer of machine tools, DMG MORI is supporting its customers on their path to complete digitisation with the help of the CELOS® app-supported system.

A central component of DMG MORI's customer-oriented innovation strategy is the app-supported CELOS® operating and control system, which the machine tool manufacturer introduced three years ago. Since then, it has been continuously and specifically developed. Using a common interface for machine and office PC, both manufacturing and production planning staff can manage, document and visualise the sequence of jobs and processes as well as the machine data.

Along with its tasks on the factory floor, CELOS® also enables data to be exchanged with high-level structures thanks to its open architecture. CELOS® therefore enables the customer to fully integrate machines into the company organisation while, at the same time, creating an interface between the machining process and cyber-physical production systems of the future.

The advantages for day-to-day operation are impressive; a time-saving of 30 per cent for set-up and half the effort and time required for calculating technical values or for searching for important data are examples of savings, which can be achieved with CELOS®. Thanks to the continuous development of further future-oriented applications, CELOS® ensures a trouble-free introduction of Software Solutions for Industry 4.0.

Mitsubishi eases the issue of difficult machining

Nickel based heat resistant alloys such as Inconel 718 are regarded as formidable opponents for the cutting tool industry. However, the composition of these materials sees them soften when heated to temperatures beyond 800 degrees Celsius, making them easier to machine. To efficiently carve through these difficult to cut materials, Mitsubishi Materials has now developed its innovative new line of ceramic end mills, the CESRB Series.

Whereas cemented carbide end mills deteriorate drastically when working at these temperatures, ceramic end mills retain their strength. This enables them to conduct high speed machining with large depths of cut and at high feed rates on difficult to cut materials such as Inconel. Ceramic end mills can double tool life whilst machining at feeds and speeds up to 10 times higher than conventional tools.

The concept behind this new range is that it should run without coolant at high speeds and feeds with relatively heavy depths of cut to generate higher frictional heat. By generating an increase in temperature, the component material softens and enables the end mill to work more efficiently. As such, Mitsubishi's R&D department suggests that these new end mills operate at speeds from 13000 to 26000rpm depending upon tool diameter, with feed rates in the region of 1500 to 2000mm/min. The creative geometry design reduces cutting forces and prevents the 'pull-out' effect that is common during heavy machining.

Available with a four-flute designation for pocketing and slotting operations, whilst a six-flute design is available for profile machining. Both types are available in diameters of 6, 8, 10 and 12mm with a corner radius of 0.5, 1 and 1.5mm depending on diameter.

Due to the high performance characteristics of this new ceramic range, Mitsubishi recommends that customers utilise a robust machine tool with a sturdy tool clamping configuration such as a precision milling chuck.

OSG sponsors satellite mission to tackle space debris

To create a more sustainable space environment, OSG has partnered with Astroscale, a Singapore-based start-up, to construct the world's very first in-situ microsatellite.

The In-situ Debris Environmental Awareness OSG 1 microsatellite or "IDEA OSG 1" will contribute to the global effort of cataloguing small-size orbital debris and improve future manned and un-manned space missions' safety.

Space debris is made of man-made objects such as rocket upper bodies, non-functioning satellites, metal fragments, etc. Most active satellites are situated at the Low Earth Orbit (LEO) region, and it is where most of the space debris is found. Micro-debris has the potential to inflict lethal damage to satellites and yet neither its distribution nor quantities are fully known.

IDEA OSG 1 is a 20kg microsatellite that will collect key information characterising small-size debris from 100μm or larger in the LEO's most congested areas. It measures 38cm × 38cm × 60cm and is equipped with two film penetration-type micro-debris sensors known as "space debris monitors".

Micro-debris resulting from collisions will be absorbed by the IDEA OSG 1 through the sensors. This data will be collected and analysed to help complete the mapping of small-size orbital debris to prepare for the next stage of debris removal.

As IDEA OSG 1's main sponsor, OSG also provides technical support on the manufacturing of the satellite. The flange ring of the satellite, where it will be detached from the rocket, is manufactured at OSG's Global Technology Centre in Aichi, Japan. Eighteen types of cutting tools have been used in the machining of the flange ring. As it is connected to the rocket body, precision and balance are most critical. Machining accuracy was inspected throughout the manufacturing process to ensure the highest quality possible.

The IDEA OSG 1 microsatellite is scheduled to launch in late 2016 or early 2017.

Cost of manufacture reduced with multifunction turning centre

Gosport-based contract machining firm Norjon Precision Engineering has upgraded its multi-tasking, turn-milling capacity with the addition of a Japanese-built Okuma Multus U3000 2SW from UK agent, NCMT.

Equipped with a Y-axis on the column, a motorised B-axis tool carrier and a 12-station lower turret, the twin-spindle machine is capable of 3+2-axis machining, although fully interpolative 5-axis machining is an option.

Regarding the purchase of his first Okuma, Managing Director Kevin Fox, said: "The first job onto the Multus was a family of 10 high-precision components for the defence industry, which have to be machined from 316 stainless steel billets to within 10 microns tolerance on some dimensions in batches of typically 50-off.

"We previously produced the parts in two hits on a lathe and a 5-axis machining centre, but they now come off the Okuma complete.

"It is much easier to hold tolerance without a second clamping and manufacturing cost per part is 30 per cent lower than previously due to less manual handling."

Another job that has been earmarked for the multitasking centre is the production of nitrided EN40 spline tooling for a US manufacturer of automotive test rigs. With this in mind, Norjon bought Okuma's optional gear hobbing package, which will allow the components to be produced in one hit. Again, the result will be substantial economies in production costs compared with the previous production route of turning on a lathe and gear cutting on another machine.

The ability to produce gears economically in any quantity and of any size up to the lathe's capacity on a single machining platform provides flexibility and enhanced accuracy as well as lower capital investment. The hobbing option synchronises the C-axis spindle and the motions of the tool in the B-axis to produce straight or helical splines.

Collaborative working of humans, robots and measurement technology for large aircraft parts

Alicona have developed collaborative systems with interaction between universal robots, Alicona optical metrology technology and humans to provide flexible quality assurance in a production environment that can also be used in engine overhaul and repair.

The measurement systems can be used either manually or automatically for inspection of features and quality assurance of large, round, heavy components with a weight of up to 120Kg; or large flat objects on which detailed features need to be measured.

Applications for the system include the measurement of sharp edges or break out on aircraft engine turbine blades and disks, detection of chipping along the edges, measurement of imperfections or scratches at discreet locations on the surface and verification of minimum radii; all of which are essential for safety and reliability in an engine.

Other applications include the measurement of mismatch on large turned and machined objects such as landing gear.

The automatic modes can be pre-programmed and the measurements made unattended. In manual mode the operator uses an app for precise positioning and measurement, manipulating a robotic arm and measuring sensor to the required positions. At the end, the users receive a measurement report with 'OK' and 'NOT OK' statements.

For Alicona, smart manufacturing is based on the interaction of machines and their operators. Alicona smart systems unite the measurement and machining process, allowing for automated measurements and the integration of advanced robotics. Users benefit from higher accuracy and speed of production, which increases workplace efficiencies and worker safety.

Sandvik Coromant enables production facilities to enter Industry 4.0

Cutting tool and tooling systems specialist Sandvik Coromant has unveiled its CoroPlus™ suite of Industrial Internet of Things solutions aimed at helping manufacturers prepare for Industry 4.0.

The concept is designed specifically to improve the control of productivity and costs, through a combination of connected machining and access to manufacturing data and expert knowledge.

CoroPlus™ is a new platform of connected tools and software; comprising of technologies that can send and/or receive data.

The concept makes it possible to reduce data waste and improve manufacturing processes, from pre- to post-machining, through the use of connected technology and machining knowledge from Sandvik Coromant.

"Users not only get access to Sandvik Coromant product and application data through connected software and hardware, but with sensor-equipped tools they can adjust, control and monitor machining performance in real time," says Head of Digital Machining, Göran Näslund. "The entire machine shop can be controlled via accurate on-site data dashboards, through the cloud and via integration with the user's software and machine environment.

CoroPlus™ connects into existing software environments through open APIs, offering two-way connectivity and accurate data quality."

The principal benefit for production managers is that CoroPlus™ makes it possible to optimise manufacturing through better understanding and insight into what's happening in the workshops and machining environment, on either a micro or macro level.

From a CAM programmer's perspective, connection with accurate tool and application data means that recommendations can be adapted to specific tasks. With advantages for operators of remote monitoring of machine processes and the ability to control specific sensor-equipped tools to ensure breakages are avoided and performance secured.

Lord Mayor's AMRC visit paves the way to spread the manufacturing excellence message worldwide

A visit by the Lord Mayor of London to the AMRC could help spread the message about local inward investment opportunities on a global stage.

The Lord Mayor, Lord Mountevans, was among a party who visited the AMRC before attending the Cutlers' Company's annual Forfeit Feast, in Sheffield.

The party, led by Master Cutler Craig McKay, chief executive of precision engineering group Evenort and a member of the AMRC Training Centre's Industrial Advisory Board, toured the AMRC's new Factory 2050 development and AMRC Castings.

Lord Mountevans also heard about plans to develop the UK's first Advanced Manufacturing Innovation District and Europe's largest research-led Advanced Manufacturing cluster in the Sheffield-Rotherham corridor, which is already home to the AMRC.

As Lord Mayor of London, Lord Mountevans heads the City of London Corporation, responsible for the 'Square Mile' at the heart of London, where many leading financial and professional services organisations are based.

His role involves travelling extensively around the world, in collaboration with the Foreign and Commonwealth Office and UK Trade & Investment, fostering goodwill and boosting British trade.

AMRC Chief Executive Officer Colin Sirett said: "We were delighted to be able to show Lord Mountevans our world-beating facilities.

"Investment in the UK's advanced manufacturing capabilities has never been more important.

"The Cutlers' Company plays a key role in encouraging that by bringing to the region high profile visitors who can influence major investment decisions and spread the message about UK manufacturing excellence globally."

Touring Factory 2050, Lord Mountevans saw research into robotics and automation, digitally assisted assembly and manufacturing informatics, 'intelligent' machines and processes that can monitor and optimise their operations and new production line

configurations that allow machines to be moved easily around the factory floor.

AMRC Castings recently unveiled the first custom-built steel foundry to be commissioned in the UK since the early 1980's.

The organisation is currently installing the biggest furnace in Western Europe for casting Titanium aerospace components as part of a major investment and R&D programme to enable UK companies to break into global markets for large-scale titanium aerospace engine and structural components.

Pioneering manufacturing research centre hosts Royal technology incubator

The Duke of York has praised the University of Sheffield Advanced Manufacturing Research Centre with Boeing and its award winning, state of the art reconfigurable digital factory, Factory 2050.

Prince Andrew told guests attending a round of Pitch@Palace, his prestigious technology contest, in Factory 2050: "I have watched this incredible institution grow over the years and to be able to see this wonderful new building being filled with some really clever advanced manufacturing is fantastic."

Prince Andrew was welcomed to the facility by University of Sheffield Deputy Vice Chancellor, Prof Shearer West and AMRC co-founder Prof Keith Ridgway, CBE.

Around 25 hi-tech businesses pitched their innovative ideas to the Prince, local dignitaries and leading business people and a judging panel including Prof Ridgway.

Prof Ridgway said: "It is a great honour to have one of the AMRC's facilities selected to host this prestigious event.

"We created Factory 2050 to be the home of cutting edge research and innovation involving technologies that will underpin the future success of UK manufacturing and to inspire the next generation of engineering leaders.

"That made it an ideal location for a new generation of entrepreneurs to explain and seek backing for their ground-breaking ideas and, hopefully, seeing what is already being achieved at Factory 2050 will inspire them to achieve yet greater things."

Pitch@Palace was set up by The Duke of York's Charitable Trust to support start-up businesses and entrepreneurs in the UK.

It gives potential entrepreneurs the chance to explain their hi-tech business ideas to Prince Andrew and a panel of experts, in front of an audience of investors, business leaders and mentors, in a bid to secure the backing they need to take them to the next level.

More than 200 businesses have been helped to grow since Pitch@Palace was launched, less than three years ago, with some now enjoying huge global success.

Each Pitch@Palace focuses on different areas of the UK Tech industry, with budding entrepreneurs attending a special boot camp to help them prepare.

Most events are held at St James's Palace, the sovereign's official residence and the most senior royal palace in the United Kingdom.

The Factory 2050 event was a special Pitch@Palace On Tour event, aimed at the UK regions.

AEROBATIC AIRCRAFT TESTED BY THE AMRC put through its paces at top global airshow

A spectacular aerobatic aircraft, which passed airworthiness tests at the AMRC with Boeing, has been put through its paces at the world's largest recreational aviation, experimental aircraft and aeronautics airshow.

The GB1 GameBird was the first fixed wing, light aircraft to undergo a full airworthiness test in the UK for more than 30 years.

It took to the skies above Wisconsin, in the USA, at the EAA AirVenture airshow, which is attended by more than 550,000 enthusiasts from 80 countries every year.

The two-seater GB1 was developed by Lincolnshire-based Game Composites and designed to carry out complex manoeuvres in aerobatic competitions or simply be flown for fun.

Although GB1 was designed and built in the UK, it looked as though it would have to undergo full airworthiness testing in the Czech Republic until Phil Spiers, who heads the AMRC's Advanced Structural Testing Centre (ASTC), became aware of the project.

He was determined that an aerobatic aircraft being built within 60 miles of the AMRC ought to be tested in the UK, and sure his team had the skills and experience to help Game get its aircraft approved as quickly as possible.

The Centre built a special test rig which allowed it to carry out damage tolerance and fatigue tests at an ultimate load 19 times that exerted by gravity at 72°C and simulate 20,000 hours of flying.

Following the ASTC's work and further tests on seats, harnesses, the GB1's fuel tank and baggage compartment, the aircraft completed European Aviation Safety Agency flight tests ahead of its debut at the EAA AirVenture airshow.

Phil Spiers said: "It's been a privilege to be involved in proving the safety, security and integrity of this aircraft and fantastic to see the GB1 up in the air.

"This is the first, fixed wing, independently designed and built light aircraft to be certified in the UK for 30 years. Now that we have re-established this country's capability to carry out the full range of airworthiness tests we hope other designers will chose to have their testing done here."

Following European approval, production approval will be sought from the US Federal Aviation Authority and the GB1 is being offered for sale at $399,000 for a basic model.

About the GB1 Game Bird

The GB1 has a carbon composite airframe, is 6.9 metres long, has a 7.7 metre wingspan and weighs only 585 kg when empty. It can cruise at more than 200 knots and has a range of 1,000 Nautical Miles on 320 litres of fuel, or can carry 95 litres for aerobatics.

The GB1 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.

For more information about the GB1, visit www.gamecomposites.com

Europe's biggest aerospace castings facility nears completion

A new plant capable of producing some of the biggest titanium aerospace castings in the world is nearing completion at AMRC Castings' facilities on the outskirts of Sheffield, England.

Two large scale power supply units have been installed to deliver the energy required by the organisation's new Retech Consumable Electrode Casting Furnace.

The furnace is capable of melting the 1000kg of titanium required to make a 500kg casting and has three interchangeable bodies, which give it the versatility to produce components with a finished weight ranging upwards from 60kg.

Closed loop cooling systems that prevent the furnace bodies themselves from melting are being installed, along with hydraulic and pneumatic systems, which carry out a number of functions, including removing air from the furnace and casting chambers – essential when dealing with molten titanium, which reacts violently with oxygen.

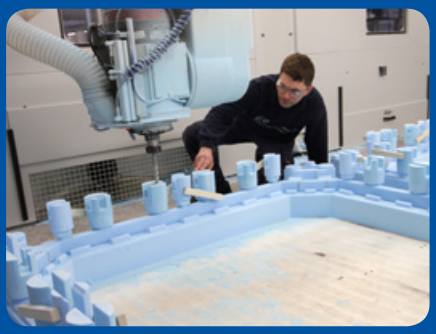
The systems are also used to rotate the furnace body to pour molten titanium into a ceramic mould in the casting chamber below, which incorporates a turntable that can spin the mould at up to 300 revolutions a minute to create a high quality centrifugal casting.

With furnace construction completed and training and cold commissioning underway, hot commissioning and the first test melts are due to begin at the end of the year, depending on when permission is given to energise the power supplies.

AMRC Castings' new furnace is part of a major investment and R&D programme, designed to enable UK companies to break into global markets for large-scale titanium aerospace engine and structural components and is backed by the UK's Aerospace Technology Initiative (ATI); its innovation agency, Innovate UK; and High Value Manufacturing Catapult.

In the past, only the United States is believed to have had the capability to cast near net shape aerospace components weighing up to 500kg.

AMRC Castings investment could help cut nuclear waste storage costs by millions



A new investment that significantly increases AMRC Castings' ability to produce large scale castings with a superior surface finish could help to radically reduce the cost of storing nuclear waste.

AMRC Castings recently installed a bespoke CMS Poseidon five-axis CNC machine to produce large scale dimensionally accurate replica patterns from polystyrene.

The machine was acquired with backing from the UK's innovation agency, Innovate UK, and the Aerospace Technology Institute as part of an initiative to give Britain the capability to produce aerospace castings weighing up to 500kg in titanium, 300kg in super-alloys and just under 3000kg in steel.

Further equipment has to be installed before that capability is complete, but the new CNC machine is already proving its worth, producing replica patterns to make prototype frames to fit on the top of high quality, stainless steel, nuclear waste storage vessels.

The project, for the Sellafield nuclear fuel reprocessing and nuclear decommissioning plant, is being carried out as part of the Civil Nuclear Sharing in Growth Programme.

Currently, the 1.6 metre square frames are fabricated from 30 separate pieces of duplex stainless steel sheet and bar – a costly and complex process, involving welding and detailed inspection of each joint.

By using the CMS Poseidon machine and its Replicast® and MEGAshell® technologies, AMRC Castings has created a ceramic mould into which the stainless steel is cast to produce a highly dimensionally accurate, one piece frame with the superior surface finish required by Sellafield.

"We believe we can reduce the cost of the box by a sixth," says AMRC Castings' Richard Gould.

AMRC Castings and Sellafield were brought together with the help of the Nuclear AMRC.

AMRC Korea launched before audience of South Korean business and civic leaders and academics

Around 100 guests including South Korean business and civic leaders and academics attended the official launch of AMRC Korea in Jeonju city.

AMRC Korea is a not for profit organisation which is a part of the University of Sheffield Advanced Manufacturing Research Centre Group and has been launched to build on the technological successes of joint projects involving the AMRC in the UK, the Korea Institute of Carbon Convergence Technology (KCTECH), other Korean high-value manufacturing R&D institutes and companies.

AMRC Korea has been established to develop collaboration with Korean partners in the fields of:

- Government-backed research and development projects focused on advanced manufacturing technologies.
- Technology development and consultancy services for high value technology companies.
- Industry training programmes, including industry-focused MSc and PhD degree programmes in advanced manufacturing technologies.
- Global networking between Korean companies and the 100+ industrial partners currently working with the AMRC Group's centres.

The organisation will draw on the expertise the AMRC Group has in developing advanced manufacturing techniques, technologies and processes; helping companies solve technology-related problems and supporting the development of national manufacturing strategies by building workforce skills and introducing advanced techniques, technologies and processes.

AMRC Korea's launch is already resulting in the development of projects with manufacturing partners in Korea and KCTECH.

Among those attending the launch were the British Ambassador to South Korea, Charles Hay, Jeonbuk provincial

governor Song Ha-Jin, Jeonju mayor Kim Seung-Soo, Jeonju university president Lee Ho-In and Boeing's Korea and South East Asia Technology Strategy Director Jonathan Lee.

Also present were the Korean Ministry of Trade, Industry and Energy Director Joo So-Young and KCTECH President Kang Shin-Jae. The AMRC was represented by Group executive director John Baragwanath, Composite Centre head Richard Scaife and AMRC Korea executive director Joung-Hwan Lee and lead research engineer Zeeshan Qureshi from the AMRC Composite Centre.

The launch ceremony was reported in a number of leading Korean newspapers.

Pioneering collaboration gives AMRC a role in China's space programme

The AMRC with Boeing and the Shanghai Academy of Spaceflight Technology are launching a new joint research institute to develop strong thin-walled structures for commercial rockets.

Shanghai Academy of Spaceflight Technology (SAST) is a key partner in China's space programme, which includes the development of the Tiangong 3 Space Station, scheduled for launch in 2020.

The organisation has an annual budget of $60 billion and is a subsidiary of the China Aerospace and Technology Corporation (CASC), a state-owned enterprise and the main contractor for the Chinese space program.

SAST is working with the AMRC on technical issues associated with creating strong thin-walled structures for commercial rockets. The organisation will fund mobility for academic and commercial staff to receive training in advanced manufacturing techniques and send China Scholarship Council (CSC) students to study for PhDs in Sheffield.

A Memorandum of Understanding (MOU) for the pioneering collaboration, which also includes Shanghai Jiao Tong University, has been signed by University of Sheffield Vice-Chancellor Professor Sir Keith Burnett and Professor Meng Guang, Vice-Principal of SAST.

The signing ceremony took place in Shanghai, where Sir Keith has been part of a ministerial delegation, led by Universities, Science, Research and Innovation Minister Jo Johnson.

Sir Keith said: "I am delighted that two world-leading organisations such as SAST and the University of Sheffield's AMRC with Boeing are collaborating so effectively to find technical solutions to complex aerospace issues. This is a priority area for China as announced

by President Xi Jinping, and also one of longstanding expertise at the University of Sheffield. We see tremendous potential for companies and products in both countries."

John Baragwanath OBE, Executive Director of the AMRC, added: "The AMRC is delighted to partner SAST on this new collaborative research programme, which will combine expertise in the two centres and lead to improved products and new innovations."

Professor Meng Guang said: "As the AMRC's first partner in China, I feel confident that our joint research initiatives will lead to significant advances in our human and technical capabilities."

GROUND BREAKING MANUFACTURING DEGREE SMASHES LAUNCH RECRUITMENT TARGET

A pioneering Foundation Degree in Manufacturing Technology smashed its recruitment target as it welcomed its first students this week.

Kerry Featherstone,
AMRC Training Centre Head of Training

The two year, part time programme, launched by the University of Sheffield and its AMRC Training Centre, is designed to ensure bright, young people, who opt to start work straight from school, don't miss out on a University qualification.

The Foundation Degree, which can be delivered as part of a Higher Apprenticeship, also aims to provide manufacturing industry with the higher skilled employees it desperately needs and could lead to a BEng degree after a further year of part time study.

The AMRC Training Centre had been set the target of recruiting five students to the first year of the course. However, the course proved so popular with trainees and companies spread across South Yorkshire and North Nottinghamshire and Derbyshire that 20 students signed up for the first year and a further four have already registered for next year.

Students' ages range from 18 to 30, with most at the younger end. Two thirds of the students gained manufacturing qualifications at the AMRC Training Centre, while three of the students have been working in industry for some years.

The course is delivered using a blend of face to face learning - lectures, seminars and tutorials - with online and self-paced learning and support to enable the students to combine their studies while in full time employment. The programme has been designed in partnership with academic staff and employers to ensure students can graduate equipped to meet the current and future needs of the advanced manufacturing sector.

"This Foundation Degree broadens access to the University," said AMRC Training Centre Head of Training, Kerry Featherstone, speaking during a welcome event for the new students, their employers and companies considering sponsoring existing staff or recruiting new staff to join the programme.

"It gives young people who never thought of studying for a degree, or were put off by the prospect of running up debts to fund their studies, an opportunity to gain undergraduate and, maybe, post graduate qualifications while being fully employed and earning a wage.

"Manufacturers in our region and the rest of the UK desperately need people with a combination of vocational and academic skills if they are to compete internationally and this degree will bridge that gap."

Students and employers attending the welcome event at the AMRC Training Centre got the chance to meet course lecturers, who are all AMRC researchers, working with industry to develop practical solutions to improve manufacturing performance.

Employers sponsoring staff on the Foundation Degree course range from large companies such as Rolls-Royce, Alcoa and Outokumpu to smaller, local firms such as Cutting & Wear and Technicut.

University of Sheffield Pro-Vice-Chancellor for Teaching and Learning, Professor Wyn Morgan, thanked companies for their support and emphasised the benefits they and the students would reap.

"This is going to be a very challenging and intense programme," said Prof Morgan.

"The AMRC Training Centre has developed a very strong academic and technical programme that responds to what employers tell us they need, while maintaining the standards you would expect of a Russell Group University.

"Anyone who successfully completes this course and goes on to secure a BEng while continuing to hold down a challenging job in manufacturing will have thoroughly deserved their success and we are determined to provide them with the support they need."

Other speakers at the event included Foundation Degree Programme Leader Kathryn Jackson, from the Nuclear AMRC, together with Nathan Bailey, from the AMRC's Integrated Manufacturing Group and Matthew Oxley from Kostal (UK) who are students on the inaugural course.

The University Of Sheffield.

AMRC TRAINING CENTRE

INDUSTRY 4.0

The future is happening now

To drive productivity the UK needs to accelerate and integrate the manufacturing technologies and processes of tomorrow, into the supply chain today.

To achieve this, UK businesses must work together to be the driving force behind ready-for-market Industry 4.0 solutions.

This advice came from Colin Sirett, the chief executive officer of the AMRC with Boeing, as he welcomed over 150 delegates to the **Factory 2050: The Smart Factory conference** hosted by the AMRC's Integrated Manufacturing Group (IMG).

Clockwise from top: Professor Sam Turner - AMRC chief technical officer, Colin Sirett - AMRC chief executive officer, Ben Morgan - head of IMG

Sirett told delegates that IMG was filling the AMRC's newest development, Factory 2050, with the technology that is the future of automated manufacturing and assembly.

"Factory 2050 provides an excellent environment for partners to work together. During the conference we will showcase the various integrated manufacturing technologies we are developing in a series of demonstrations.

"We want you to try those technologies and make decisions in an unbiased way about what the future of manufacturing looks like for your businesses."

Sirett was joined by Professor Sam Turner, AMRC chief technical officer and Ben Morgan, head of IMG. Prof Turner told delegates that the challenge for IMG is to help businesses realise the benefits of Industry 4.0 technologies and to help put the UK in a leadership position for global manufacturing:

"We are here to present our vision for the trends, technology and business models that will define Industry 4.0. A core pillar of this vision for the forth industrial revolution is the creation of the smart factory and the cyber physical systems within it.

"We make sense of how the technologies can be applied to configure connected cells and factories; as well as how we can retrofit to transform current, as well as future performance.

"Industry 4.0 technology has arrived and industry needs to address the changing skill sets and frameworks needed for new business models.

Ben Morgan said that Industry 4.0 is all about exploring how to use big data to benefit business:

"We need to find relevant ways to use the data being generated to create knowledge and improve productivity. IMG are here to help businesses understand where manufacturing is heading, what technology is available and more importantly, demonstrating why to use it though creating real business cases and process driven solutions."

"The AMRC are showcasing the art of the possible, the advanced technologies that we have developed for purpose are on display so you can see how they are beneficial."

Interactive shop floor demonstrations from the AMRC and its partners at the conference included:

Digitally Assisted Assembly Demonstrator – showing how digital information can be utilised, both before a part is even manufactured using a virtual environment and during manufacture using projected augmented reality.

SART – TESTIA showcased SART, an industrial real-time augmented reality application designed to allow operators greater control over component assembly and installation conformity.

Drone Monitoring Demonstrator: data flow and maintenance, repair and overhaul – jointly developed using PTC's ThingWorx platform, the AMRC demonstrated how information flows from machines and can be used for real time and predictive maintenance.

Machine Monitoring and Root Cause Analysis – an example of how custom systems can be quickly developed for equipment monitoring and troubleshooting applications.

Festo Cyber Physical Systems – demonstration of an Industry 4.0 learning system with some stations from Festo's Cyber Physical Factory. It demonstrated the interaction between people, machines and data.

Deloitte Analytics suite for operations and timetable planning – demonstrating design of an analytics platform and a suite of web based tools running on the cloud, developed to enable data-mining and visualisation in order to compare, validate and inform improved Timetable Planning Rules and Asset Utilisation and predictive maintenance within Network Rail.

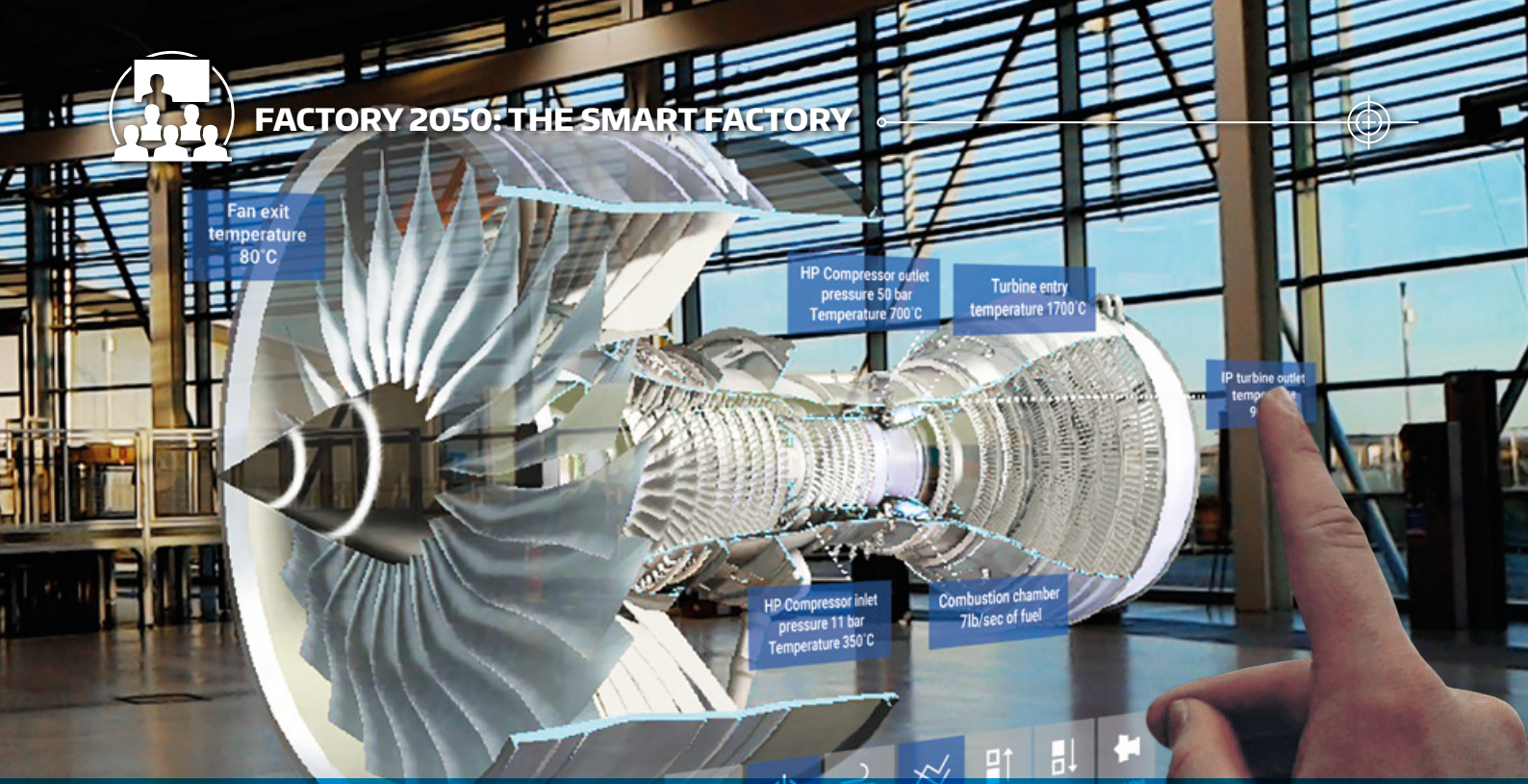
Closed Loop Adaptive Assembly Workbench – an ATI funded project between the AMRC and Meggitt plc. demonstrating the CLAAW system, which leads operators through complex assembly tasks, sometimes with no prior knowledge of the product.

Autodesk Imbedded intelligence in CAD CAM – Autodesk's Factory Design Utility demo gives a complete workflow overview including process planning over 2D to 3D layout, reality capture, and 4D timeline in virtual factory experience.

Countersinking Verification Using Data Analytics – providing a low-cost flexible method of high accuracy robotic countersinking and inspection of carbon aircraft parts; using sensors to gather data and use the results to optimise and improve the countersinking process.

AMRC Collaborative Robotics Demonstrator for Adhesive and Sealant Applications – developing the use of cobots within manual manufacturing processes to work as 'in-line assistance' robots, working in close proximity to humans and improving the efficiency and flow of a manual production line process or environment.

Factory Dashboard: Part Tracking, BMS and Energy Usage – a joint AMRC and PTC project to develop a full factory dash boarding system. Collecting data from the building management system, external weather station, energy meters at a factory and cell level and sensor data from the processes themselves. This allows factories to look at trends in energy, use, efficiency and quality levels, saving both money and time.



AMRC conference helped manufacturers peer into the future with Microsoft HoloLens

Delegates from global manufacturing companies attending the conference had the unique opportunity to interact with the first Microsoft HoloLens within a High-Value Manufacturing Catapult research centre.

The HoloLens was showcased as part of a variety of interactive demonstrations at the conference, aiming to give delegates the opportunity to interact with the Industry 4.0 technologies driving change in the manufacturing sector.

The AMRC is one of a handful of research centres in the UK to be working with the HoloLens; a self-contained, mixed reality head mounted device, capable of producing interactive, situational holograms. It is currently unavailable commercially in the UK, so the AMRC is using the opportunity to mature manufacturing processes ready for industry early adopters.

AMRC Augmented Reality Technical Fellow, Chris Freeman, said: "Along with a range of other wearable technologies such as the HTC Vive, ODG R-7 Glasses and Google Glass, we are assessing the HoloLens for its suitability to create proof of concept applications for automated assembly tasks and in-line support assistance.

Delegates saw the HoloLens demonstrated for a number of uses, including remote support and training and as a quick reference tool for complex machinery. This technology will demonstrate how engineering CAD data can be turned into full scale, movable holograms and placed within a factory layout using the HoloLens' environmental tracking.

Chris Freeman said effective and early adoption of digitally assisted assembly technologies can boost the potential of UK manufacturing:

"Engaging with new technologies early mean companies are more aware of the impact it will have on a manufacturing environment and how they can help create a robust and diverse workforce with experts in multiple fields."

"Here at the AMRC we are developing the manufacturing processes of tomorrow and promoting the most effective routes to industry; showing the manufacturing sector what impact these technologies will have on businesses in the short and medium term."

Lessons from the automotive sector can help manufacturers realise benefits of i4.0

Dick Glover, McLaren Applied Technologies

McLaren has been on a digital journey since the late 1980's, introducing various technological developments to their Formula One team such as real time data analytics, remote monitoring and decision making in the 1990s and utilising data driven design simulation in 1997.

Dick Glover, chief technology officer for McLaren Applied Technologies said these introductions are never just about the technology: "They are about optimising performance of people, processes and complex systems, through design, simulation, operational intervention and actuation of control systems, all driven by data and insight."

Gathering vast amounts of data used for offline simulation via an integrated data platform, McLaren provide a data driven decision making resource for race track engineers.

The V6 turbo hybrid system used by McLaren in Formula 1, developed in collaboration with Honda, now includes an integrated powertrain control system. The system sends instantaneous data about the car back to the team's Mission Control which is optimised by the system for technicians over a race weekend.

The data can be used by technicians to gain an advantage and control the race by predicting measurable outcomes, helping them to decide on a course of action or intervention that has the likelihood of the best outcome.

"Data drives all of our processes, it influences the strategy used in our races and is crucial to help us in our decision making," added Glover.

"Data gives us the flexibility to make design interventions for next season's cars, or even the car that appears in the next race. We can simulate these changes and run them alongside historic data to predict how they will affect future performance for continuous improvement."

Automation of decision making and improvements to productivity through simulation is not unique to Formula One. Glover said: "We obviously aren't a manufacturing company, but what we've achieved in the past 20 years in McLaren racing shows the level of cross-fertilisation and working together required to truly embrace the changes of Industry 4.0 to realise the benefits."

Securing data will give confidence to businesses engaging with industry 4.0 technologies

Stuart Moulton, CISCO

As the manufacturing sector becomes increasingly connected and moves towards hybrid cloud-based strategies to store big data, the opportunities for exploitation by hackers becomes greater too.

Stuart Moulton, regional sales manager for Global Security Sales Organisation UK & Ireland at CISCO, told delegates attacks can now come from the most unlikely of places, with CISCO having witnessed an attack originating from a management system connected to a fridge:

"The explosion in hacking and its development into producing sophisticated attacks means companies have a lot at stake. Hackers have realised the value of data and attacks are now stealthy and for profit."

Moulton told delegates that 66 per cent of company boards do not believe they are adequately secured against cyber attacks and many still have no coordinated cyber security plan for data protection.

"If we can't convince, companies, manufacturers and people that data can be secured effectively, it will be difficult to adopt new industry 4.0 technologies and big data will not provide half the potential we aim for in industry," said Moulton.

"The kind of digital disruption we are seeing with Industry 4.0 provides a rich opportunity for today's well-organised, professional hackers. As our strategies and business models are in a state of flux, so is our understanding of what we need to protect. You have to think like a hacker to be able to protect your data. Where would they attack and what would they take?"

The emergence of industry 4.0 technologies means there are more connected devices such as sensors and robots throughout a factory and these factories are increasingly connected to each other. More companies are also increasingly relying on hybrid and cloud based business models to store big data over traditional physical data centres.

Moulton told delegates that businesses need to formulate a cyber security strategy that covers the whole of their operation. He said the ideal solution is end-to-end, protecting infrastructure, critical data and defending across the network and beyond, securing mobile devices and enabling secure supply chain collaboration to drive continued growth and innovation.

Industry 4.0 – a journey to the future factory

David Ramsay-Harra, Airbus

The global aerospace market is set to double every 15 years and the manufacturing sector will need to take advantage of the opportunities the industry 4.0 revolution will bring if it is to face the challenge of meeting this demand.

David Ramsay-Harra, head of innovation and development for assembly at Airbus told delegates that a large amount of aerospace manufacturing processes still rely entirely on human expertise, based around low-volume and low-rate systems of manual production dating back to the 1970's:

"Shop-floor evolution has started and has been triggered by the Internet of Things and the new digitally assisted technologies now being developed which optimise productivity and quality."

Ramsay-Harra said that the development of these new technologies will bring the opportunity to make competitive advantages, allowing Airbus to tackle challenges such as ramping up production of their single-aisle models by 50 per cent over three years.

For Airbus this shop floor evolution is taking shape as their Future Factory transformation, using Industry 4.0 technologies to build a new digital factory designed for flexibility, with progression towards automated aerospace assembly processes.

Based around human skill, the Future Factory will use augmented reality technologies to assist in assembly, integrated wireless ways of working with connected wearables such as an exo-skeletons, to improve capacity in challenging ergonomic conditions, intelligent connected clothing for paperless ways of working and smart production systems providing real time information to operators.

Ramsay-Harra said businesses need strong leadership and to be entrepreneurial to pilot and integrate the new ideas and technology that can demonstrate the credibility of the benefits Industry 4.0 can bring:

"Our vision is to go from concepts to real examples going into factories, making the art of the possible, possible. Transformation has already started and building the factory of the future will manufacture quality and drive productivity, by enhancing operator production efficiency," he added.

SMART MANUFACTURING TODAY

Simon Keogh and Sarah Black-Smith, Siemens

Digital enterprise needs to extend across the value chain to help manufacturers adapt to the challenges of changing consumer demand.

Simon Keogh, general manager of factory automation and control products at Siemens, told delegates that consumers now required mass-production pricing with 'batch-of-1' customisation and speed, so flexibility, quality and efficiency are essential in manufacturing.

Keogh said the integration of product design, development, manufacturing and servicing is key for the future productivity improvements required to drive the manufacturing sector and its supply chain.

The solution to this integration challenge is creating a digital twin of the entire value chain used for simulation of design, planning, testing and optimisation of factory layouts; with external access for stakeholder collaboration would allow optimisation of the entire design and production process.

Sarah Black-Smith, head of manufacturing at Siemens DF MC Factory in Congleton told delegates that Siemens is achieving this by implementing Congleton 2020 strategy. The smart manufacturing strategy is designed to create a hub of production for high quality electronic products that is capable of customisation and reconfiguration, to enable growth at the Siemens Congleton plant.

The business is designing a new portfolio for flexible automated production processes and introducing simulation into every step of the design and production processes.

Siemens has deployed a virtual reality environment; using it to run product concept and design reviews, allowing more effective engagement with stakeholders and suppliers and giving operators the ability to make mistakes or adapt designs without wasting resources.

Jack simulation and digital lean cell design of production cells for pre-production planning and testing was introduced to enable teams to simulate factory CAD layouts before a physical product is made and reducing lean cell design time by six weeks.

Other tools included an automated cell that consists of a robot, cobot and a human worker, which improves productivity and assists in the upskilling of those working and a robotics learning lab for engineers and technicians to gain experience using the new technology and creating business cases before new technologies are introduced on the workshop floor.

Black-Smith said: "Integrating simulation for pre-production planning and testing into the process allows us to map out our processes and outputs using prediction analysis modelling. We can now react quickly for production conditions and have the flexibility for orders and peaks in demand."

Using standards to drive innovation and ensure success in UK manufacturing

Ben Sheridan, BSI

BSI standards support and drive innovation, Ben Sheridan, the digital manufacturing lead for BSI told delegates.

Sheridan said the role of standardisation can be to support the development of new products, processes and frameworks, and new approaches are needed to deal with complex issues such as the digitisation of manufacturing.

BSI have partnered with the Future Cities Catapult to create a Cities Standards Institute, a partnership to build on guidance and standards to help cities move towards the delivery of digital services. This guidance is already receiving recognition from countries such as India and China, leading to potential export opportunities for UK companies.

The digitisation of manufacturing offers flexibility, personalisation and tailoring of products and services, giving UK manufacturers competitive advantages in global markets. However Sheridan said the transformation to digital manufacturing must be a collaborative one, as those working in isolation were less likely to realise the opportunities for value chain optimisation.

Potential future guidance from BSI will help manufacturers to adapt digitally in collaboration with others and create scenarios for digital adoption of smart factory technologies, including automatic e-sourcing, real time factory scheduling, flexible factory automation and complete product and lifecycle management.

Sheridan said that Germany is ahead of the UK in standardising digitisation and its RAMI 4.0 standards will end up being the basis for the international adoption of Industry 4.0 technologies.

As the UK is yet to have much manufacturing input, Sheridan called delegates to action to work with the BSI and the High Value Manufacturing Catapult to develop UK standards and frameworks. Sheridan said this will be the best way to ensure UK manufacturers have a seat at the international table and to lead in manufacturing innovation on a global level.

Cloud computing tools deepen our understanding of how big data improves decision making

Stefan Ghose, Deloitte

For Deloitte, Industry 4.0 is about physical data feeding the digital world, Stefan Ghose, manager of analytics and information management at Deloitte told conference delegates. That data can be used to gain new insights and knowledge for improved decision making through cognitive computing tools.

Deloitte create digital infrastructures and bespoke cloud-based analytics solutions for business. Using modular operating products available from providers such as Amazon Web Services, they assist businesses such as Network Rail to develop ways to improve timetable planning and reduce rail delays.

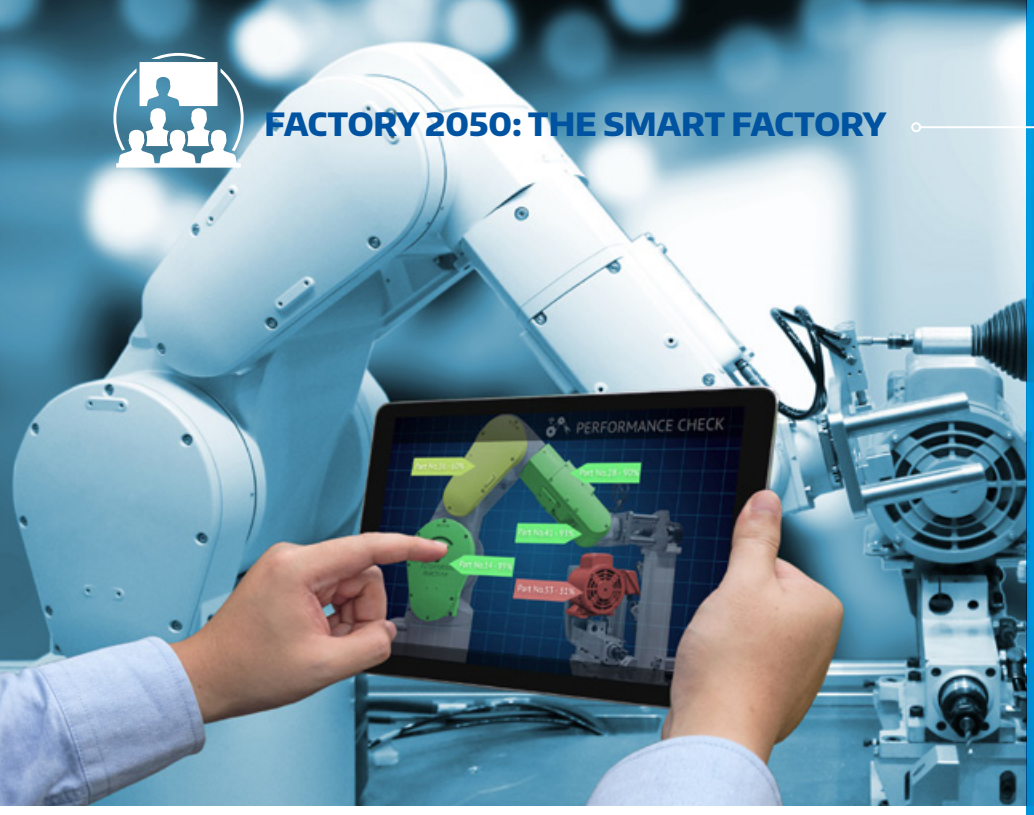
Network Rail required a new method of processing data to test the hypothesis that a third of all delays on the rail network were caused by faulty assets. Deloitte built an online cloud repository, integrating a variety of siloed data sources and created a visual dashboard and suite of analytics tools that enabled visualisation of the data.

These cloud based tools allowed Network Rail to query actual running times of trains against data such as timetable planning rules, location and stopping-time analysis and train safety distances. It also reduced time spent analysing data to investigate route causes to delays, processing 18 months of data in minutes.

Ghose said creating visualisations of data gave the user a deeper understanding, knowing when and where delays were happening: "Network Rail can now focus investment on assets and implement predictive maintenance processes to reduce delays, enhance running time performance and improve decision making."

Ghose told delegates these digital solutions need to be used within the manufacturing sector for improvements such as dynamic re-routing of production flaws, adding: "This kind of optimisation would use the same set of principles to organise data storage, saving time and money and delivering value for manufacturers."

> "This kind of optimisation would use the same set of principles to organise data storage, saving time and money and delivering value for manufacturers."
>
> Stefan Ghose.



How Industry 4.0 technology can impact the construction sector

Dr Graham Herries, Laing O'Rourke

Laing O'Rourke aim to deliver certainty for their clients by using the latest digital technologies to further advance design for manufacture and assembly said Dr Graham Herries, director of digital technologies in the engineering excellence group of Laing O'Rourke.

"To achieve the government Construction 2025 targets we need to invest in research and development and smart manufacturing facilities to enable faster delivery and turnaround, higher quality and offer a growing product range."

Using Industry 4.0 technologies, the integration of data can be used to create a digital twin of the entire construction process. Building information modelling can assist in the planning, manufacture and assembly of structures offsite before constructions starts.

Herries said this kind of digital engineering can be used to gain certainty about cost, quality and logistics for clients. It allows Laing O'Rourke to provide up to a 60 per cent reduction in onsite workforce and 30 per cent time saving on projects, with 70 per cent of components being manufactured offsite.

Herries also told delegates that Industry 4.0 provides a vision for the future, from integrating full lifecycle management, to longer term goals of creating completely reconfigurable factories for fully automated construction assembly.

Through an EU Horizon 2020 Factory of the Future project, Laing O'Rourke will measure, simulate and optimise the entire manufacturing process.

"The new advanced manufacturing facility being designed by Laing O'Rourke for the advanced manufacture of volumetric accommodation products will improve productivity and produce homes that have been tested in the virtual world which can be accredited and mortgaged, meeting the challenge of future demand," said Herries.

SHOP FLOOR INTEGRATION IN FIVE EASY STEPS

Mark Priestley, ATS Global

The increasing digitisation of services, integration of cyber and physical factory systems and understanding the problems, objectives and strategies for how to collect and utilise big data are all challenges to be overcome for the effective integration of Industry 4.0 technologies.

Mark Priestley, I4.0 consultant for ATS Global said businesses need to work out how far along they are on a scale of integration and monitor their facility to enable control and standardisation of manufacturing processes.

Then businesses will be able to make effective decisions to address industry challenges including reducing costs, waste and shortenings cycle and lead times.

Advocating five steps for shop floor integration, Priestly told delegates that Industry 4.0 won't solve problems, but it can be used as a tool to change business models.

Firstly businesses must work out their requirements and what they want to achieve. What data is needed and by whom? Consider also what data will be used for, to conduct preventative maintenance for machines or quality monitoring for defects?

Business owners need to set targets and understand how the changes will affect people, equipment effectiveness and management of operations, maintenance and quality and inventory.

Priestly advises businesses to look long-term for benefits and impacts of targets and not to use them as a poking stick. Assessing the value difference after achieving a target to get back to basics and create opportunity.

As different machines use different interfaces, OEMs need to demand standardisation and customisable solutions to assist in the integration of new facilities and be able to collect data in its native language and translate it, maintaining legacy systems.

Lastly businesses need to deploy new technologies and realise that cultural change is also needed to develop, deliver and embed new technology, with Priestly adding: "Prepare for change by turning the vision into a reality, using Industry 4.0 technologies to simulate and predict the future."

In a rapidly changing industrial environment, invest in the workforce to create value

Christoph Hanisch, independent consultant

To achieve the goal of value creation during the Industry 4.0 revolution, there are many other factors that are as important as the technology itself.

Christoph Hanisch, an independent consultant who worked for industrial control and automation company FESTO, was speaking to delegates about the value of human input into the manufacturing industry.

"Businesses need to identify what factors affect them economically and understand what technology will help them achieve the goal of high value creation," said Hanisch.

This goal of value creation and economic success within Industry 4.0 not only includes integrating supply chains and addressing how to make manufacturing sustainable, but also factoring in human input and the qualities they can bring to manufacturing outputs and the high value creation process.

Hanisch said Festo has done this by offering continuous educational development to create a content workforce that is productive at generating new ideas.

"Progression can support more people, but if you approach business with profit as your only margin, you will destroy that human value," he added.

"Industry 4.0 is the potential for human–robot cooperation as well as automation. We need to think beyond the technology and reinforce the value of the human perspective. Human skill is still an economic asset and therefore an important component to be fully integrated into new industry 4.0 business models."

Cognitive computing: adding smart to the factories of the future

Professor Andy Stanford-Clark, IBM UK

Smart functions like predictive maintenance can be made possible using cognitive computing, but manufacturers need to adapt to embrace the coming changes of industry 4.0 Professor Andy Stanford-Clark, a distinguished engineer for the Internet of Things team at IBM UK, told conference delegates.

"Change is coming and it will redefine the relationships between people and machines, it won't necessarily reduce jobs, but people may end up doing different jobs to what they were doing before."

Stanford-Clark told delegates that cognitive systems such as IBM Watson use semantic knowledge and analytics to mimic human understanding, reason and learning; supporting human experts to gain insights and assist in decision-making and hypothesis development.

These systems can provide the most suitable and likely solutions for a query; evolving manufacturing processes such as condition monitoring into error prevention and predictive maintenance; reducing cycle time, eliminating machine down time, quality defects and increasing output.

Cognitive analytics of big data from machines, production lines and the supply chain can also optimise production by using predictive logistics to improve efficiency.

Stanford-Clark told delegates that the only barrier to integrating this kind of technology is imagination:

"Connectivity is the first, but not the key step to developing cognitive manufacturing processes. It is the knowledge and insight gleamed from the big data generated that is valuable, not the data itself.

Industry 4.0 – end user prospective

Steven Carter, Rolls-Royce plc

Industry 4.0 is a continuation of the Rolls-Royce Plc business digitisation journey which has been part of the organisation's DNA for a long time. Steven Carter, manufacturing systems specialist for SMART Factories at Rolls-Royce plc told delegates that future developments will further optimise current digital manufacturing capabilities and overall business operational efficiency.

An important part of this digital journey was the development of the Rolls-Royce Advanced Blade Castings Facility sited on Rotherham's Advanced Manufacturing Park, to manufacture single crystal cast high pressure and intermediate pressure turbine blades.

The new facility enabled high volume manufacturing with a high level of automation, utilising the latest measurement technologies, integrated as a connected enterprise with manufacturing system capabilities to optimise processes and operational efficiency.

Carter told delegates that for Rolls-Royce 'End User Prospective' future developments will focus on an array of different sub themes, including further developing the cyber-physical production systems theme and digital thread throughout the business with the application of predictive analytics.

Other advances also include further developing the SMART connected factory capabilities theme and transferring digital technology capabilities to the external supply chain.

"New emerging standards from industry standard bodies, such as the Reference Architecture Model Industrie 4.0 (RAMI4), will give structure and common terminology for technology providers developing new hardware and software solutions; which is important for business end users integrating these standards into their business data work flows and OT-IT architecture solution design."

NEW INITIATIVE TARGETS A STEP CHANGE IN THE CAPABILITIES OF ROBOTS USED IN AEROSPACE

Work has begun on a £500,000 project to give the UK aerospace sector a unique capability for high accuracy robotic machining.

The Flexible Robotic Machining in High Accuracy Applications project has been launched by the AMRC with Boeing, with backing from the Aerospace Technology Initiative (ATI).

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

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

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

The organisation is having the latest accurate rotary encoders incorporated into its Kuka 'Titan' robot and linked to the robot's Siemens 840D controller.

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

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

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

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

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

> "...the most accurate large volume envelope robot in the world."
>
> Ben Morgan, head of the AMRC's Integrated Manufacturing Group

University of Sheffield statisticians and AMRC engineers collaborate **to create new autonomous manufacturing processes**

L to R: Hatim Laalej, Dr Keith Harris and Tom McLeay, head of core research - machining

A pioneering collaboration between the University of Sheffield School of Mathematics and Statistics and the Machining Group of the AMRC with Boeing is developing simulation tools that can be used to create new automated manufacturing processes.

Identifying the scope for the use of statistics to improve the outcomes of manufacturing processes, the School of Mathematics and Statistics approached the AMRC's Machining Group to work on a project with the aim to create time and cost efficiencies by automating the selection of cutting parameters for machining titanium components.

"The challenge is to do this by creating a process that is robust against the variations in material properties," said University of Sheffield Professor of Statistics, Jeremy Oakley.

"The problem manufacturers have when machining material such as titanium, is that the material properties can vary from one batch to the next and require new cutting parameters.

"However you would not necessarily know they have changed until identified in the quality checks of finished components," he added.

AMRC Machining Group Project Engineer, Hatim Laalej, said: "The variation in material batches not only affects dimensional accuracy and surface quality of a finished component, but also tool life during machining, all which contribute to waste and scrappage.

"At the moment a machine operator observes the cutting process at pre-determined times, manually stopping the machine to check on the cutting tool, but this can be a costly process and relies on the experience of the machine operator."

The AMRC Machining Group conducted physical cutting trials on batches of titanium alloys with different properties, and used an orthogonal peripheral climb milling operation to collect data such as temperature, cutting forces and vibration. A finite element (FE) model which replicated the machining process was also used to extract the same data through simulations of the process.

University statisticians used the output data from the cutting trials and FE model to identify robust optimal cutting parameters to use during the manufacturing process, which allow for the uncertainty of the material properties changing between batches.

Project Research Associate, Dr Keith Harris from the University of Sheffield said it was fairly new to use this kind of statistical modelling within manufacturing:

"The challenge here is in how to summarise large amounts of data from multiple sensors and integrate the data with the FE model predictions to get useful, usable results. One aim is to identify correlations in the data to predict the average lifetime of a machine tool."

Following the identification of optimal cutting parameters, the second stage of the project involved tool wear tests successfully completed at the AMRC. Sensor data from these experiments was used to develop a statistical process control (SPC) strategy to automate the decision of when to replace the cutting tool.

A feedback adjustment method is now being developed for taking corrective action to prolong the life of the tool: "This will allow the tool piece and machine to react to the properties of the material and automate the decision to adjust the cutting parameters independently; without the operator having to stop the process," added Prof Jeremy Oakley.

Project Engineer Hatim Laalej, said: "A fully automated system could be applied to any manufacturing processes outside of the titanium milling process. This will ensure the quality of components is standardised, no matter what the variations in the properties of the material and will save manufacturers time, cut waste and minimise the financial cost of producing any component."

AMRC Advanced Structural Testing Centre

partners with Gripple UK to drive industrial innovation

A Sheffield-based world-leading manufacturer of wire joining and tensioning systems has partnered with the Advanced Structural Testing Centre (ASTC), part of the AMRC with Boeing.

Gripple UK have been working with the ASTC to develop a new test rig with the capability to conduct longer and more accurate tests on the struts produced for their seismic bracing systems.

Engineered to brace and secure non-structural equipment and components suspended within a building, such as pipework or cable trays, the systems help minimise damage from earthquakes to vital infrastructures in factories and businesses all over the world.

The ASTC have conducted previous testing for Gripple struts, but as the product development process moved forward, Gripple required a bespoke testing solution to further test the rigidity of the struts and their ability to resist buckling under the forces of seismic activity.

Head of the ASTC, Phil Spiers, said: "We worked with Gripple to develop a new test rig tailored to their design specifications, and capable of conducting longer and more accurate loading for better control of the testing process.

"The five metre tall daylight test rig was constructed in its entirety here at the AMRC, using a smaller actuator and load cell than used previously and completed with a new hydraulic control unit supplied by Advanced Hydraulics through Systems Services."

The bespoke rig is capable of testing components up to approximately 4m long and can exert loads from four to 200 kilonewtons. The range allows for the application of large tensile and compressive loads, but its lower range allows for smaller loads, offering precision control during testing, vital for testing larger struts.

The testing will ensure Gripple's product development programme continues to create components of the highest quality for a range of uses, which are market leaders in their field.

Gripple Design Engineer, Simon Davis, said: "Gripple had already worked with ASTC to test and approve our innovative seismic bracing range, however further development of the product range demanded a bespoke test rig.

"We partnered with ASTC to develop the Seismic Test Rig which greatly increases the range of products we can test and develop. The ASTC were able to provide not just a UKAS accredited testing facility but an experienced team that delivered the test equipment bespoke to our needs.

"Having the facility local to us in Sheffield has significantly improved our flexibility ultimately helping reduce time to market. Gripple look forward to working with ASTC in developing our next range of innovative seismic products."

Phil Spiers added: "The partnership between Gripple and the ASTC provides us with the opportunity to enhance our capabilities for the future. Investing in a new control unit, means in the future we are now able to run two distinct and separate tests, with separate hydraulic supplies simultaneously, thanks to investing in new equipment for our work with Gripple.

"Our partnership is also a fantastic example of how our work here at the AMRC is industrially driven for the benefit of the local economy and how our research can keep local manufacturers competitive."

Edward Allen, ASTC apprentice

TESTING TIME FOR APPRENTICE HELPS THE AMRC EXPAND ITS SERVICES FOR EXPORTERS

Specialists from the AMRC with Boeing are helping city centre steel fabricator A K Orme & Sons, a Sheffield based company, to export strengthening rings to China after expanding their testing capabilities.

The AMRC's Advanced Structural Testing Centre is also using its new capabilities to support projects developing new steels for aircraft landing gear and investigating the quality of recycled metal powder.

Advanced Structural Testing Centre (ASTC) head Phil Spiers says the expansion is the result of collaboration between different AMRC departments and the skills of ASTC apprentice Edward Allen.

"Our tensile testing services were limited by the need to have test pieces manufactured elsewhere," says Spiers.

"It was taking a long time to turn them around. Ed was in his final year as an apprentice, so we got him to refurbish an old CNC machine we had been given, which allows us to make test pieces ourselves.

"We have also invested in a bench top CNC machine which can make even smaller test pieces and, while some of us in the Testing Centre have machining experience, none of us has used CNC machines, so Ed is now going to teach us.

"He's done a really good job and it means we can get on with the job of supporting local businesses, giving them a far faster turnaround."

Refurbishing and recommissioning the old CNC machine was quite a challenge, not least because it had stood idle and full of old oil for years, but that wasn't Edward Allen's only challenge.

A K Orme's Chinese contract involves creating rings by cutting steel rods to length, bending them and welding the ends together. The Arundel Street company's client wanted the weld strength measuring, which meant cutting the welded section out of the ring and machining it so that the tensile strength could be measured perpendicular to the weld surface.

"I had to cut the sample to length and drill the centres in the right place, which meant making accurate jigs" says Edward Allen.

"Milling metal jigs from steel would have taken weeks and been expensive. Fortunately, I was able to design the jigs on our CAD systems and feed the data into the AMRC Design and Prototyping Centre's additive manufacturing machines to rapidly make polymer jigs."

More shared AMRC resources came into play when Allen used the AMRC National Metals Technology Centre's highly accurate cut off machine, before transferring samples from the rings to the recently refurbished CNC machine.

"I had to program the machine the old school way, putting the code in by hand, but the experience was really worthwhile," says Allen.

The experience set him up for the next challenge – making test samples the size of a little finger from sections he cut from a finished landing gear component as wide as a human thigh.

"I'm really pleased with the results of expanding our capabilities," said Phil Spiers.

"It shows we are still doing what we were set out to do when the AMRC was founded – working in collaboration to maximise what we can do to support local companies in global markets.

"Now, we are looking at how A K Orme might use non-destructive testing to check the welds on the rings. Ultimately, that will do us out of a job, but we don't mind that if it is a better solution for the client."

Customised nozzle and laser systems expand additive manufacturing's capabilities

New technologies developed for laser-based additive manufacturing (AM) systems could make it easier to create superior components with a previously difficult to achieve range of properties and improve the quality of parts made by Direct Laser Deposition.

Dr Ing Frank Brückner, head of Additive Manufacturing, Fraunhofer Institute for Material and Beam Technology IWS

The new developments were outlined by Dr Ing Frank Brückner, head of additive manufacturing at the Fraunhofer Institute for Material and Beam Technology IWS, speaking to researchers from the Nuclear Advanced Manufacturing Research Centre and the AMRC.

Dr Brückner outlined work on powder and wire deposition technology, carried out at the Institute, which has also played a significant role in the development of hybrid machine tool technology by DMG Mori, one of whose hybrid machines was recently installed at the AMRC.

The Fraunhofer Institute has developed a nozzle system which can feed up to four different powders into a Direct Laser Deposition (DLD) machine.

The system could be used to create a component with a carbide core and a combination of soft and hard metals or a combination of corrosion and wear protection for components used above and below the water in offshore energy applications.

"We can build up functionally graded materials to adjust the properties of the component, with different metals in one part and simply a sharp transition between them," said Dr Brückner.

When it came to wire deposition, the Institute had taken the opposite approach, splitting the laser beam so that laser light surrounded the centrally fed wire, instead of powder being fed from a series of nozzles around a central laser beam.

Splitting the beam into three produced good results, allowing the machine to change direction without compromising the smoothness of the component's surface or producing any spatter.

"Powder has higher deposition rates, but, in some cases, it is better to go for wire. It might be a slower, but cleaner process," said Dr Brückner.

The largest diameter wire that could be used was around 2mm, after which it became difficult to feed. The range of standard wires available currently is also not as wide as the range of powders and it was better to use powder for brittle materials like carbides. Wire has a strong advantage related to material efficiency because all filler material goes into the workpiece without any overspray.

Dr Brückner predicted a major role in the future for hybrid machining, combining additive and subtractive manufacturing.

The 'Buy-to-Fly' ratio for components made using conventional subtractive machining could be very bad – eight to one or even higher - compared with lower values, for example, two to one, for AM. In addition, AM components might have a reduced weight because of their more optimised structure.

"You can make the final part lighter and the process is more productive, saving resources, which reduces the price," said Dr Brückner.

Hybrid machining allowed a manufacturer to move between the technologies during the manufacturing process, building a part additively and then machining features which would be inaccessible when it was finished.

Additive technologies allowed medical implants to be designed that could be fitted using minimally invasive surgery or aero engine structures designed so that ceramic surface coatings could do their job more efficiently, raising the temperature the engine could run at.

"You can fabricate porous structures to reduce weight and bone like structures with a porous core and a dense skin," added Dr Brückner.

INTERNATIONAL ACADEMY RESEARCHERS MEET AT THE AMRC

Rebuilding the UK's machine building capabilities, using robots for parallel machining and designing for hybrid manufacturing were among areas for collaborative research discussed by UK affiliates from The International Academy for Production Engineering (CIRP), meeting at the AMRC's Knowledge Transfer Centre.

Dr Richard Bailey, CIRP's senior manufacturing for the future manager

CIRP is the world leading organisation in production engineering research and is at the forefront of design, optimisation, control and management of processes, machines and systems.

The Academy has restricted membership based on demonstrated excellence in research and has some 600 academic and industrial members from 50 industrialised countries.

It aims to promote research and development among its members from academia and industry to contribute to the global economic growth and well-being of society.

Attendees were welcomed by CIRP Fellow, Prof Jane Jiang, from the University of Huddersfield.

In addition to hearing a number of presentations, outlining opportunities for collaborative research, CIRP affiliates heard from Ben Morgan, head of the AMRC's Integrated Manufacturing Group about the work being carried out at its new Factory 2050 development. They also heard about the new funding priorities of the Engineering and Physical Sciences Research Council (EPSRC) from Dr Richard Bailey, the organisation's senior Manufacturing for the Future manager.

New trends in machining offer the opportunity to rebuild UK machine building capabilities

Professor Sam Turner, chief technology officer, AMRC with Boeing

Changing perceptions about what constitutes a machine tool platform could open the way for the UK to re-establish itself as a machine builder and reduce dependency on overseas innovators to provide machine solutions.

AMRC Chief Technical Officer, Professor Sam Turner, told the CIRP Manufacturing Research Day that machine designers and builders gained expertise that users could not gain on their own.

"The machine builder holds the key to the technology and there is an opportunity for the UK to rebuild its skills in the field, developing the technology and the capability," said Prof Turner.

"A disproportionate number of machines used for production and research into production methods are sourced from outside the UK and Ireland. There is a will for industry and end users to reduce their dependency on overseas innovators to provide machine solution."

Prof Turner said attempts to rebuild the British machine tool industry had to be on the basis of new developments not "me too" products or attempts to catch up with overseas manufacturers.

"What we think of as a machine tool platform may be changing and perhaps the competitive advantage may come down to software and process knowledge, as much as to creating hardware," said Prof Turner, citing production systems based around robots as an example.

In those cases, UK developers could focus on applying process knowledge, undertaking software development and adding metrology to enhance the robots' capabilities, rather than building robots themselves.

UK companies could also focus on identifying new trends in fields like ultra-accurate machining where the UK had research capabilities, but might lack manufacturing capabilities.

"There is some residual capability for machine building in the UK and a strong political and economic interest in rebuilding the capability," said Prof Turner.

Robot research could open the way to techniques for exploiting the benefits of parallel machining

Dr Erdem Ozturk, AMRC technology fellow

New opportunities for collaborative research into robotic machining are opening up as manufacturers look for ways to produce large parts at a lower cost, introduce easily reconfigurable production systems and capitalise on technologies like parallel machining.

AMRC Technology Fellow, Dr Erdem Ozturk, told the CIRP Manufacturing Research Day that robots would have a big role in the machining sector in the future, but there were a number of challenges to overcome.

"There are challenging accuracy issues because robots are more flexible, setting up and programming a robot is more difficult than with a normal machine and safety is an issue," said Dr Ozturk.

People interested in reaping the benefits of parallel machining were pushing machine tool manufacturers to develop their products so that they could use the technology, but using two robots, working in tandem could provide an alternative solution.

Research was already underway in identifying and compensating for errors in robotic milling, optimising tools for robotic machining, getting robots to work with machine tools and collaborate safely with humans.

Opportunities existed for collaborative research in the fields of sensing, applying artificial intelligence to control systems for robotic machining and metrology, Dr Oztuk told delegates attending the Research Day.

Dimitrios Chantzis, senior research engineer, Manufacturing Technology Centre

New funding for research into surface engineering from the UK innovation agency, Innovate UK, could be used to back research into new techniques for finishing and improving the performance of additively manufactured components.

Dimitrios Chantzis, senior research engineer for non-conventional machining at the Manufacturing Technology Centre told CIRP Research Day delegates work was underway on developing a polishing process using selective laser melting to improve the surface integrity and functionality of additively manufactured components.

There wasn't simply a need to develop the process, a capability for simulating post processing was also essential and there were opportunities to work together to develop a zero defect process.

Meeting the design challenges of additive and hybrid manufacture

Dr Vimal Dhokia, assistant professor of engineering design at the University of Bath

Additive manufacturing (AM) has found a niche for the development of high value aerospace, automotive and medical components, but there are still issues when it comes to producing viable parts that are right first time.

Dr Vimal Dhokia, assistant professor of engineering design at the University of Bath, said it was an 'open secret' that a lot of AM parts needed to go through secondary processing, which could sometimes be quite significant.

However, there were opportunities to improve on current methods by using a hybrid manufacturing (HM) approach, combining additive and subtractive manufacturing and metrology either on the same platform or in a logical sequence (i.e. additive followed by subtractive).

"Additive manufacturing is growing across all sectors," said Dr Dhokia.

"The global market is worth approximately $5 billion a year and is growing significantly. The UK has a strong presence in AM, but current research centres on AM, not HM, and most research is machine and process focused."

One of the major research challenges is to develop new thinking on how parts can be specifically designed for additive and hybrid manufacturing (AM and HM), said Dr Dhokia.

Dr John Erkoyuncu, Cranfield University

Research into predicting, managing and predicting the impact of obsolescence could lead to the creation of new design tools that help to make tomorrows products last longer, according to Dr John Erkoyuncu, from the Through-life Engineering Services Institute at Cranfield University.

Dr Erkoyuncu told the CIRP Manufacturing Research Day embedding through-life considerations early on could help to minimise and plan maintenance services as well as guaranteeing the performance of complex engineering systems.

Opportunities for collaborative research included developing techniques to quantify the risks of failures occurring, building in preventative and repair activities and managing and minimising the impact of eventual obsolescence.

There were also opportunities for exploring how robotics might be embedded into systems to automate inspection and maintenance and improve procedures.

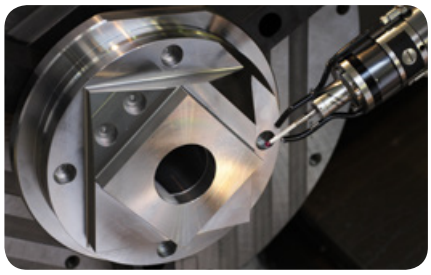
New technologies increase the pressure for the development of on machine metrology

Richard Leach, professor of metrology, University of Nottingham

New machining technologies and the advance of additive manufacturing are helping to fuel significant changes in the field of metrology.

"Metrology is changing before our eyes," said Richard Leach, Professor of Metrology at the University of Nottingham.

"The days of the Gauge Room are coming to a close and we are seeing metrology on the spot."



Prof Leach said a lack of assurance and questions over quality were a key technical barrier, preventing manufacturers from adopting new technologies, which could be overcome by novel methods of controlling processes in real time, requiring on the spot metrology.

Prof Leach highlighted three phases in the development and production of a process which each present different challenges for metrology and opportunities for research.

The first challenge came during design and prototyping when everything needed to be measured at a high resolution to allow developers to understand the process and quantify differences.

The next was to boil the process down to focus on what needed to be measured when the prototype was taken into production.

"You may have to completely redesign the process," said Prof Leach. "Things have to be done fast so that you don't hold up the manufacturing process and, very suddenly, you have a problem with the volume of data you are generating."

Finally, there was the process control phase, when data generated by metrology was used by a feedback mechanism to control the process.

Different steps could require different instrumentation and metrology researchers need to decide whether they were going to focus on the whole of advanced manufacturing, on metrology itself or metrology linked to feedback and control and the management of 'Big Data.'

Simplifying machining processes could be the key to a shift towards design for manufacture

Professor Nick Weston, general manager, Renishaw Edinburgh

Companies that want to introduce design for manufacture have been encouraged to simplify machining processes and reduce the number of machines they use.

Professor Nick Weston, general manager for Renishaw Edinburgh, told delegates attending the CIRP Manufacturing Research Day how Renishaw, the world leading engineering and scientific technology group, had used the strategy to achieve high levels of productivity and quality.

"Design for manufacture is very, very difficult if you have 10 different machines cutting metals so, over the years, we have rationalised and gone from 10 different machine types in 1990 to just two families of machines," Prof Weston explained.

The company had developed the Renishaw Automated Milling, Turning and Inspection Centre – known as RAMTIC – and was carrying out specialised machining of prismatic parts on a mid-range CNC machine with low effective labour and overhead costs.

"A single CNC operator can run eight machines, which, with our product range, is very impressive and we can carry out in house development, milling, turning and inspection on the same machine," Prof Weston added.

When it came to the introduction of a new technology like additive manufacturing (AM), Prof Weston encouraged delegates to think of it as "just a link in the tool chain."

"AM is digital investment casting," said Prof Weston, but required a different design approach, outlining how Renishaw had responded to a challenge from Empire Cycles to make a additively manufactured bicycle seat post support, by making the whole bicycle frame using the process.

The company had also helped manufacturers improve the quality and speed of injection moulding processes by using AM to create cooling galleries and fine features within mould tools, instead of standard prismatic machining.

Renishaw has developed a range of AM machines, some of which are used as part of its medical business, to make bridges, crowns, medical implants and fixtures for use in operations, but had sold many more machines than it used internally.

One of the key differences between machining parts and manufacturing them additively was how products could be qualified.

"With machine tools, you can calibrate to a national measurement system. With AM, we are generally having to make something and then measure it, said Prof Weston.

"Rather than qualifying the machine's motion, we are qualifying the part itself."

OPTIMISING MACHINING PERFORMANCE

Sandvik outlines strategy to boost productivity by raising the time machines are cutting metal

Ian Lain, Sandvik

Reducing downtime, optimising economic tool life and keeping a close eye on throughput should be among the priorities for companies keen to optimise their machining performance, according to Sandvik business development manager Ian Lain.

Making components with high added value, requiring the use of advanced manufacturing techniques, meant producing small batches, which tended to rule out using automation, best suited to high volumes, to improve productivity.

Instead, companies had to rely on complex and expensive machine tools, operated by a skilled workforce.

"We reckon that 31 per cent of the total cost of a part comes from the people employed, 27 per cent is the cost associated with the machine tool and 22 per cent is building costs," Lain told the AMRC Forum on optimising machining performance.

The challenge for cutting tool manufacturers who wanted to help customers become more productive was that cutting tools typically made up three per cent of the cost of a part and at most five to seven per cent for difficult to machine materials.

Sandvik's strategy was to try to make the cutting tools and materials costs fixed and turn the machine tool, employment and building costs into variable costs, said Lain, adding: "If you can get more parts through in the same time, the cutting tool and raw material costs remain the same and you make better use of the fixed costs."

According to Lain, companies are typically only adding value by machining components for a quarter of the time their facilities are operational.

A number of measures could be taken to increase productivity and competitiveness by increasing the percentage of the time that components were being machined.

These included maximising tool capacity, using quick change tooling and rapid set up systems like Sandvik's Coromant Capto, EasyFix and QS systems, reducing cutting cycle times by optimising metal removal rates while retaining economic tool life and employing on machine measurement.

Opportunities open up for suppliers who can help aerospace giants meet demand and control costs

Denzil Lawrence, Boeing

The aerospace sector is continuing to grow and provide opportunities for UK suppliers who can help aircraft manufacturers satisfy increasing demand while controlling costs, according to Boeing's Denzil Lawrence.

"Aerospace is a very resilient sector," Lawrence told the Forum. "We are still confident that it is a good sector to be in and a growing sector with the biggest growth coming from the Far East and Asia."

Competition to supply that market is increasing, with new entrants like COMAC emerging in China and talks of a potential alliance between Russia and China.

The priorities were price, safety and performance, including fuel efficiency, reliability and maintainability. Aircraft manufacturers and their suppliers needed to reduce their costs in order to be competitive, while increasing their capacity to meet challenging new delivery targets.

"We are heavily reliant on the supply chain – 65 per cent of an aircraft comes from the supply chain and we need the supply chain to help us deliver more aircraft, at lower costs," said Lawrence.

Aircraft builders recognised they needed to improve their supply chain management and to react faster to the innovations companies in the supply chain were creating.

Lawrence urged smaller producers to develop closer links with larger suppliers.

"In 2015, Boeing spent £1.8 billion in the UK. Most of that spend was at a systems level, rather than component level, with our top UK suppliers managing their own supply chains. Make sure you know who those systems companies in the UK are because the majority of what we spend in the UK will continue to be at that level," he advised.

Structured approach to identifying weak links and partnership can bring a step changes in performance

James Needham, AMRC Machining Group

Identify the weakest link in any machining process and you have the key to what could be major improvements in performance, according to James Needham, head of applications with the AMRC's Machining Group.

Finding that weakest link lies at the heart of the AMRC's Critical Path Approach to optimisation, which begins with the current machining strategy and examines limiting factors such as vibration, tool wear, geometric accuracy, surface finish and integrity and part movement.

In addition to studying the limits on productivity and exploring possibilities for improvement, the approach also examines how the process fails if it is pushed harder.

Key technologies underpinning the approach include dynamic analysis, simulation and advanced fixturing and tool design, while AMRC research into machinability and material characterisation underpins an understanding of how fast it should be possible to remove material and how a component will behave.

"The closer you get to the edge of performance, the more important effect an individual variable can have," said Needham, adding that some of the biggest successes achieved at the AMRC had resulted from bringing different suppliers and partners together to meet a particular challenge.

"When we draw together expertise from different partners we can go beyond marginal gains to achieve a step change in performance, which can help to avoid expenditure on new machines and factory extensions because you can do more with what you have got."

Examples of successes included reducing the time required to manufacture aero engine shafts by 45 per cent and manual intervention by 50 per cent, while raising the 'right first time' target.

Optimising machining performance helps precision engineers double turnover and create jobs

Jeremy Ridyard, Produmax

Optimising machining performance has helped innovative high precision engineering company Produmax double its turnover and the number of people it employs and laid the foundations for similar growth in the future.

Managing director Jeremy Ridyard told the AMRC Forum his West Yorkshire-based company had raised its turnover from £5 million to £10 million and now had the capability to reach a turnover of £20 million.

The company focuses on machining hard metals and titanium, with more than 95 per cent of its output going to the aerospace sector.

Ridyard said Produmax had used backing from the UK Government-backed Sharing in Growth programme to secure advice from the AMRC and other experts on how to get the best out of its five and six axis milling machines.

A combination of Ballbar and Tap testing enabled the company to optimise the physical performance of its machine tools, while further work focused on coolants, fixturing, cutter and tool holder selection and CAM strategies.

Studies identified problems when water was used in cutting fluids at certain times of the year, caused by the presence of pollen and microscopic plants and algae.

Further studies identified the optimum tools, holders and fixturing solutions from a myriad of potential solutions which it would have been impossible for an SME like Produmax to test themselves.

As a result, the company introduced a plunge milling strategy, which it would never have considered before, using new fixturing and a changed spindle.

Switching from a cheap cutting tool which gave reasonable performance for one operation to a top end tool also resulted in substantial savings, even though the new tool was five times more expensive.

Last, but not least, Produmax trialled different CAM systems - some of which produced "alarming" results - before settling on a system that best suited its production processes.

Each area Produmax optimised resulted in marginal gains that resulted in significant savings over a year and created capacity to meet rising demand which could otherwise only have been satisfied by a £500,000 investment in a new machine tool.

Ridyard told the Forum that the optimisation exercise had expanded Produmax's knowledge and understanding. Above all, the optimisation process had emphasised the importance of one thing.

"Measure everything!" said Ridyard.

Hilal Senuysal, researcher

Arman Zonuzi, researcher

MICRO MACHINING

Inaugural micro milling research identifies new opportunities for further development

The first research project focusing on micro milling to be carried out at the AMRC has identified a range of opportunities for developing new simulation and software tools.

Researchers Arman Zonuzi and Hilal Senuysal told attendees at a seminar in the AMRC's Knowledge Transfer Centre that micro machining had applications in fields including aerospace, watch and jewellery manufacturing, surface finishing, biotechnology and medical sectors, fuel cells production and the development of micro scale pumps, valves and mixing devices.

The technique was cheaper and more accessible than the alternative of micro fabrication using techniques like etching, electrical discharge machining (EDM), lithography and laser machining and could also benefit from the experience gained in conventional machining.

However, micro machining currently relied heavily on operator experience and trial and error.

The AMRC's first foray into the field of micro machining aims to develop ways of optimising the process using scientific methods while benchmarking its capabilities by producing a 'Round Robin' test part, developed by several institutes affiliated with The International Academy for Production Engineering (CIRP).

Researchers used a Kistler type 9317c dynamometer, mounted on the AMRC's KERN Evo ultra-high precision CNC machining centre to collect data on cutting forces as part of the project.

They also focused on the effect of feed rates and the size effect of using cutting tools down to 0.1mm in diameter.

Challenges included developing an understanding of how much force the tools would withstand when machining the aluminium test piece and how novel fixturing techniques, using a heat-activated, wax-based compound, embedded in precision paper to attach the workpiece to the dynamometer would perform.

The researchers also uncovered anomalies when using CAD/CAM and post processor software designed for macro machining to develop processes for micro machining.

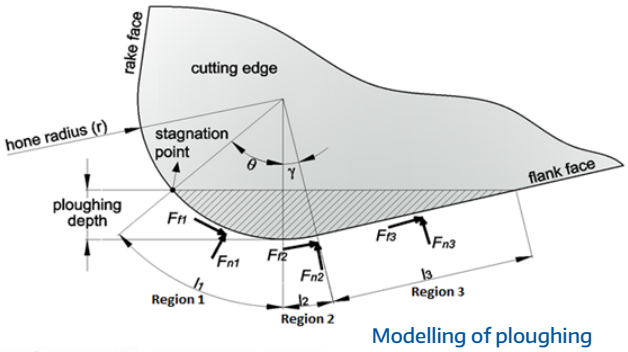
Issues included tool breakages caused by the retraction of cutting tool from the surface at full feed rate and increased cutting load in the corners of the pockets.

The researchers' work confirmed the importance of ensuring workshop temperature and humidity levels do not vary when micro machining centres are operating and also identified the need for precautions to avoid the potential hazards caused by the tiny chips produced by dry micro machining.

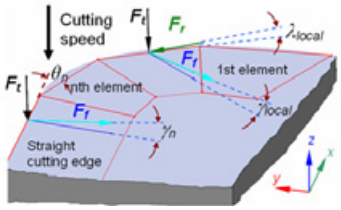
They now plan to develop simulation and optimisation techniques and see opportunities for future work studying micro machining using different coolants and workpiece materials, developing process simulation software tailored to the challenges posed by micro machining.

THERMO-MECHANICAL MODELLING

opens way for expanding understanding while reducing cutting tests



Modelling of ploughing forces in machining



Semi-Analytical modelling of cutting forces in turning with nose radius

Professor Erhan Budak, Manufacturing Research Laboratory, Sabanci University

A move from developing individual models for different machining processes to creating a unified thermo-mechanical model has helped to radically reduce the requirement for cutting tests, Professor Erhan Budak told an AMRC seminar.

Prof Budak is the founder of the Manufacturing Research Laboratory at Sabanci University, based on the outskirts of Turkey's most populous city, Istanbul, a fellow of The International Academy for Production Engineering (CIRP) and a recipient of CIRP's Taylor Medal, presented for research of outstanding merit.

He told the seminar in the AMRC's Knowledge Transfer Centre that once a thermo-mechanical model had been calibrated it was very accurate, allowed users to reduce the number of cutting tests by nearly an order of magnitude and removed the need to carry out investigation for different cutting parameters.

In recent years Sabanci's Manufacturing Research Laboratory had used the model to study the formation of the third deformation zone, where contact between the cutting edge and work material resulted in edge forces, which can be especially important for micromilling.

The Laboratory has also started using the model for calculating and predicting temperatures on the cutting edge and inside the material of the tool.

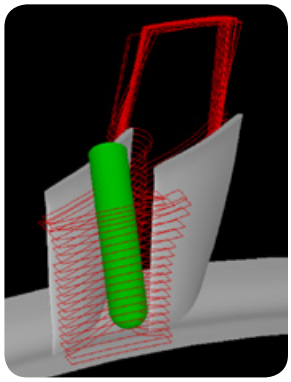
The model allowed users to vary feed rate to achieve a constant force, torque or power resulting in reductions of 25 to 30 per cent in roughing cycles in multi-axis milling operations and to predict and trouble shoot problems like tool breakage.

"When it comes to feed rate optimisation, most software is based on material volume and doesn't take cutting mechanics into account. That whole approach is based on cutting volume, but we know physical characteristics are not linearly dependent on volume," said Prof Budak.

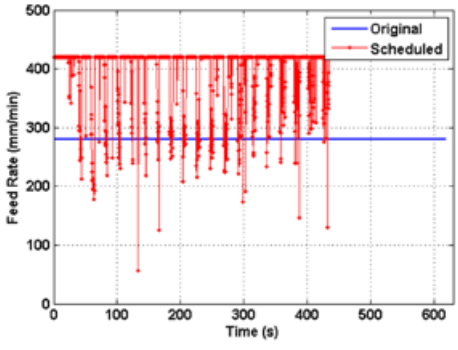
With applications like broaching, tool design was highly critical where almost all the parameters were built into the tool; tools were expensive and lead times could be as long as six months, so optimising the tool design was very important.

Similar to milling, processes simulating broaching could reduce the forces, deflection and stresses on the tool resulting in a 25 per cent reduction in cycle time.

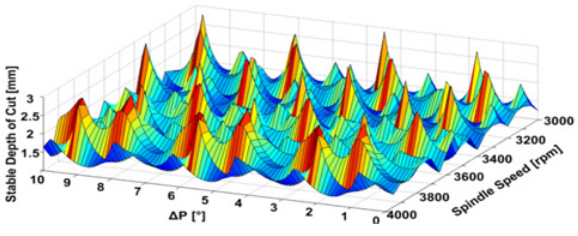
Prof Budak also explained how using structural modification matrix manipulation could help to determine stability conditions for machining thin walled parts, while the Sabanci Manufacturing Research Laboratory's modelling techniques could also be used to investigate ways of substantially increasing metal removal during parallel machining.



Point mill roughing cycle for manufacturing of turbine discs



Cutting force based feed rate scheduling



Stability limits for variable pitch cutters

AMRC Training Centre **Courses**

For further information please contact **cpd@amrctraining.co.uk**
View all scheduled courses at **amrctraining.co.uk/course-calendar**

10th January
Combating Corrosion
– ENERGUS, Workington
The course aims to provide delegates with a full understanding of the principles of metallic corrosion and prevention mechanisms appropriate to a variety of applications.

17th January
Metals Processing & Manufacturing Technologies
– AMRC Training centre, Rotherham
This course outlines the primary and secondary processing of the major industrial metals and the downstream processes used to engineer finished components.

30th January – 2nd February
Introduction to CNC Milling
– AMRC Training Centre, Rotherham
A four-day introduction to the basic concepts of CNC milling and typical applications in today's modern engineering environment.

31st January
Non-Ferrous Alloys
– AMRC Training centre, Rotherham
A technical course describing the production, features and applications of aluminium, copper, nickel and titanium alloys.

1st February
Introduction to ISO 9001: 2015
– AMRC Training centre, Rotherham
A one-day overview of the key features and requirements of this quality management system.

6th – 9th February
Introduction to CNC Turning
– AMRC Training centre, Rotherham
A four-day introduction to the basic concepts of CNC lathe-work and typical applications in today's modern engineering environment.

New **partners** at the AMRC with Boeing

Dontyne Systems offers software and services aimed at the optimum production of gear components and their use in the transmission industry.

Schunk offers the world's largest range of clamping technology and gripping systems and the broadest range of standard gripper components on the market.

XpertRule specialises in capturing knowledge from domain experts and combining with data analytics and machine learning to optimise and improve manufacturing method/process.

Keep up to date with all the latest news from the **AMRC with Boeing**

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