

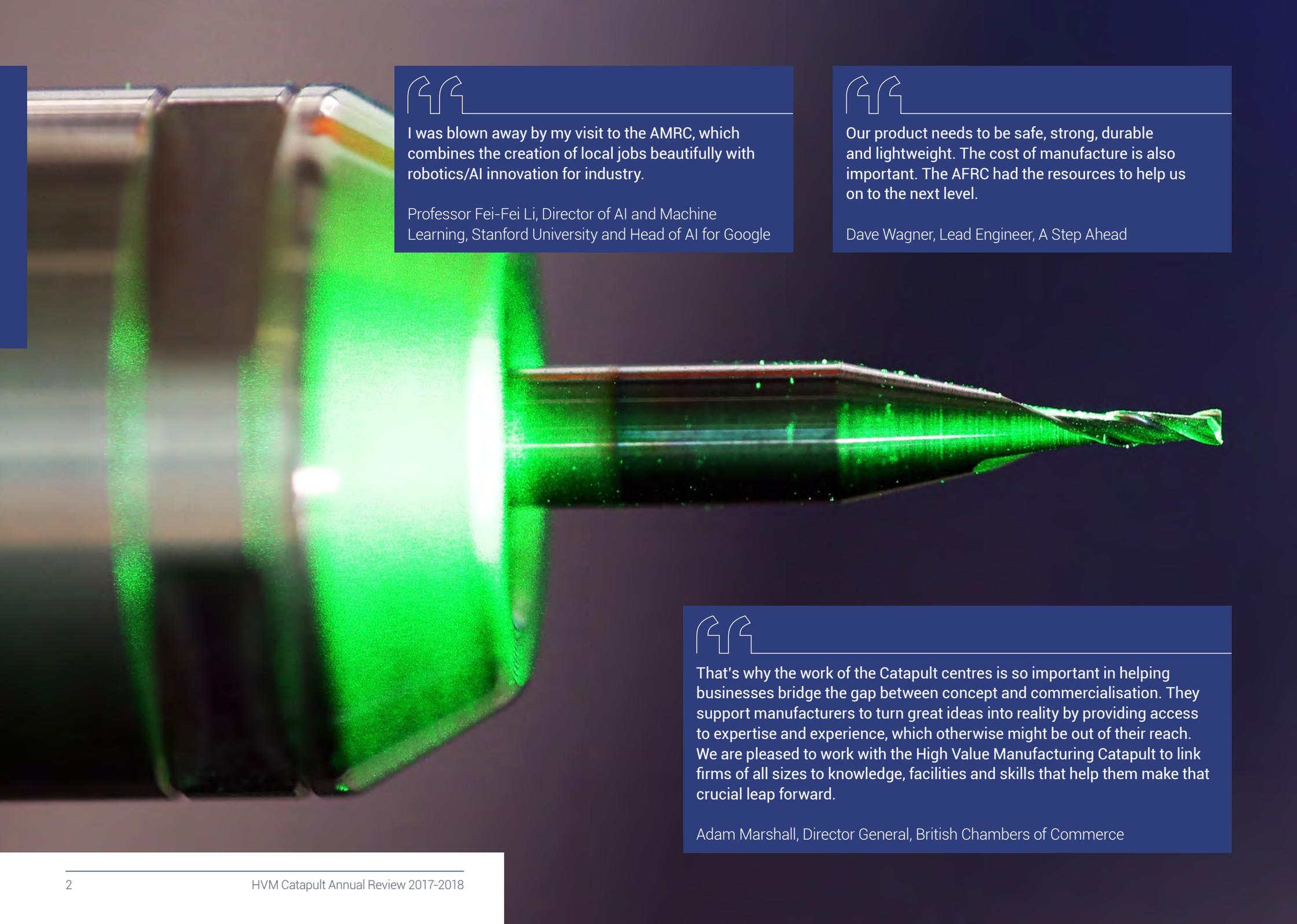
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High Value Manufacturing Catapult
Annual Review
2017-2018

2017-2018



Seven world-class
centres of industrial
innovation



I was blown away by my visit to the AMRC, which combines the creation of local jobs beautifully with robotics/AI innovation for industry.

Professor Fei-Fei Li, Director of AI and Machine Learning, Stanford University and Head of AI for Google



Our product needs to be safe, strong, durable and lightweight. The cost of manufacture is also important. The AFRC had the resources to help us on to the next level.

Dave Wagner, Lead Engineer, A Step Ahead



That's why the work of the Catapult centres is so important in helping businesses bridge the gap between concept and commercialisation. They support manufacturers to turn great ideas into reality by providing access to expertise and experience, which otherwise might be out of their reach. We are pleased to work with the High Value Manufacturing Catapult to link firms of all sizes to knowledge, facilities and skills that help them make that crucial leap forward.

Adam Marshall, Director General, British Chambers of Commerce



For an SME to be able to access this technical level of knowledge to develop a project or resolve manufacturing issues is incredible. To have access to an organisation that is currently developing the ideas and processes for some of the most advanced technical businesses in the world is a privilege.

Ken Shackleton, MD, The Cardboard Box Company



We selected CPI because of their strong reputation for innovation in bioprocess development, and the technical expertise we could access through the project... working with CPI has been a true collaborative effort.

David Gruber, Downstream Process Manager, Ipsen



The HVM Catapult can play a hugely important role in managing the risk involved in innovation. Technology is changing at an ever-faster rate and helping businesses to navigate the landscape is key to enabling them to take advantage. The HVM Catapult can really help companies understand what new technology could mean for them.

James Selka, Chief Executive Officer, MTA

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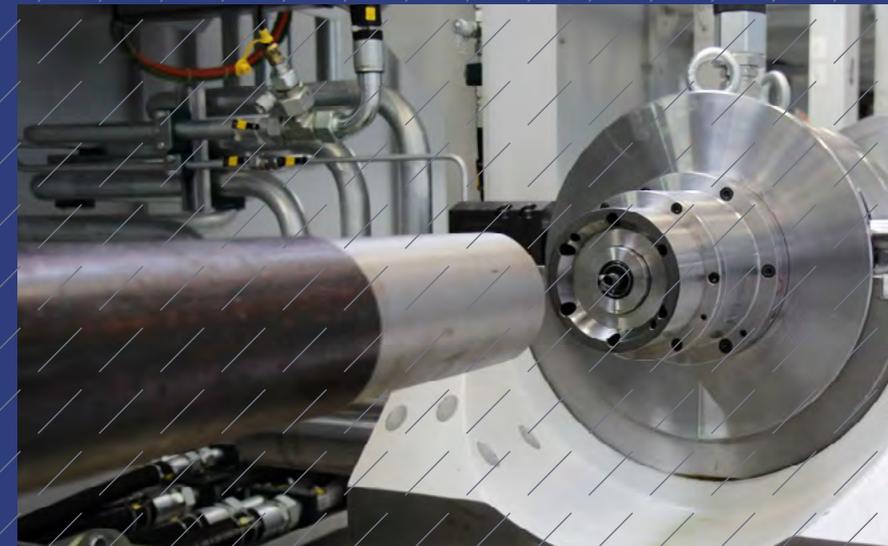
Our centres

AFRC:	Advanced Forming Research Centre
AMRC:	Advanced Manufacturing Research Centre
CPI:	Centre for Process Innovation
MTC:	Manufacturing Technology Centre
NCC:	National Composites Centre
Nuclear AMRC:	Nuclear Advanced Manufacturing Research Centre
WMG:	WMG Centre

Chairman's statement



HVM Catapult sits at the fulcrum of the relationship between our research community and innovation-hungry businesses.





Bob Gilbert

Bob Gilbert CBE
Chairman (2011 to 2018)
High Value Manufacturing Catapult



In 2011, UK businesses were facing a bumpy ride. Output growth was weak and expected to stagnate, held back by worries about the euro zone and weak demand at home. By the end of the year, the International Monetary Fund chief, Christine Lagarde, was warning that the world risked sliding into a 1930s-style slump. Doom-laden daily headlines meant confidence was low. This was the backdrop against which the High Value Manufacturing (HVM) Catapult was created with a mission to accelerate the new concepts flowing from the UK's world-leading research base into the commercial realities that would delivered a sustainable high value manufacturing future for the UK. In my time as the HVM Catapult's first Chairman I have been proud to see how the seven centres which make up the HVM Catapult – with leadership from the organisation's outstanding Chief Executive, Dick Elsy, and his core team – have seized that mission and worked with great passion, energy and focus to deliver on it.

Today, as this report makes clear, the HVM Catapult sits at the fulcrum of the relationship between our research community and innovation-hungry businesses. It is reaching an increasingly diverse array of manufacturing businesses. It is increasing their confidence to invest in innovation. It is connecting them with the concepts, expertise and equipment they need to turn that investment into growth. It is bearing down on the spectre of persistent low productivity levels to improve the bottom line performance of companies across the land and, in turn, increasing the prosperity of their employees and local communities.

No surprise then that in its short life, the HVM Catapult has established itself as the 'go-to' place for advanced manufacturing technology in the UK, its seven centres working as a country-wide network to provide world-class innovation capability and technical expertise to those companies with the potential to benefit from their support. Inevitably there are highlights. For me these include the strong

growth in the HVM Catapult's commercial and collaborative income, our growing reach beyond traditional manufacturing businesses and the progress we have driven in digital manufacturing, though there are certainly many more.

This year has seen another year of strong double-digit growth in commercial and collaborative income, showing that we are continuing to meet industry demands. We feel that we have still to test the boundaries and limits of appetite for our support. Industry is voting with its cash on the relevance of the HVM Catapult to the modern challenges it faces.

I'm really pleased to see our initial foray into the world of construction beginning to make tangible progress. Since our first meeting with the Construction Leadership Council, we now have a well-developed technology plan to transfer knowledge from aerospace and automotive to help a willing construction sector address its challenges with productivity and build rate.

Similarly, we have been a big influence in the new world of digital manufacturing – the so-called Fourth Industrial Revolution. As the go-to place we have been ideally positioned to help to demystify the digital technologies, to be a guide for companies finding their feet and also provide tangible demonstrations that companies can feel and experience.

The HVM Catapult's performance in the past year shows it is continuing to deliver. As the organisation enters the next phase of its development, under the insightful chairmanship of Allan Cook, and with confirmation of its future funding from Government, I will be watching its continued progress with both pride and genuine delight.

Chief Executive's statement



A stylized, handwritten signature in black ink, appearing to read 'Dick Elsy'.

Dick Elsy CBE
Chief Executive
High Value Manufacturing Catapult

Industrial appetite for the High Value Manufacturing (HVM) Catapult's capability continues to rise year-on-year. In this last 12 months we have seen a 23% growth in our commercial and project revenues, demonstrating enduring demand for our offer which is now in its seventh full year.

At the heart of our offer is the access to leading-edge, full-scale manufacturing equipment and the expertise to develop new processes and technologies. The scale of these assets has now topped £700m across our seven centres and represents by far the greatest concentration of manufacturing research and development (R&D) activity in the UK, cementing our position as the go-to place for advanced technology in our field. Also, at the heart of what we do is collaboration, we've worked with 3,700 companies in the year on over 1,500 projects bringing large companies together with SMEs. We've dispelled the myth that the HVM Catapult is only about large companies. Through our focused efforts in the year we have supported over 2,000 SMEs, 46% more than last year and now 54% of our overall client base. I'm also pleased that the commitments we made in 2015 to increase our SME focus have been met. We said that by 2020 we would increase the number of SMEs by 50% and would double the amount of Collaborative R&D they are accessing. I'm pleased to report that we have already hit both targets in the last year.

When working on complex projects among the collaborators who value the support of the HVM Catapult, it has an intuitive feel of being the right thing to do. It is reassuring then that independent eyes can also see the same. In this year we have submitted ourselves to a very comprehensive independent review and were also part of a wider review on Catapults by Ernst and Young. Reviews like these demand that we go back to first principles to evaluate the business model and examine the true impact of our work. It was reassuring that both reviews concluded that our strategy and operations were robust and that we were delivering beyond expectation.

This year has also seen us develop our strategy and plan for the next five years. This very comprehensive process took inputs from many sources. Through our relationship with thousands of UK manufacturers, we have unique insight into their future needs and where the technologies are heading and what is needed to exploit them. Through our membership or chairmanship of over 130 industrial and trade groups that we contribute to, we are placed right in the centre of all of the sector strategies, and with our excellent relationship with our government sponsors we have been helping to craft many of the nation's strategies (industrial) and the sector strategies. All of this places us in the most informed position for strategy input.

This input has guided where we need to invest to grow the nation's advanced manufacturing capability. This has led us to develop our technology investment plans which congregate around five top level themes:

Digital manufacturing

Robotics and automation

Materials processing and new materials

Process engineering, biotechnology and biologics

Product design and verification

We are also fortunate to have complete clarity of the highest level national objectives for our work. The Government's commitment to raising the level of R&D from its current level of 1.7% GDP to a level commensurate with the OECD average of 2.4% by 2027 has been widely reported. What is not so widely mentioned is that 68% of current R&D investment hails from manufacturing, so manufacturing must be at the heart of action to boost investment further. The HVM Catapult is a proven delivery partner to achieve this. We have a track record of productivity improvement and in

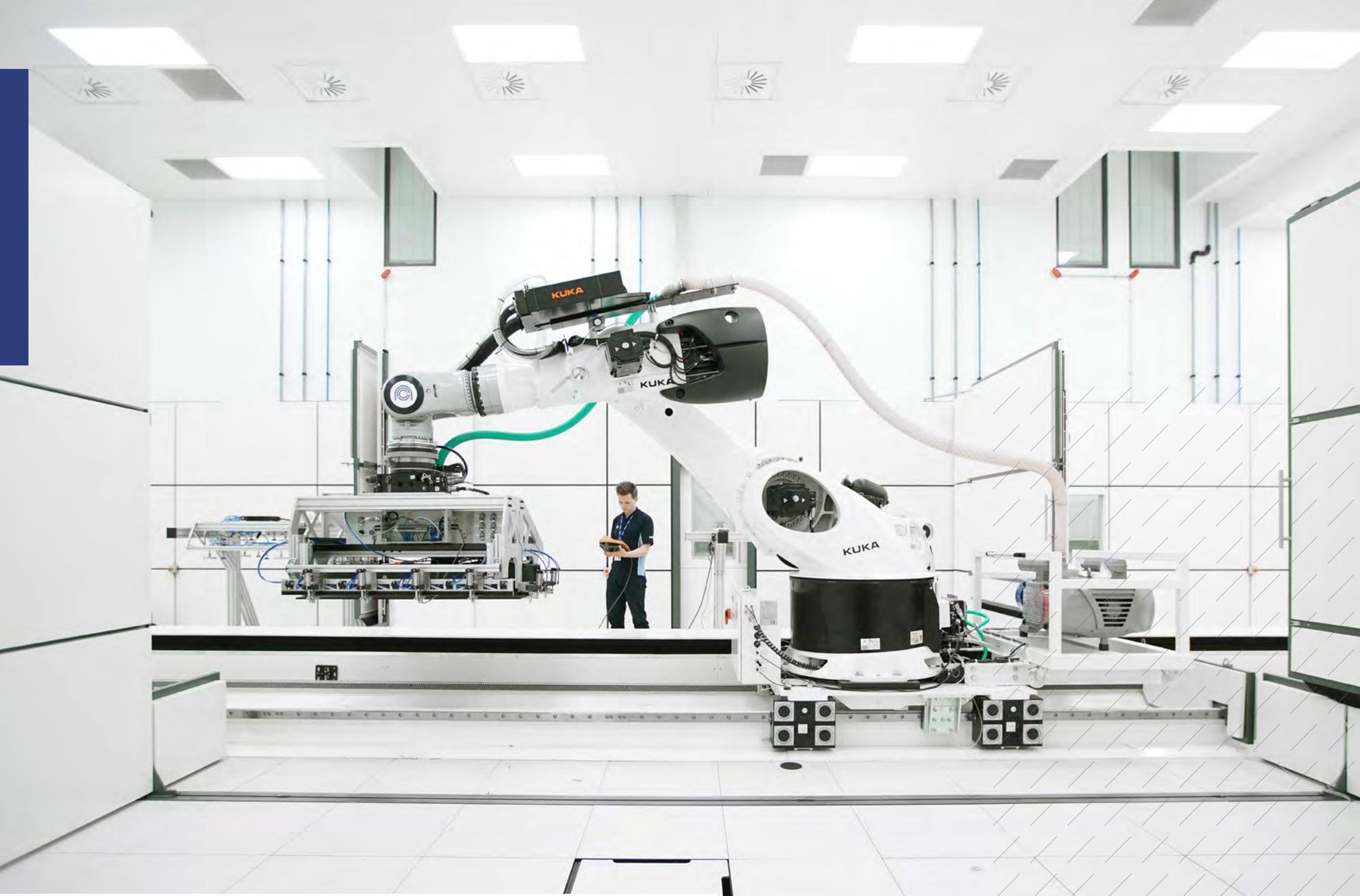
our first six years of operation we have generated £1 billion of direct new R&D. Our new five-year plan, driven by industrial demand, but with its eye on affordability, will double this to £2 billion and will broaden our productivity impacts while equipping British firms with the tools they need to compete in uncertain and challenging international markets.

With a very large portfolio of new technologies being developed in our centres we have been disciplined to ensure that they are developed with sustainability and the environment in mind.

Many of our developments naturally reduce the amount of energy and resources used for manufacture. As we slash production time, we automatically slash production energy and other production resources like water. It feels like a natural part of what we do. In addition to this we have also been working on some game changing technologies which support the Clean Growth agenda. A good example is the mass electrification of the car fleet in the UK. The HVM Catapult is delivering some of the great science being developed in our universities and is central to the development and scale-up of battery technology which will be used on our cars and for energy storage as we push to de-carbonise the UK power and transport sectors.

This review shows the breadth of activity through which the HVM Catapult team worked to drive up UK manufacturing performance in 2017/18. The plan we have set out for the next five years will build on our early successes and drive improvements in UK manufacturing productivity and competitiveness through innovation born of excellent research. We will harness our exceptional insights, expertise and connections across the research base and into business to make an ever greater contribution to major national challenges such as the push for improved productivity and the goal of raising investment in R&D. Our support has never been more needed.

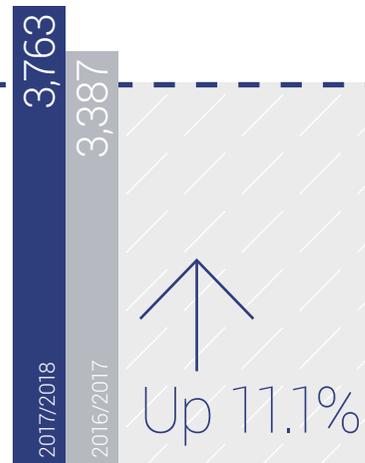




Performance highlights

Total private sector clients:

3,763



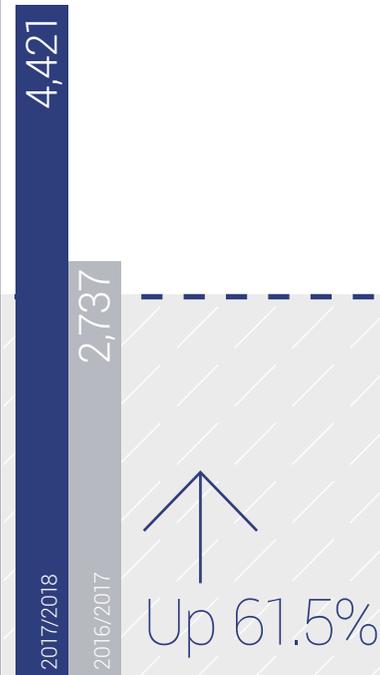
Total SME clients:

2,032



Total SME engagements:

4,421



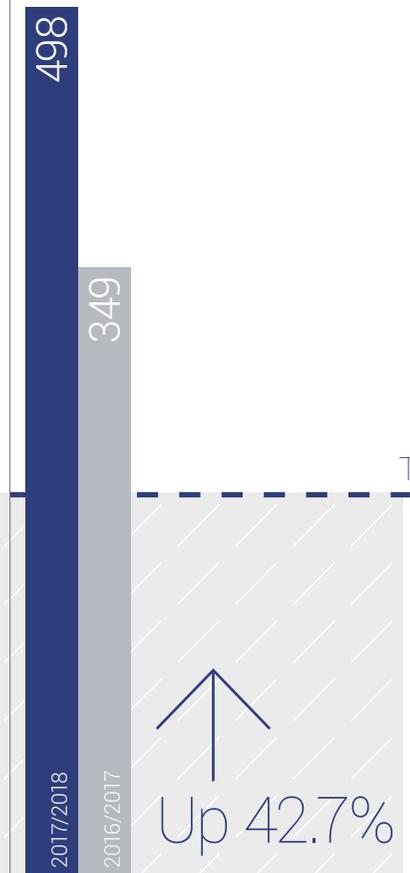
Value of Collaborative R&D secured with SMEs:

£116.4m



Number of engagements with UK academic institutions:

498



Success stories

Boxing clever

A low-cost robotic manufacturing solution for improving process time and health and safety in the manufacture of cardboard boxes has been developed by the Advanced Manufacturing Research Centre (AMRC) in a project with Accrington-based SME, The Cardboard Box Company. The firm was able to access expertise and state-of-the-art capabilities at the AMRC thanks to a High Value Manufacturing (HVM) Catapult funding initiative which match-funds the costs involved in conducting research and development projects for SMEs.

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





Klipp-it®

Manufactured in the UK, Klipp-it® is a clever but simple reusable product which clips to scaffolding or any tube for example to attach banners, netting, or brickguards or to help with cable management. The benefits over traditional single use methods like cable ties are clear: not only does Klipp-It cut down on waste, it also helps to cut out the accidents that can arise when workers use knives or cutters to remove other forms of fastening. But to use Klipp-it in industry, companies need to be confident that the product can withstand the stresses and strains of normal use. That's where the Advanced Forming Research Centre (AFRC) stepped in.

Working with Klipp-It maker Adtondeo, researchers and engineers at the AFRC used their deep insights into metals, materials and metrology to deliver 3D measurements and conduct a detailed analysis of the product's structural integrity and tolerance limits. The data produced by the AFRC helped determine the product's critical safety pull off forces and has given Adtondeo the confidence to invest in further development of the product and the evidence needed to market it successfully.

Success stories

Safe landing for Safran as costs are halved

Aerospace is one of the world's most competitive sectors. Bringing more attractive products to market, more swiftly and at a fair price is therefore a real advantage for companies looking to build their market share. Safran Landing Systems were therefore delighted when, by tapping into the AFRC's exceptional knowledge of metals and materials science, they were able to identify a more economical method of manufacture which cut their costs by 50% thanks to reductions in material wastage.





Machining times tumble

The reactor pressure vessel is at the heart of any nuclear power plant. These giant vessels are made from a series of large forgings which must be machined down to their final size, before being welded together. This requires a large portion of the metal to be cut away – even for a small modular reactor with a pressure vessel measuring around two metres in diameter, around six tonnes of the 15-tonne forging has to be removed during rough milling. This process can take hundreds of hours of cutting time.

Speeding up this cutting process while maintaining accuracy and quality was the centre of the Nuclear Advanced Manufacturing Research Centre's (Nuclear AMRC's) focus in a major investigation into innovative forging and fabrication solutions for the energy sector, led by Sheffield Forgemasters with funding from Innovate UK.

Drawing on their deep insight into best practice and the latest technologies, Nuclear AMRC researchers applied a range of advanced techniques, analysis, modelling and cutting trials on a large forged dome section which proved that cycle time for rough milling could be reduced by 41%. This will potentially save weeks of work in the production of each small reactor pressure vessel, helping ensure that new advanced reactors can be delivered to cost and to schedule.



Wear it well

In 2014 consultants Deloitte estimated that the global market for digital health, then worth some £23 billion, would almost double to £43 billion by this year. Since then we have certainly seen an explosion in the market, not least in the wearable health tech devices that allow us to track activity and are transforming patient and self-care in hospitals and at home. The growth signalled by Deloitte is undoubtedly continuing. Our WMG Centre has been working to help one UK SME, Nanoflex, to seize the opportunities created by burgeoning demand. Working with WMG, in a short space of time the company has been able to develop product prototypes, which use cutting edge sensor technologies to give real-time feedback on metabolites in the wearer's sweat to help them make more informed diet and lifestyle choices. In the future, such a device could even be used to manage diabetes and other diseases.

Developing our offer





The UK is the 9th largest producer in the world, accounting for 3% of global manufacturing output.

Our manufacturers employ 2.7 million people at pay levels well above the national average, but with high labour and energy costs and productivity levels which lag behind those of other developed economies, the UK's share of global markets is at risk. We will never win in competitive global markets on price alone. If we are to succeed, our best option is to compete through technology and innovation.

Our position at the intersection of industry, academia and government puts the High Value Manufacturing (HVM) Catapult in a privileged position to understand the manufacturing sector and its needs. Drawing on our relationships across these groups, our day-to-day work with individual businesses and research produced by organisations like the Institute for Manufacturing, we build insight into the future technology challenges and opportunities facing the sector. We use this insight to develop our capabilities to support the development of a UK competitive advantage in global markets.

In 2017/18 we focused our attentions on building our technology capability in five areas where we believe investment has the potential to deliver the greatest economic benefits and drive progress towards our ambition of an innovation-led manufacturing sector including:

- Digital manufacturing
- Robotics and automation
- Materials processing and new materials
- Process engineering, biotechnology and biologics
- Product design and verification

We have also extended the HVM Catapult's reach to manufacturers in parts of the UK where we previously had no physical presence – with the AMRC opening up an AMRC North West in Lancashire and AMRC Cymru in Wales, and the Nuclear AMRC creating a new facility in Derby – to build ever-stronger connections with those businesses, academic and innovation partners best placed to increase our impact.

If we are to succeed, our best option is to compete through technology and innovation.

Developing our technology capabilities

Through our seven centres we offer technology innovation and scale-up capabilities across the spectrum of process and discrete manufacturing industries in the following areas:



Advanced Assembly



Automation



Biologics



Biotechnology



Casting



Composites



Design



Digital Manufacturing



Electronics



Flexible Manufacturing



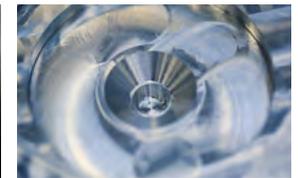
Formulation



High Temperature Processing



Joining



Machining



Manufacturing with Polymers



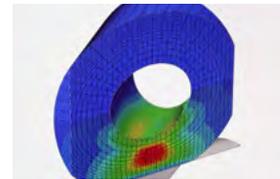
Materials Characterisation



Metal Forming and Forging



Metrology



Modelling and Simulation



Net Shape and Additive Manufacturing



Powder Technology



Power and Energy Storage



Printable Electronics



Resource Efficient and Sustainable Manufacturing



Surface Engineering



Tooling and Fixtures



Visualisation and Virtual Reality



Professor Sam Turner
Chief Technology Officer
High Value Manufacturing Catapult

Focusing resources where they will deliver the greatest impact is a challenge for any organisation.

The same is true within the High Value Manufacturing (HVM) Catapult and a key question is how best to identify which capabilities offer the best prospect of support for a vibrant UK manufacturing sector. With Chief Technology Officers in our seven centres, I have been driving a new approach designed to make sure that we will invest the funding we receive from government in building capability and expertise in those areas where public research, foresighting and industrial consultation tell us it is most needed. Together with the insight and intelligence afforded by our position at the intersection of government, business and academia, that has led us to focus our investment on five key themes (right).

In each of these areas we see significant opportunities for UK manufacturers to secure valuable outcomes, increasing their productivity, improving their overall competitiveness and positioning themselves well to increase their market share by responding quickly and effectively to global trends. The next pages give a sense of how we have been developing our offer in these areas so that the UK's manufacturers can harness the new technologies to make an ever-greater contribution to our national prosperity.

Our five key themes:

- 1 Digital manufacturing
- 2 Robotics and automation
- 3 Materials processing and new materials
- 4 Process engineering, biotechnology and biologics
- 5 Product design and verification

Digital manufacturing

Advanced manufacturing is a highly knowledge-intensive sector where advances in IT systems have a huge role to play in improving manufacturing intelligence; capturing, sharing and managing big data; supporting collaboration; increasing efficiency; speeding up innovation; and enabling new business models and technologies. Over 10 years industrial digitalisation could boost UK manufacturing by £455 billion, increasing sector growth up to 3% per year, and creating 175,000 new jobs whilst reducing CO₂ emissions by 4.5%. We are working to make sure that manufacturing businesses understand the opportunities and can tap into the help they need to seize them.



Silent Sensors

Silent Sensors is an innovative UK SME with a focus on applying the Internet of Things to tyres and tyre management. It develops key components for intelligent tyres, which have the potential to reduce the total cost of operations of fleet vehicles while benefiting the environment.

Increased volume of vehicles on the roads and tighter automotive regulations has led to greater demand for fleet operators to monitor and reduce fuel consumption and CO₂ emissions. Suboptimal tyre inflation exacerbates all these factors and increases the risk of road accidents. However, manual tyre checks are expensive, time consuming and require the vehicle to be off the road.

Silent Sensors is bringing a new, innovative system to fleet operators and major tyre manufacturers that will give them the flexibility needed to stay safe and efficient by monitoring driver behaviour in real time.

Once commercialised, the technology will manage tyres throughout the supply chain. From the manufacturing process to the running of the vehicle on the road, a continuous stream of data will be collected and used to inform or warn drivers on the road, becoming part of the whole tyre lifecycle.

Silent Sensors is collaborating with CPI alongside the University of Bath to bring the Internet of Things component of this new product to market. Multiple stages of development are covered, including a printed kinetic energy harvesting element, power management, and sensing devices that enable real-time monitoring of individual tyre performance. The project relies on CPI's world-class manufacturing facilities at the National Printable Electronics Centre, used for the scale-up and commercialisation of innovative printed electronic products.

Back to the future with a Bantam

A 1956 Colchester Bantam Lathe may not be the most likely piece of kit to take to one of the world's most prestigious machine tool exhibitions. But that's what the young engineers at the University of Sheffield's AMRC decided to ship down to the MACH show at Birmingham.

As this workhorse of the second industrial revolution was being lifted into place the look on the faces of the surrounding exhibitors was one of utter bewilderment – what was this long extinct dinosaur doing at a tradeshow where other stands were sporting state-of-the-art equipment?

By the end of the week they knew. The Colchester was the star of the show.

What was it doing there? It was showing how even the oldest, grubbier piece of kit can be brought into the age of the Fourth Industrial Revolution. This once faithful servant of UK manufacturing had been retro-fitted with sensors to monitor vibration, temperature and current, with the data captured by the sensors displayed on an easy-to-read dashboard for the operator to see in real time. It's just the sort of data that allows production line managers to boost performance, maximise output and tackle problems before they bite. In short it delivers a huge productivity boost. And the cost? A whopping £250.

And that was the message: for a relatively small amount – and with the HVM Catapult's help – anyone can join the Fourth Industrial Revolution.



Productivity gains through visualisation

The AFRC has developed an application that will bring 3D visualisation to the shop floor. The app, developed in partnership with a leading software vendor, can read a machine cutting programme and simulate the part created by the programme. The system will allow operators to verify machine programmes on the shop floor before live deployment without the need to refer back to office-based simulations. This system will enable machining companies to increase productivity through faster machine set up and reduced errors.



Robotics and automation

The new generation of robotic and automation technologies offer huge potential to manufacturing industries to transform their work practices, boost productivity and increase safety while improving the service levels they offer to customers. In increasingly competitive global markets, where new entrants are growing their market share rapidly, making sure that UK manufacturers can seize and apply the benefits of these new technologies is one key to our future economic growth. The High Value Manufacturing Catapult is working to make sure that UK manufacturing businesses can see how they could use robotics and automation technologies to heighten their performance in ways that help them secure new and existing customers and grow their bottom line.

Navigating the factory floor

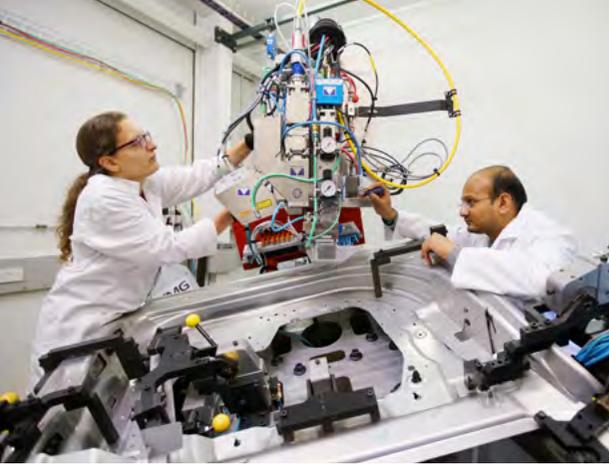
In huge factories, moving components and tools to where they need to be can involve significant costs, can waste the time of talented personnel and slow production. The AMRC has therefore been working with Airbus to develop and deploy an autonomous mobile robot (AMR) to handle and transport small aircraft components and assembly tools around its Broughton factory – the largest of its kind in the UK.

Using laser scanners, the AMR vehicle builds a real-time 3D picture of its environment so that it can navigate autonomously between locations, avoiding people and obstacles. With racking designed using augmented reality during a design review using the Microsoft HoloLens, the AMR has storage for tools, a flashing beacon and lamp to indicate the its intentions and direction of travel.

Software engineers at the AMRC's Factory 2050 are working alongside colleagues at Broughton to develop a complex set of algorithms that will calculate and negotiate a safe route around pre-programmed positions. They are also working with research colleagues at the University of Sheffield's Department of Automatic Control and Systems Engineering to establish a 'highway code' for autonomous vehicles operating close to people.

Airbus now plans to develop the capabilities of such vehicles further to allow for the automated handling of large components within the factory. In addition, the technology could eventually be rolled-out across other Airbus sites.





WMG project wins coveted Tata Group 'Innovista' award

A Remote Laser Welding (RLW) project for lightweight aluminium doors has won the Tata Group Innovista 2018 award for Piloted Technologies. WMG's Digital Lifecycle Management research group, led by Prof Darek Ceglarek, worked with Jaguar Land Rover to develop an online quality control system that enables the control of weld quality in real-time. The concept was proven out on steel doors as part of the EU-funded RLW Navigator project, but the team are now validating the application of the tool to aluminium structures. RLW for aluminium doors is shown to have numerous benefits, including reducing vehicle weight, improving safety and increasing productivity (the process is up to five times faster and uses 50% less floor space than the incumbent Resistance Spot Welding method). In addition, the RLW approach produces better quality welds than existing methods, with 50% less thermal distortion and 10% stronger welds than tactile laser welding.

AMRC leads way in high-accuracy robotic machining

A collaborative research project led by the AMRC has developed the most accurate large volume machining robot in the world to provide advanced manufacturing companies with a step change in high accuracy robotics.

The Flexible Robotic Machining in High Accuracy Applications project, by the Aerospace Technology Institute, builds on the AMRC's growing reputation in the development of smart robotic systems for the aerospace and high value automotive manufacturers.

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

The AMRC is combining an existing KUKA Titan accurate robotic solution with world-leading expertise in computer numerical control (CNC) machine tool dynamics to enhance the robot's accuracy and overcome any lack of stiffness.

The modifications that have been carried out will ensure the robot will be at the heart of the AMRC's automation research in collaboration with UK aerospace original equipment manufacturers (OEMs) and Tier One companies.

Morgan added: "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 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."



Materials processing and new materials

Understanding materials and how to get the best from them is at the heart of manufacturing. New materials and new approaches to processing materials offer the potential for products that are lighter, stronger, more resilient, less environmentally damaging, more recyclable and cheaper. These features matter as we work to keep the UK at the forefront of global supply chains. The High Value Manufacturing Catapult is growing its capability to help manufacturers add value to components and products through the production process. Our work includes both development of long established processes such as machining, casting, forging, tape laying, and joining and the advancement of new processes such as powder and bulk additive manufacturing.



When performance counts

Technology experts from the seven HVM Catapult centres have used their range of technology capabilities to demonstrate how current and emerging manufacturing technologies in areas such as sensors, composite materials, 3D printing and virtual reality design techniques can be applied to achieve success in new – and possibly unexpected – applications.

Working with Paralympic skiers, the team from the HVM Catapult used mobile phone technology to develop an instrumentation harness which could measure accelerations, lean angles and suspension deflection and used the data to design a new sit ski, leveraging the benefits of additive manufacturing technology and

topology optimisation to reduce weight at the same time as increasing performance.

Connections within the HVM Catapult meant that the project not only created a buzz within the Paralympic ski community, but also with manufacturing businesses using our facilities. For example, its low cost sensor technology caught the eye of Rolls Royce whose Supply Chain Designer, Gary Capewell commented "The digital measurement technology used in Sit Ski proved vital to help validate an improved supply chain. This mitigated a large equipment spend for us, with the ability to go 5% higher on customer delivery, creating supply chain duality"



Electron beam breakthrough

Following an upgrade of its large electron beam facility, the Nuclear AMRC has successfully demonstrated a full-penetration weld of 150mm thickness in S355 structural steel. The electron beam team has also demonstrated the additive manufacture of tantalum components. Tantalum, a highly corrosion-resistant Group V metal used in pressure vessels, reacts with oxygen at temperatures above 300°C so requires a vacuum environment for additive manufacturing. The team showed that this technique can achieve the desired cleanliness at desirable deposition rates – it also offers design and manufacturing opportunities to produce homogeneous structures containing ‘built-in’ vacuums, with applications in areas of nuclear science such as particle accelerators.

Lighter and more efficient Fords

Ford cars could be more fuel efficient and environmentally friendly, thanks to a new lightweight rear suspension component, designed by the award-winning Innovate UK project Composite Lightweight Automotive Suspension System (CLASS), involving WMG. Led by Ford Motor Company, in partnership with WMG, Gestamp Chassis and GRM, the CLASS project consortium developed a new tieblade-knuckle for a Ford Class C vehicle, a key element for the car’s rear suspension. An optimised design and manufacturing process developed by WMG enabled the researchers to replace the car’s current multiple-piece fabricated steel component with a single moulding - making a weight saving in excess of 4.5kg per vehicle, a 35% saving on the current part. This will result in CO₂ savings over the lifetime of the vehicle, and the technology is appropriate for much wider vehicle chassis and body applications. In March 2018, the CLASS project won a JEC Innovation Award, in the Automotive Innovation category.



Process engineering, biotechnology and biologics

Process engineering focuses on the design, operation, control, optimisation and intensification of chemical, physical, and biological processes.

The process industries include businesses where the primary production methods are either continuous or occur on a batch of materials. One example might be a cosmetics company making a face cream in a continuous, uninterrupted flow from receipt of ingredients right through to packaging. The process industries are diverse, including everything from food and drink, chemicals, pharmaceutical, nutraceutical, consumer packaged goods, and biotechnology industries. Their economic impact is huge and the global opportunity for UK process industry firms considerable: the global market for formulated products alone, for example, is worth some £1,250 billion. We're determined to equip UK firms with the ability to capitalise on the market potential.

The new National Formulation Centre created by CPI is a key part of delivering on that ambition. An open access, state-of-the-art innovation facility based at NETPark in County Durham, the new

centre provides access to facilities and expertise to allow companies to overcome innovation challenges associated with the development and scale-up of formulated products.

The centre is home to world-class laboratories, and accompanying expertise focusing on measurement, high-throughput formulation, chemistry and dispersions, process chemistry, process technology, complex particles, nanomaterials and composites.

CPI will guide companies through the steps needed to take their next-generation formulated products to market with reduced risk on their decisions or capital investment plans. This unique centre will create an environment for innovation that will allow companies to be more efficient in the use of resources and generate further value for the UK formulation industry.

Biostreamline

BioStreamline is an £11.3 million collaborative project that is focused on improving the development of novel biotherapeutics to deliver drugs faster and cheaper, while reducing the costs and risks involved in their manufacture.

The global biotherapeutics market is growing rapidly, but there are many challenges that must be overcome to deliver cost-effective drugs to patients more quickly. One of the greatest needs is to reduce the number of failed drugs during development. For biotherapeutics, failure often results from safety issues, or manufacturing and formulation difficulties.

The BioStreamline project aims to overcome these challenges through applying new technologies that will make it easier to identify failing drugs earlier in development, as well as improving development and manufacturing processes.

Ultimately, the project will deliver a novel decision-making tool that can predict key information about a biotherapeutic molecule, including its performance characteristics, and how easy it will be to manufacture and formulate, based on its genetic sequence.

This multi-disciplinary collaboration, funded by the Government's Advanced Manufacturing Supply Chain Initiative (AMSCI), involves six diverse organisations – CPI, Lonza Biologics, UCB Celltech, Sphere Fluidics, Horizon Discovery and Alcyomics Ltd – working together across nine work packages to develop and validate a robust methodology for improved understanding of candidate molecules.

Each work package uses innovative technologies, such as clustered regularly interspaced short palindromic repeats (CRISPR) and machine learning, to target critical points in the biologics supply chain. The collaboration relies on CPI's facilities and technical expertise, as well as project management skills to take the project successfully through to completion.

Out of the ashes

The William Tracey Group, a recycling and resource management company, supplies ash collection and processing services to the majority of Scotland's waste and biomass plants.

Currently, the majority of this ash is sent to landfill. The William Tracey Group wanted to investigate the possibility of turning this current waste stream into a usable construction product that would have a number of commercial and product benefits.

The project, funded by the Construction Scotland Innovation Centre, investigated different methods of heat treating ash waste material with the aim of removing contaminants to produce a high-quality concrete pellet.

The AFRC's in depth knowledge of heat treatment enabled the William Tracey Group to identify suitable temperature and heat treatment duration parameters for the drying and sintering processes to produce lightweight concrete pellets from the waste ash.

This process has the potential to divert 100,000 tonnes of waste per annum from landfill by converting it into a new raw material that is an alternative aggregate product for the construction industry.

Powder Chariot

The Chariot project brought together world-class capability in research, innovation and business to drive the commercialisation of new and improved specialist powders for markets such as consumer goods, healthcare, personal care, ceramics, catalysts and food.

Chariot has developed powder processing technologies to profit a broad range of powder producing industries. Part funded by the Advanced Manufacturing Supply Chain Initiative, the project was led by Procter & Gamble and involved high profile academics from the Universities of Leeds, Birmingham, Cranfield and Durham, alongside UK-based SMEs, International Innovative Technologies and Ajax, as well as CPI.

The expertise and capabilities developed within the project have cemented the UK as a world leader in the manufacture of superfine powders and has supported the drive towards next generation powders that are higher performing, cheaper to manufacture and transport, and are also environmentally sustainable. Broader UK industries are also benefiting, as the technologies developed within the consortium can be reapplied and further commercialised.

During the project, CPI made a significant investment into process analytical technology-enabled wet granulation technologies, a packing and filling testbed, as well as extensive characterisation capability in particle size distribution, powder rheology, and surface properties. The expertise and facilities developed during the Chariot project are available to assist all companies in developing new powder processing products and techniques and optimising existing processes to improve productivity.



Production design and verification

Design

Creating better products in better ways begins with design. The High Value Manufacturing Catapult is working to develop next generation software tools and processes that will help manufacturers to condense design and new product introduction lead times and improve productivity. Our work includes simulation tools to enable right first-time manufacturing for metallic and composite components enabling the rapid design, simulation and build of prototypes. We are also working to improve the way firms approach measurement, metrology and evaluation, applying state of the art technologies to reduce the amount of time needed to complete these processes and showing how the data they yield can improve every stage of the manufacturing process.

Product Verification

In the world of manufacturing there is a saying, "if you can't measure it you can't make it". Measurement is at the heart of manufacturing and the MTC has been growing its capability on the optimisation and automation of inspection for its customers. The MTC has been aiding industry in developing something called the Quality Information Framework. This a new standard for storing the measurement information of a component from the beginning of design through its manufacture and onwards into its operating life. It's now possible to describe the full inspection of a component, tolerances and dimensions required, so that inspection programs can be generated automatically. This removes the long lead time for programming, a common bottleneck in industry, and allows standardisation within a supply chain to ensure consistent results are obtained. This work has already benefited aerospace customers, but the knowledge is now being replicated with automotive customers.



Shaping future mobility in the Midlands

The world of connected and autonomous vehicles poses a new and incredibly complex challenge. WMG is bringing its insight to bear by leading a £25m programme of investment to turn roads in Coventry and Birmingham into a world-class UK testbed for developing next generation connected and autonomous (CAV) vehicles. Undertaken by a consortium of research and industry partners, the test bed will make UK roads ready for CAVs by developing wireless networks, analysing how vehicles behave in real urban environments and carrying out public evaluations. The Midlands Future Mobility test bed will be based on 80 kilometres of urban roads, creating a world-leading connected infrastructure and eco-system, and positioning the Midlands as a centre for cutting-edge automotive and communication technologies.

Virtually right first time

Software engineers at the AMRC are taking computer gaming languages and translating them into powerful industrial tools for smart visualisation to enable manufacturers to develop right-first-time prototypes.

In a fast turnaround project with Yorkshire Water, Mike Lewis, Technical Lead at the AMRC's Factory 2050, developed virtual reality technology to design and visualise a range of prototypes from single pumps to whole treatment works, which could help save the company £1m in design costs by 2020.

Nevil Muncaster, Director of Asset Management at Yorkshire Water, said: "Virtual reality is a brilliant way of communicating with all our stakeholders, providing an instantly recognisable visual experience that enables them to not only understand the design, but also to convert it into a powerful, immersive experience."



Mike said: "At the end of this project, Yorkshire Water will have the equipment and the skills to be able to do this themselves. From there, we could work with them on more advanced systems, pulling in real-time data from sites that improve productivity and maintenance regimes. We could also develop augmented reality training systems, including health and safety, that take the same assets and use them to upskill the Yorkshire Water workforce of the future."

Nevil Muncaster added: "What we now have is an immersive experience that enables us to check all the interfaces; to check that everything fits where it is supposed to fit before it goes on site; to ensure that safety and efficiency are fully integrated into the design, to give our operators and maintenance engineers a plant that is easy to run. It is a step change in how we design our new engineering projects and has the potential to generate significant cost savings."

Less reliance on expensive physical prototypes will also help the firm lower its carbon footprint by keeping design in the virtual, rather than the real world.

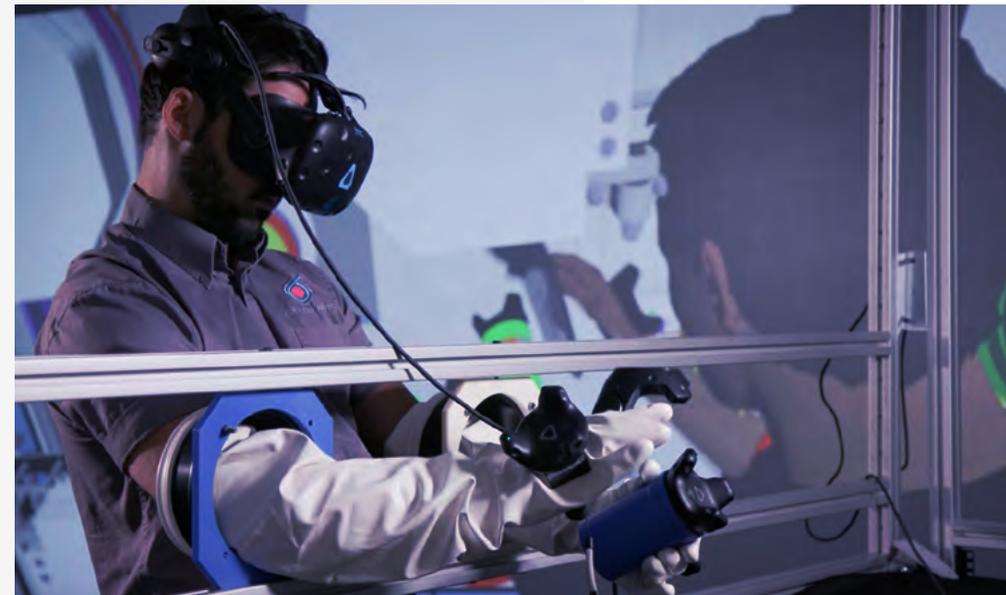
Virtual glovebox

The Nuclear AMRC has completed a demonstration project with National Nuclear Laboratories and Sellafield Ltd to create an interactive model capable of being reconfigurable to adapt to handling

a vast array of glovebox designs used to handle hazardous material for the decommissioning programme.

The technology demonstrator combines an adaptable physical mock-up with a detailed virtual model viewed with augmented reality. Gloveboxes designed for different applications for different sites can vary widely in size, shape and configuration. The physical model can be adjusted to simulate any configuration, and provides an extra level of realism by restricting the user's movements in the same way as the real box.

With further development, the model will support the design of the next generation of glovebox, the planning of experiments and waste handling programmes, and training of operatives.



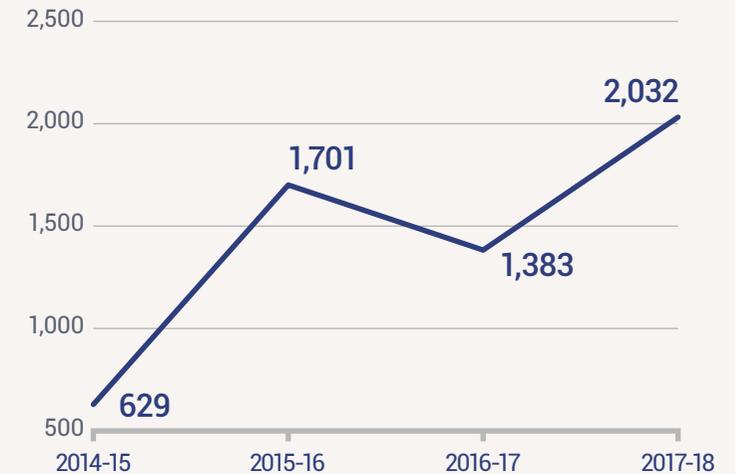
Extending our reach

Well managed innovation has the potential to transform any business. In 2017/18 the High Value Manufacturing (HVM) Catapult continued its work to make sure its services are visible to a wide range of companies from a diverse range of manufacturing sectors in locations across the UK. Our efforts and our growing reputation as the go-to place for manufacturing technology in the UK saw the number of industrial clients we worked with grow by 11.1% to 3,763 in the past year.

These clients included a significant increase in smaller businesses as the number of SME clients rose from 1,383 in 2016/17 to 2,032 in 2017/18 – an increase of 46.9%.

The results we have delivered for these clients are impressive. An independent evaluation of our work concluded “the HVM Catapult has effectively supported firms to bridge the gap between research and commercial exploitation and that the 20 most substantial HVM Catapult projects from their first five years of operation are likely to have contributed £15.7 billion of GVA over the next 10 years”. Our work in the last years has seen us taking action to increase the benefits we deliver still further by making it easier for businesses to connect with us in parts of the UK where we have no physical centre, by deepening our relationships with a wider range of manufacturing subsectors and by continuing our work to engage innovation-hungry smaller businesses.

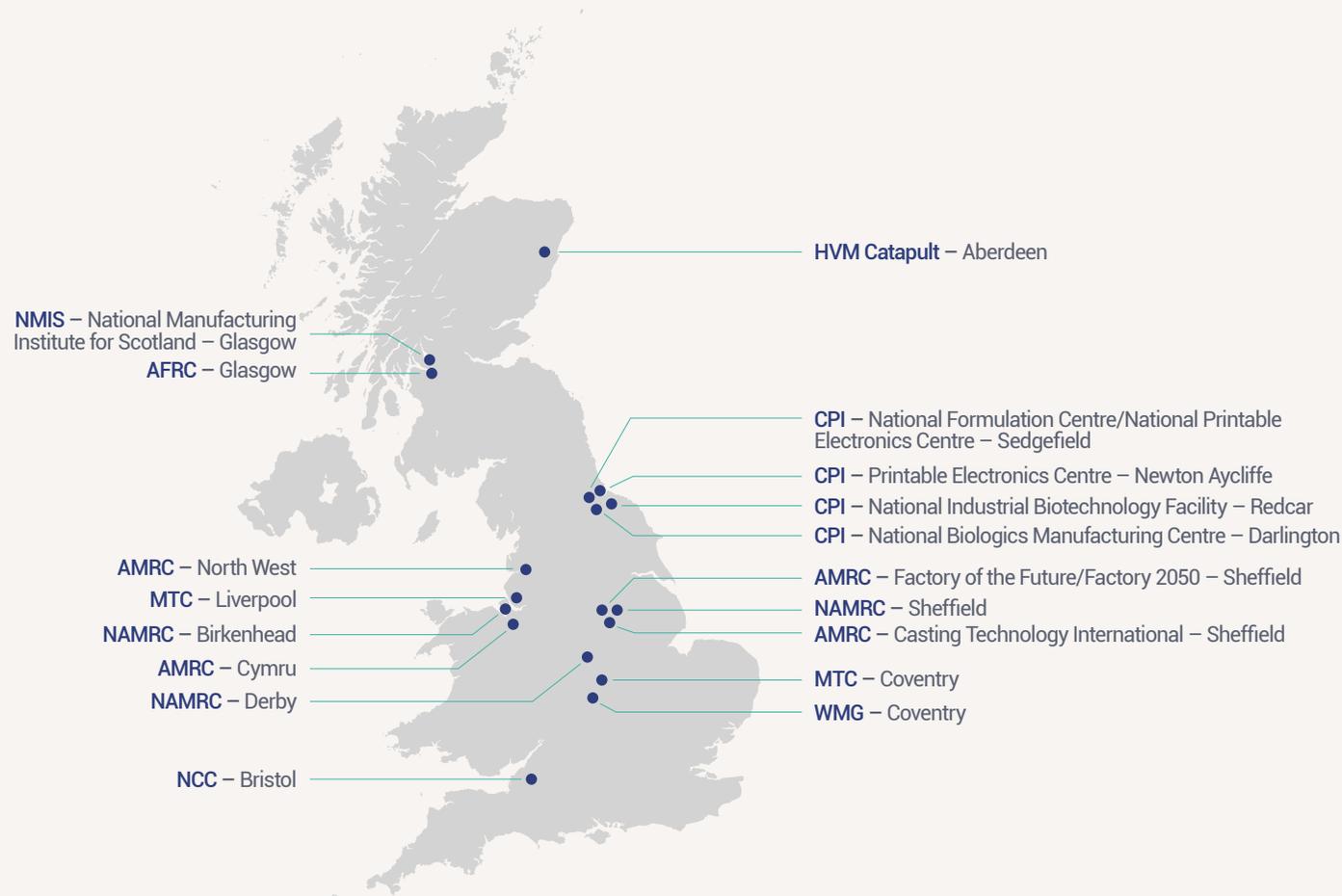
SME clients



Industrial clients



Reaching out across the country



When the High Value Manufacturing Catapult was created in 2011, our footprint reflected the locations of the seven centres which came together to boost UK manufacturing performance. Since that time, recognising that businesses often want to talk to someone closer to their base, our centres have been extending their reach to connect with more businesses up and down the UK.

Building UK-wide success

Scotland

Scotland has a world-renowned manufacturing heritage. Today some 190,000 people work in a Scottish manufacturing sector that is both innovative and diverse and boasts world-class dynamic companies. Manufacturing accounts for over 50% of Scotland's exports. The HVM Catapult's AFRC has been working with the Scottish Government to make sure that manufacturers based in Scotland get the support they need to develop, embrace and apply the new manufacturing techniques that will help them capture an even greater share of the global market and grow.

A key part of this will be the development of a new National Manufacturing Institute for Scotland. Based in Renfrewshire alongside the AFRC, the Institute will comprise a number of complementary initiatives which will form an extended footprint for the AFRC, and the HVM Catapult, in Scotland. Announcing the new Institute in December 2017 First Minister Nicola Sturgeon said: "Research, industry and the public sector will work together to transform skills, productivity and innovation, attracting investment and making Scotland a global leader in advanced manufacturing. It will help companies right across Scotland

embrace new manufacturing techniques, support cutting edge research and help to further develop the skills of our workforce."

The Institute complements the new Lightweight Manufacturing Centre, announced in 2017 and opening late this year, which will focus on the manufacture of lightweight components for a range of industries in which lighter materials offer benefits, including, aerospace, automotive, oil and gas, renewables, medical, marine and off-highway transport. This specialist centre will develop new manufacturing processes for lightweight materials such as titanium and carbon fibre and help Scottish businesses capitalise on the opportunities that are emerging as many sectors look to make more and more use of lightweight materials as they strive to minimise waste, reduce fuel consumption and bring down carbon emissions. As Andrew Colquhoun, CEO of Doosan Babcock, said: "The investment to expand the capabilities of the AFRC with this new Lightweight Manufacturing Centre will help transform the manufacturing industry, keeping Scotland at the forefront of innovation and engineering excellence."

Embracing the North West

Making sure that we can connect with the strong manufacturing communities in the North West of England was a key focus for both the AMRC and the MTC in 2017/18.

The MTC's partnership with Liverpool John Moores University in 2016 began to take shape and deliver with 40 SME projects in the region and local graduate recruitment programmes to retain, and attract talent, in the Liverpool City Region.

Meanwhile, as part of an ambitious expansion programme to meet demand for high value manufacturing research and innovation support across the Northern Powerhouse, the AMRC is working to establish a new facility in the North West. Directors of the new AMRC North West are now in post and recruitment is underway for research and innovation staff to spearhead the transformation of one of poorest performing enterprise zones in the UK. Discussions are underway with a number of regional SMEs, and larger national and international manufacturers, about working with the new team on research projects and demonstrators.

Currently based in interim accommodation provided by the University of Central Lancashire, AMRC North West will transfer to a new state-of-the-art research and technology transfer facility in the Samlesbury Aerospace Economic Development Zone in 2019. A major feature of the centre will be to demonstrate the use of step-changes in technologies to reduce manufacturing time and cost without compromising safety or quality.

“Our goal is to place Lancashire amongst the most innovative regions in the UK, with applied research facilities comparable with the best in the world, ensuring the region is an attractive destination for inward investment and the creation of new businesses, in addition to providing world-class support for existing manufacturers.”

James Hughes, Research Director of AMRC North West

Nuclear Connections

Plans for nuclear new build and development at home and abroad present a significant opportunity for the UK's nuclear supply chain to grow its market share. Our Nuclear AMRC has been spreading its wings to connect better with those companies well placed to capitalise on that opportunity. At the same time it's been reaching out to firms which could apply techniques used in the nuclear industries to boost their performance in other sectors. In July 2017 it opened a new modular manufacturing R&D centre at the Birkenhead site of member company Cammell Laird.

The centre is the first in a new network of regional nuclear supply chain hubs, which will help the Nuclear AMRC provide on-the-ground support to companies of all sizes across the UK. The launch marks the start of a research collaboration, led by Cammell Laird, to develop modular manufacturing techniques to support the UK's nuclear new build programme. Already used in shipbuilding, aerospace and other safety-critical industries, modular techniques have the power to reduce construction risk significantly and help deliver new power stations to schedule and cost. The Nuclear AMRC's Birkenhead site will host specialised machining, joining and assembly equipment to develop and prove modular manufacturing techniques – which could deliver time and cost savings of up to 30% – for nuclear applications. Work will address modular manufacturing for new reactors of all sizes, as well as the challenges of decommissioning and waste management.

Take up of the Nuclear AMRC's offer to business is so strong that the centre is also expanding its footprint in the East Midlands. 2018 saw a new agreement with Derby City Council and the D2N2 Local Enterprise Partnership to establish a new industrial R&D centre at Derby's Infinity

Park. The new facility will initially include two workshops in Infinity Park's iHub facility, to develop technology demonstrators and test ideas. One will be used as a flexible incubator for new manufacturing technologies, operating at an earlier level of manufacturing readiness, and featuring a series of reconfigurable manufacturing bays to meet the needs of different projects. The other will be used to develop the centre's capabilities in new areas including controls and instrumentation (C&I) and equipment qualification. The facility will create new jobs in the area and will combine the strengths of the Midlands Engine and the Northern Powerhouse to put both regions at the centre of the development of a cost effective, sustainable energy base for the UK economy.



Connecting with new sectors

Manufacturing is a diverse sector. In recent years we have been working to broaden the range of sectors we work with, recognising that the innovation knowledge we acquire from working with core manufacturing sectors such as aerospace and automotive, can drive up productivity and business success in other parts of manufacturing. Today, we are offering our expertise to the oil and gas sector, the healthcare industry, food and drink businesses, construction companies, and the defence sector.



Picture courtesy of Shell

Energy

The NCC has been working closely with the oil and gas industry to examine how composite materials could impact the industry. In addition to a growing relationship with the Oil & Gas Technology Centre (OGTC), the centre has a number of significant projects underway with key Oil and Gas partners. These include developing a pathway to certification for thermoplastic composite pipes with Magma Global and Equinor. Work is also being undertaken to evaluate thermoplastic composite pipes on fatigue evaluation equipment funded for use by the wider industry by Shell.

Work is under way in the renewable energy field with the NCC working on five forms of renewable energy (on-shore and off-shore wind, kitepower, tidal and wave energy devices). It is engaged in some of the key challenges for the sector including how to develop blades of over 100m in length.



Food and Drink

The MTC's emerging markets team focuses on new business areas and broadening engagement in a range of emerging sectors. Food and drink has been a particular focus. Here the MTC has extended its working relationships with key universities including the University of Nottingham and Sheffield Hallam University and with the National Centre for Food Manufacturing at the University of Lincoln. 2017/18 also saw the MTC working with the Food and Drink Federation (FDF) to help spearhead technology adoption in the sector and to assist with the challenges it faces introducing technology into a sector heavily reliant on manual labour.

October 2017 saw the MTC hosting the annual 'Appetite for Engineering' show. The event gave the 150 companies who attended an opportunity to learn about

successful engineering strategies, and the latest innovations that could help increase productivity, efficiency and safety. It helped to engage companies in Industry 4.0 and the technologies that will improve food science, food production and help tackle food waste.

Within the SME Reach Programme, which offers manufacturing innovation support tailored to the needs of smaller businesses, the MTC is also starting to connect with more SME food businesses and has run a number of projects around production efficiency. As advances in intelligent connectivity and automation technologies continue and the Industrial Internet of Things and smart machines and factories become the standard, the UK's food and drink manufacturing industry has an opportunity to make a major productivity step change.

Construction

With almost half of the economy reliant on the built environment and the services it enables, the construction industry is vital to the UK. It is one of our largest sectors with an annual turnover of £370 billion per some 3.1 million employees and hugely impacts our quality of life. But the sector is challenged by low margins and high-risk business models. HVM Catapult centres have been looking closely at how our insight and expertise could help boost its performance

Drawing on the experience of developing and using transformation tools and in close collaboration with experts at the Building Research Establishment and the Centre for Digital Built Britain, the MTC is developing a suite of tools for the Construction and Infrastructure sector. The tools aim to deliver step change improvements in construction projects, reduce costs and development time, improve efficiency, quality, safety and de-risk construction projects.

Its PACMAM Project (Platform Architecture for Construction using Manufacturing and Assembly Methods), an Innovate UK-funded collaboration with award-winning architects, Bryden Wood, and industrial robotics firm, Kuka, has demonstrated how applying manufacturing technologies like robotics,

large volume metrology, manufacturing execution systems, and smart tools can dramatically improve productivity.

The MTC has also been working with the i3P consortium construction companies to explore the next steps for technology in the construction industry. i3P members undertook a technology road-mapping exercise with the MTC in 2017 and identified that robotics and automation was a strategic priority for exploration across the group of companies.

To demonstrate that robotics are available and are proven in the scale required by the construction and infrastructure sector, the MTC mounted a Kuka Titan robot on a specially designed frame allowing it to be moved around a representative off-site facility. Work was completed to ensure that the robot would be sufficiently stable for handling of large components, up to the robot's 1,000kg payload limit. The project showed how design for manufacture and assembly could be harnessed to reduce or eliminate the need for traditional manual handling and 'fitting' activities on site.

New materials

The HVM Catapult has been using its materials insights to help the construction industry address the notorious challenge of major price fluctuations in stainless steel, a core construction material.

Composites are gradually gaining acceptance for bridges and large structures, offering advantages of structural efficiency through reduced self-weight and corrosion resistance that dramatically reduces maintenance cost.

Composites offer designers and architects incredible opportunities to introduce new more flowing and organic forms. The NCC has been actively seeking engagement on the use of new composites materials in the sector and expects that with any significant drive to composite uptake large companies involved in 'traditional' materials will also look to manufacture composites, particularly high-volume modular items.



Safer homes

In the wake of the Grenfell Tower fire, working on behalf of the Ministry of Housing, Communities and Local Government and the Grenfell Industry Response Group, the MTC conducted a study into the use of advanced manufacturing tools to find a method of inspecting building cladding materials and workmanship in situ and to increase the rate of removal and replacement of external cladding from high-rise buildings.

The MTC's work showed how, by adopting technology and practices common in manufacturing, construction firms could reduce time, improve safety and quality, and deliver value for money. The MTC is now in discussion with businesses interested in developing a product based on the solutions developed.



Offsite construction

Off-site manufacture for construction describes a range of construction activities that involve bringing together construction processes, components, elements or modules in a factory before they are installed into their final location. While it is not a new idea the level of technology now available means it is much more viable as a modern method of construction and many believe it holds the potential to deliver both radical productivity improvements in construction and release capacity to upgrade public infrastructure like schools and hospitals faster. HVM Catapult centres have been looking to see how their insight and expertise could help secure those benefits.

The MTC completed a project for the Department for Education which looked into the opportunities, technical development requirements and the benefits for off-site construction. The MTC team reviewed current build specifications and concepts for schools before developing a Method of Manufacture driven design concept, named 'Generation 20'. Based on a hybridised volumetric and panelised system, the project showed that, after initial capital equipment costs, the build cost per m² could drop by up to 40%.

In Rotherham, the AMRC teamed up with Laing O'Rourke to help design its new factory for offsite modular manufacture of buildings. The AMRC helped identify a range of solutions from relatively simple quick fixes to the de-risking of investments

through augmented reality, robotics and other digital approaches that will help to drive productivity, performance and quality. Using Microsoft's HoloLens technology – the AMRC was the first in the UK to have access to it – the team developed a HoloLens based augmented reality application for Laing O'Rourke that guides the user through a continuity testing process with an augmented overlay and heads up display. Using a back-end database and a wireless multimeter, up-to-date testing processes are loaded and results stored remotely, reducing Laing O'Rourke's reliance on scarce, external, electrical testers. As Laing's David Brass commented "Bringing the AMRC's cross sector knowledge into the construction sector is helping us to reduce risk and increase confidence in the solutions that will enable our new factory to set new benchmark standards in the industry and to reduce costs and times."



Harnessing insights from other sectors, like manufacturing, and making better use of digital technologies has the power to transform construction in the UK and dramatically boost the sector's productivity. The work the High Value Manufacturing Catapult and its MTC are doing will help the UK to modernise construction practice and develop an affordable construction supply chain. It is key to delivering on the Construction Sector Deal.

**Andrew Wolstenholme,
OBE, Co-Chair, Construction
Leadership Council**

Connecting with smaller businesses

Big businesses may steal the headlines but the majority of firms that make up the UK's manufacturing sector are smaller businesses. Helping these SMEs to become more competitive through innovation is a vitally important part of the high value manufacturing agenda. Our SME engagement programmes deliver a suite of manufacturing innovation products designed for SMEs and to ensure that more of the economic value generated by firms at the top of supply chains is captured in the UK. In 2017/18, 54% of our private sector clients were SMEs. By offering increased access and more tailored provision to the world class equipment and expertise available in our centres we helped them to become more productive and to win more business.

A blank canvas

SME clients at the MTC's Business Launch Centre (BLC) will have exclusive use of the facility's Incubation Cells; 'blank canvas' spaces that allow the MTC's clients to configure equipment to meet their needs. By 2023/24, the BLC's ambition is to engage with 2,600 SMEs, supporting the most vulnerable through the early stages of new business and creatively implementing innovation into their processes.

Automation Insights

Automation has huge potential to transform UK manufacturing with potential advantages including higher production rates and increased productivity, more efficient use of materials, better product quality, improved safety, and reduced factory lead times. For SMEs, however, it can be hard to understand how and where automation might best benefit their businesses. Together with the Scottish Manufacturing Advisory Service, the AFRC has introduced a new service which seeks to identify the areas of SME manufacturing business that may benefit from automation technology.

Research for All

The AMRC's Integrated Manufacturing Group based at Factory 2050, has unveiled a new opportunity for smaller companies to conduct research into machining and assembly technologies within a new 'reconfigurable factory' research cell. The new facility gives SMEs access to a research and development cell where they can work with expert engineers on manufacturing projects in a safe and cost-effective environment designed to take the risk out of trialling new technologies and processes before putting them into production. The cell can accommodate projects from the trialling of new robotic assembly techniques for mass customisation or even small batch manufacturing techniques, small component assembly, and finish machining and polishing operations. It can be reconfigured to the specific requirements of an SME with a shorter lead time allowing easier, quicker and more affordable engagement for SMEs.

Create, Test and Launch

WMG's Create, Test and Launch (CTL) programme supports small firms to optimise their business activities and explore new markets, by helping them access the lean tools and methodologies that could reduce their time to market, minimise investment risks and maximise their chances of success. WMG have conducted four successful CTL pilots, working with companies to validate customer demand, creating prototypes and test selling new-to-market products. This has resulted in higher margin offerings which are often sold direct to customers. One participant in the programme saw potential to generate up to a third of their existing turnover, selling a new aftermarket automotive product to a mainstream automotive OEM. The potential of the programme to generate new value for manufacturing SMEs has been recognised by NatWest, who have partnered with WMG to subsidise existing clients to go through the programme. Chris Oscroft of Oscroft & Sons Ltd, said "I feel massively more confident than when we started this process and hugely more informed. It's given me a lot more confidence that we'll actually achieve."

Fit For Nuclear

The Nuclear AMRC's flagship Fit For Nuclear (F4N) supply chain development programme is a unique service to help UK manufacturing companies get ready to bid for work in the civil nuclear supply chain. The programme which was launched in 2011 and expanded in 2017, helps companies to measure their operations against the standards required to supply the nuclear industry – in new build, operations and decommissioning – and take the necessary steps to close any gaps. More than 640 companies, about 90% of which are smaller businesses, have now completed the initial online F4N diagnostic and almost 500 have received follow-on support, with around 140 companies now being granted F4N status after driving business improvements through a tailored action plan. As Toby Bailey of RED Engineering commented "The F4N programme has enabled us to ramp up our activity in the nuclear sector, approaching tier two suppliers in a project-ready state." A survey of the programme in 2018 found that 89% of participating companies would recommend F4N to other manufacturers and 90% expected their turnover to grow in the next year, with 57% confident of winning new work in nuclear.



From research to success



The HVM Catapult is the first point of call for UK academics looking to translate advanced manufacturing research from concept studies and laboratory experimentation to full scale commercial reality. It gives meaning to their work and enhances the impact of research.

Professor Sir Jim McDonald, Principal,
Strathclyde University

A strong and effective relationship with the UK's research community is a critically important part of the way we work. By making our equipment and wider facilities available, we offer academics and researchers the opportunity to investigate the application of their research findings and then collaborate in their transition and scale up to a point ready for use in industry. By bringing together academics and businesses, we also help to stimulate demand-led research.

The High Value Manufacturing (HVM) Catapult's relationship with universities runs deep with seven universities as founding partners and over 100 active collaborations with universities.

Researchers in residence

Over the last three years, the Engineering and Physical Science Research Council (EPSRC) and the HVM Catapult have been piloting a scheme (the 'EPSRC HVM Catapult Fellowship scheme') to attract leading academics into the HVM Catapult centres on short sabbaticals to begin the process of transitioning scientific breakthroughs into the industrial manufacturing environment. The pilot has developed into a new 'Researcher-in-Residence' program that has been opened to all Catapults and is attracting participation from other Research Councils. The programme is already generating a solid evidence trail of active and successful knowledge/technology transfer, and collaboration: 18 EPSRC Fellows have been appointed and are actively engaged with the HVM Catapult centres; more than 20 HVM Catapult/industry projects receiving direct input from the Fellows; 25 peer reviewed journal papers published, and more than 50 conference papers delivered.



Manufacturing Forum

In 2017 the HVM Catapult launched a new body called the Manufacturing Forum to help drive ever better connections between the UK's research and innovation communities and spur collaboration around the technologies that will address UK industrial needs. The Forum, which will meet annually, brings together leading academics, senior figures from industry and the HVM Catapult to explore both emerging trends and opportunities for collaboration across the national manufacturing ecosystem to lever the greatest benefit for the UK and multiply our economic impact.

Airbus Chair – digitalised manufacturing

Professor Ashutosh Tiwari is the Airbus/Royal Academy of Engineering (RAEng) Research Chair in Digitisation for Manufacturing. This is a five-year senior position aimed at establishing a unique, world-leading research collaboration in Advanced Manufacturing between the Department of Automatic Control and Systems Engineering (ACSE), Airbus UK and our AMRC centre at the University of Sheffield.

The research is structured around the four research challenges facing digitisation of manufacturing. These challenges include how to instrument both new and legacy machines to surmise the quality of work-in-progress products and to adapt machine settings for new tasks; how to digitise interactions of humans with the manufacturing shopfloors; how to digitise parts, trays, jigs, fixtures and Automated

Guided Vehicles (AGVs) using live material movement data; and how to learn from anomaly resolutions to build the overall capability at the manufacturing system level.

Professor Tiwari said: "My vision is to establish a world leading engineering research group that focuses on developing a digitised factory that requires no setups for manufacturing wing variants and no intrusive measurements of wing parts for ensuring quality.

"I am particularly excited with the prospect of pursuing both use-inspired digitisation research and underpinning fundamental research, supported by industrial-scale facilities at Airbus and AMRC."

Skills for success

The primary focus of the High Value Manufacturing (HVM) Catapult is to accelerate the translation of great ideas from the research base into commercial products that deliver a sustainable future and a growing economic contribution from the UK's high value manufacturers. However, to reap the full benefits of new technologies, manufacturers also need access to relevant skills. These are currently in short supply within the UK's manufacturing workforce.

Individual centres within the HVM Catapult have therefore evolved approaches to building the manufacturing skills base at all levels to enable the effective use of new technologies and secure related productivity and competitiveness improvements. This work is funded through our commercial work and takes no funding from our core grant from Government.

AMRC Training Centre

The AMRC Training Centre provides training in the practical and academic skills that engineering and manufacturing companies need to compete globally. Since taking on its first 140 apprentices in autumn 2013, the Training Centre has grown rapidly into an award-winning centre of excellence with over 700 employed-status apprentices. Working with employers, it identifies and provides the practical and academic training required to build the skills that manufacturing companies need to compete globally, from apprenticeship through to doctorate and MBA level. 2017/18 saw record numbers of apprentices wanting to enrol at the Training Centre with record inquiries from business. With more than 300 regional companies, many of whom are SMEs, the Training Centre is also attracting apprentices from further afield: with Toyota sending apprentices up from the Midlands, and Rolls-Royce about to follow suit.

2017/18 also saw the first cohort apprentices to graduate from the Training Centre with foundation degrees. Graduate Tom Kaye, who works for Arconic Forgings and Extrusions in Sheffield, is planning to continue his studies with the Training Centre. He said: "It's been a really great experience and it was good to feel a part of the university and have that academic achievement recognised. It feels very good. The two years have been worth it."

A new degree apprenticeship programme, designed in a collaboration between

academic staff and employers, is now underway. It will ensure students graduate equipped to meet the current and future needs of the advanced manufacturing sector.

Louise Cowling, Head of Degree Apprenticeships at the Training Centre, said: "Our programmes have been developed with employers to make sure the content is relevant, is informed by the research taking place at AMRC to ensure apprentices are exposed to new technologies, and has the academic rigour expected of a Russell Group University.

"Many of our students have taken business improvement ideas and techniques back to their workplace. They have discussed new processes or systems with their managers, planned the implementation and generated tens or hundreds of thousands of pounds of savings per year for their organisations. Other apprentices have changed measuring systems to improve accuracy and made small but significant changes to production methods to improve the number of pieces produced per shift."



Train at the MTC

The Advanced Manufacturing Training Centre at the MTC, sponsored and part financed by Lloyds Bank, helps develop, maintain and build upon the vital skills required by manufacturing engineers and technicians to use new technologies and keep their companies globally competitive. Its face-to-face training programmes take place in a 'clean' research environment, away from the pressures of production. Using skill gap analysis, courses can be designed and tailored to reflect individual sector and company needs, for example in response to the rapid pace of change, to accommodate business growth or to upskill in line with job requirements.

With the combined engineering programme and the inclusion of business administration apprenticeships, AMTC has seen significant year on year increase in female cohorts, rising from 8% in 2016 to 19% in 2017. Well on the long journey of achieving equality in engineering sectors, they are delighted to be expecting 25% of cohorts to be female in September 2018.

George Lowndes, 19, graduated from his apprenticeship at AMTC and with his foot on the gas secured a role at Mercedes-AMG Petronas Motorsport in September 2017. The role sees Lowndes working in the model and prototype shop at HQ in Brackley and he acknowledged the skills he gained through the programme gave him the experiential edge and assisted him significantly into the prestigious role.

George said: "It is absolutely brilliant and I'm really excited. I'll be working in the modelling and rapid prototyping (RP) team. The model shop make scale models of the F1 car and they test it aerodynamically in the wind tunnel. With RP, they 3D print all of the aerofoils and it'll be my job to oversee that and prep the parts out and fit them to the models."

Lowndes is one of a number of success stories of apprentices going on to enhance their career after undergoing the MTC Apprenticeship Programme.



"The MTC apprenticeship has definitely helped me to get this role. I have gained industry experience and learned the basics of engineering."

George Lowndes, Mercedes-AMG Petronas Motorsport

NCC leading composites conversion

The lightweight, corrosion resistant and durable properties of composite materials, together with their great versatility, means that they offer huge potential advantages to manufacturers. To seize those advantages however, firms need engineers who understand how to work with composites. Sadly, they are in short supply. In 2017, the NCC therefore introduced a new training package to give engineers with experience of working with other materials an introduction to working with composites and a foundation level of knowledge. Developed in collaboration with the University of Bristol, the programme covers manufacturing processes and methods, design, analysis and application of engineering composite materials. It also includes a Design Build Test Task to give participants the opportunity to put what they've learned into practice.

Course participants feel the course brings real value into their businesses. Chris Knight, Advanced Research Engineer commented: "The composite conversion course provided me an accelerated learning opportunity which has enabled me to switch industries. Through using my blend of experience of metallic component design and newly obtained composites knowledge, I have developed tooling and manufacturing processes for number a companies, including Airbus and Dymag."

Informing the bigger picture

The work we do to help individual businesses turn ideas into the great products and services that boost our economy, is increasingly recognised through the business community. But the High Value Manufacturing (HVM) Catapult is also working to help shape wider thinking around the Government's Industrial Strategy by sharing its insights into the technologies and innovation that will best help UK manufacturers grow their contribution to our economy.

Industrial Strategy

Last year saw the publication of the Government's Industrial Strategy 'Building a Britain fit for the future'. The Strategy set out four 'Grand Challenges' to put the UK at the forefront of the industries of the future: Artificial Intelligence and Data Economy; the Future of Mobility; Clean Growth; and the Ageing Society. The Strategy then identified five 'Foundations of Productivity' under which the Strategy seeks to base its key policies. These five themes are Ideas; People; Infrastructure; Business Environment; and Places.

We see that the HVM Catapult has a key role to play in helping to deliver the ambitions set out in the Industrial Strategy, under which Government has committed to raising total research and development (R&D) in the UK to 2.4% of GDP by 2027. Given that manufacturing accounts for 68% of all business investment in R&D it makes sense that we look to manufacturing to help achieve this ambitious target.

During the year we dedicated a considerable amount of time towards mapping our technology plan and high level priorities against the four Grand Challenges in order to ensure that we are focusing our efforts on the technologies with the greatest chance of success and, most importantly, impact. This mapping exercise was shared with a number of external organisations and stakeholders as a means of identifying collaboration opportunities and leveraging maximum benefit to the UK taxpayer from the UK's Research and Technology Organisation (RTO) infrastructure.

The result of this meant that in the past year we have seen extensive activity across the HVM Catapult and our centres in developing Industrial Strategy Challenge Fund (ISCF) proposals and supporting a significant number of sector deals.

On the opposite page are some examples of how we have contributed in the past year.



Construction Sector Deal

HVM Catapult, through the lead of the MTC, has been at the centre of efforts to develop a national Construction Sector Deal to accelerate collaborative efforts by the construction industry to raise its game and to respond to the UK's wider productivity, skills and environmental impact challenges. The deal is focused on three strategic outcomes:

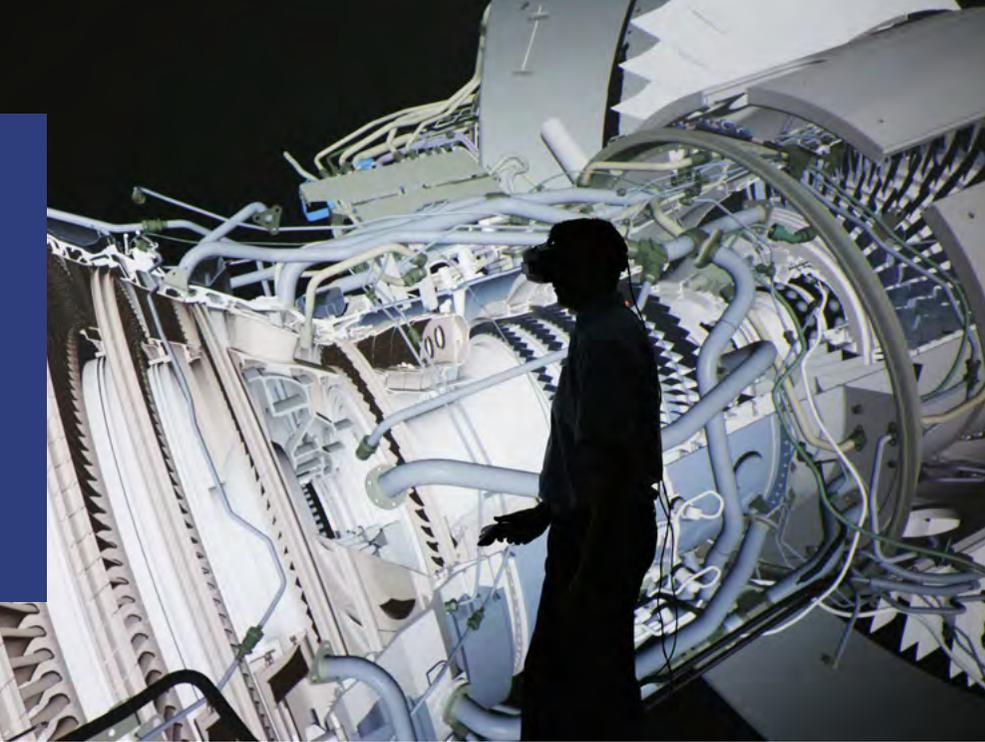
Digital – delivering better, more certain outcomes using digital technologies

Manufacturing – improving productivity, quality and safety by increasing the use of manufacturing

Performance – optimising through-life performance through the development of smart assets

Key HVM Catapult contributions have included:

- Thought leadership in facilitating the launch of the Technology Roadmap for UK Construction and National Infrastructure (via the Infrastructure Industry Innovation Platform (i3P)).
- Developing the proposals (in partnership with the Centre for Digital Built Britain (CDBB), Innovate UK and Construction Industry Training Board (CITB) for the digitally enabled job roles of the future.
- Developing production system and product family architecture thinking for the industry working with CDBB and the Government Construction Board working group for Modern Methods of Manufacture.
- Contributing to a joint submission to the ISCF which has resulted in the Transforming Construction: Manufacturing Better Buildings £170 million fund. This will deliver a range of capital facilities and R&D programmes to drive industry innovation.



Made Smarter Review

We have worked with industry and academia on behalf of the Made Smarter project team to shape the outline for a proposed ISCF call for Made Smarter. We have helped to shape four research challenges and six innovation challenges that will deliver business outcomes such as improved productivity, reduced lead time and evolution of new business models through the advancement and adoption of industrial digital technologies. We have also supported the Made Smarter team with the formulation of the Made Smarter UK commission and strategic implementation group and the role out of the North West (NW) adoption pilot. HVM Catapult is mapping the NW innovation assets and proposing a framework for business engagement.



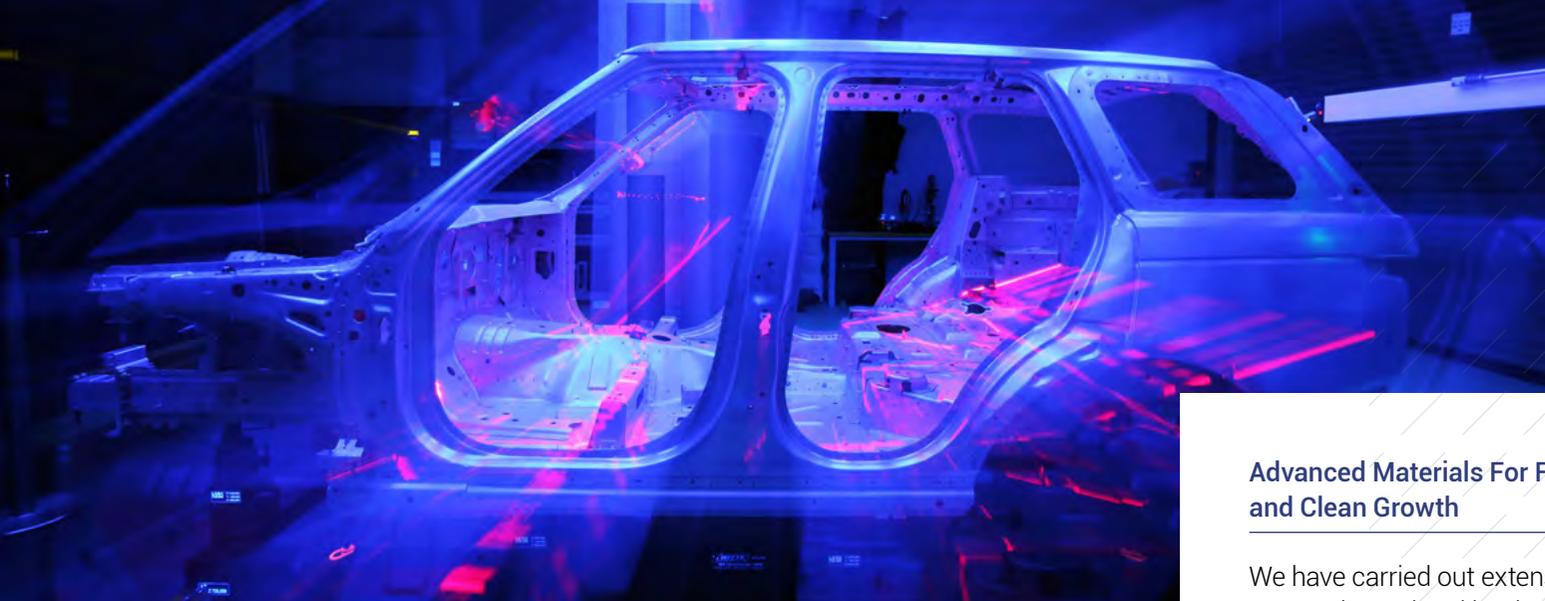
Food and Drink Sector Deal

Supporting the Food and Drink Federation (FDF) in creating a sector deal for food and beverage manufacture in the UK that focuses on productivity rather than food science or food technology. We are developing a technology roadmap with particular focus on:

- **The opportunities to increase the capabilities and uptake of automation to reduce the dependency on a migrant workforce in agriculture (with Brexit, this becomes important).**
- **The drivers and challenges in the adoption of new technologies (e.g. digital manufacturing, automation) in the food and drink manufacturing sector.**
- **Opportunities through improved in-manufacturing processes to deliver resource efficiency.**
- **The potential of cellular agriculture, an emerging area of biotechnology that applies advances in cell culture, tissue engineering and synthetic biology to produce agricultural products in bioreactors rather than through raising livestock.**

Nuclear Sector Deal

HVM Catapult, through the lead of the Nuclear AMRC, has been instrumental in shaping and coordinating the Nuclear Sector Deal. This work brought together key organisations from the research community, new nuclear build, decommissioning and marine to commit to developing and advancing the UK nuclear industry. The Nuclear AMRC will be working with the UK nuclear industry to develop advanced modular reactors and a fusion technology platform to ensure the UK stays at the forefront of nuclear innovation. The aim is to reduce the cost of new build and decommissioning by 30% and 20% respectively through development of advanced manufacturing and construction methods. Support to the UK supply chain will be provided through a national supply chain and productivity programme to assist companies to expand existing nuclear capabilities or develop capabilities from other sectors to enter the nuclear sector.



High Value Design

We have worked with the aerospace, automotive, defence and marine sectors, together with the Department for Business, Energy and Industrial Strategy (BEIS) to develop a proposition that will deliver a step-change in the processes for the design and assurance of high value complex engineering systems. A UK, with world leading High Value Design (HVD) capabilities, will secure and grow its role as solution architects for complex systems such as aircraft, cars, ships, submarines et al thereby increasing the potential to anchor downstream manufacture via UK based supply chains.

Faraday

Over the last 12 months, the HVM Catapult has played a key role in producing the Faraday Challenge a £246 million commitment over the next four years on battery development for the automotive electrification market proposal (announced by The Rt Hon Greg Clark, Secretary of State for Business, Energy and Industrial Strategy, in July 2017 as part of ISCF Wave 1). The strength of activities within the WMG team has been instrumental in the award of £80 million of Faraday funding to establish a new National Battery Manufacturing Development Facility (NBMDF) via a partnership between WMG, Coventry and Warwickshire Local Enterprise Partnership, and Coventry City Council (announced by the Secretary of State while attending an energy conference on the University of Warwick campus on 29th November 2017).

Advanced Materials For Future Mobility and Clean Growth

We have carried out extensive engagement across the national landscape to:

- Identify the future material needs of the product and services sector.
- Determine the reasons for the poor track record in the UK of transitioning the fruits from its world leading materials science base into downstream competitive advantage.
- Identify key interventions that will overcome some of those market failures.
- Develop detailed intervention delivery plans, working with industry, academia, other RTO's, sector councils, the Advanced Materials Leadership Council, UK Research and Innovation (UKRI) and BEIS.

As a result, HVM Catapult has facilitated and provided submissions into ISCF Wave 3.

Our resources

Based on best practice established by the German Fraunhofer approach, the High Value Manufacturing (HVM) Catapult strives to secure broadly equal amounts of income from:

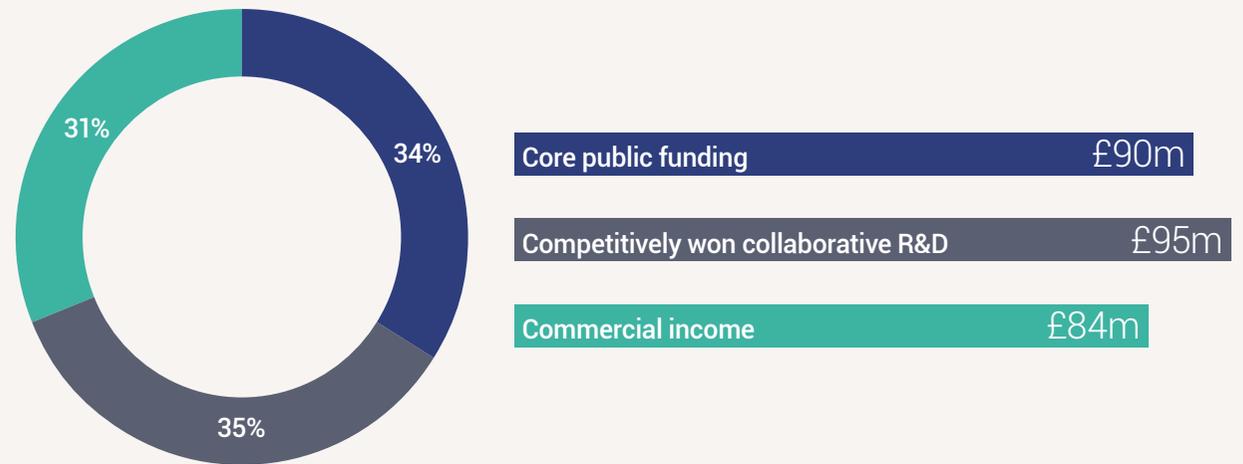
- Core public funding from the Innovate UK grant for long term investment in infrastructure, expertise and capability development.
- Collaborative R&D projects funded jointly by the public and private sectors and awarded on a competitive basis.
- Commercially funded R&D contracts.

Maintaining the funding model in proportion ensures that an innovation 'sweet spot' is maintained - encouraging risk taking, collaboration and stimulating innovation in areas that are relevant and of benefit to industry.

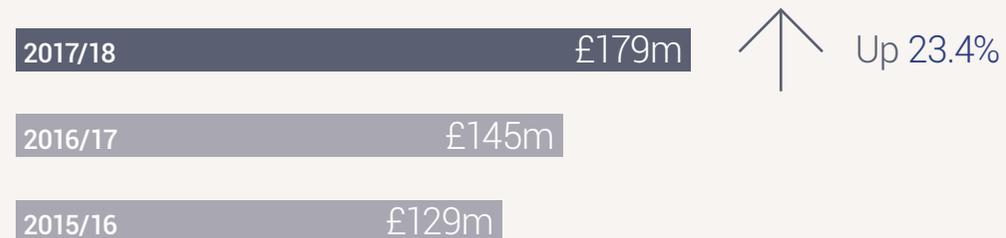
These charts show HVM Catapult income sources in 2017/18.

2017/18 saw strong growth in our Collaborative R&D and Commercial income which rose 23.4% on the previous year.

HVM Catapult Income Sources 2017/18



HVM Catapult Collaborative R&D and Commercial Income



Our sales order book

£234m

↑ As at March 2018
Up 14% on 2016/17

£170m of this is Collaborative R&D

Investment in capital projects and capability during 2017/18

£82m

↑ Up 57%
on 2016/17

Total value of our assets

£683m

↑ Up 11%
on 2016/17

Our people

2,482 full-time
equivalents

↑ Up 22%
on 2016/17

Building a strong manufacturing future

In our first six years of operation the High Value Manufacturing (HVM) Catapult has established a proven track record, generating investment in R&D and driving improvements in manufacturing productivity and competitiveness.

In August, Government confirmed that it would continue to invest in the HVM Catapult and announced a five-year funding package which allows us to build on our early successes, broadening our productivity impacts while equipping British firms with the manufacturing innovation they need to compete in uncertain and challenging international markets.

As we look to the future, we are determined to multiply our impact. We have an ambitious agenda geared to building on our early success and driving improvements in UK manufacturing productivity and competitiveness through innovation born of excellent research. It harnesses our exceptional insights, expertise and connections across the research base and into business to deliver year-on-year improvements

in the benefits we generate for the UK economy and to make a significant contribution to major national challenges such as the push for improved productivity and the goal of raising investment to 2.4% of GDP by 2027 and 3% in the longer term.

As part of this you will see the HVM Catapult continuing its work to connect with more of the UK's manufacturers and to deepen its relationship with the world-leading researchers whose findings can help supercharge the UK's manufacturing performance. You will also see us driving activity in areas where we already see great opportunities for the UK, in particular:

- Increasing the uptake of digital and automation technologies to increase UK productivity and global competitiveness.
- Establishing the UK as a global leader in additive manufacturing.
- Making sure that the UK has a presence in the manufacture of the next generation aircraft wings and aero propulsion.
- Increasing the uptake of automation to create a more productive food and drink sector.



- Developing and commercialising the technology for vehicle electrification to help government achieve its carbon reduction and emissions targets.
- Establishing a UK nuclear supply chain creating sector market share, jobs and growth in the UK.
- Modernising UK construction practice and developing an affordable construction supply chain.
- Creating growth in the UK pharmaceutical and healthcare sectors by increasing efficiency and developing new products and processes.
- Enabling the shift from petrochemical based products to products and ingredients that are derived from sustainable bio-mass.
- Increasing the UK's share of the through-life services market by better integrating design, manufacturing and through-life performance.
- Developing and commercialising the technology for vehicle autonomy.
- Improving the competitiveness and resilience of the UK defence sector delivering better value for money for the taxpayer.

The HVM Catapult has a proven model to deliver substantial manufacturing innovation to market and provide a bridge between UK technology research and market application. In our first six years we have established ourselves as the 'go-to' place for advanced manufacturing technologies and a principal delivery instrument for UK companies in innovation programmes. The next five years will see us making an even greater contribution, driving up the UK's investment in R&D, giving businesses the tools to boost their productivity and attracting the high value international investment that benefits communities across the UK. The High Value Manufacturing Catapult will be part of a bright future for UK manufacturing.



Looking ahead



Allan Cook CBE
Chairman (2018–)
High Value Manufacturing
Catapult

From my very early years, I always wanted to be an engineer and throughout my career the success of British manufacturing has been a personal passion. So I'm delighted to have been appointed to be the Chairman of the HVM Catapult and to guide its development for the next six years. This role comes at a time when there is a national recognition that wealth creation through manufacturing is vital to a thriving economy. That has generated unprecedented levels of support for advanced manufacturing in the UK as evidenced by the important investment committed by government and industry to grow the delivery capability of the HVM Catapult over the next five years.

Today manufacturing faces both major risks and significant opportunities. The leadership of the HVM Catapult and I are determined to help British firms navigate the uncertainties and succeed in a changing world.





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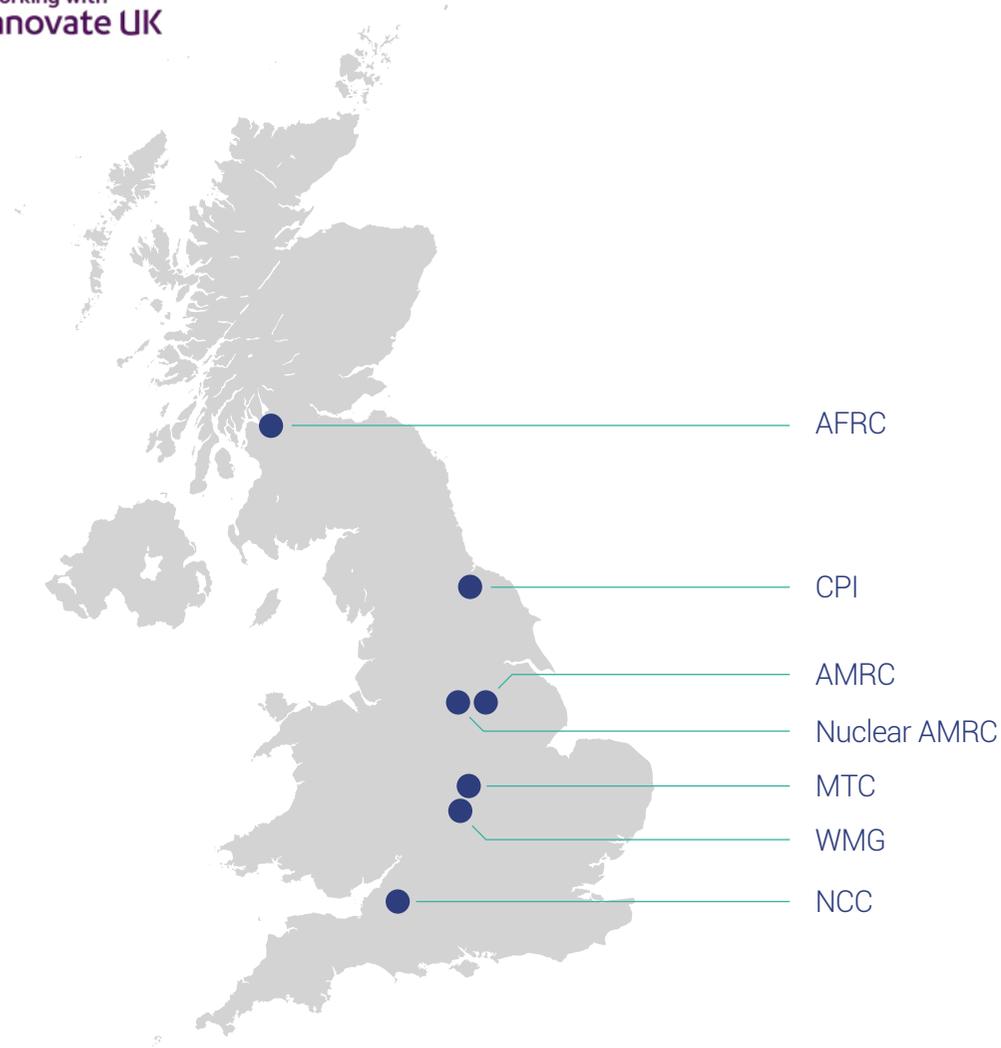
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CATAPULT

High Value Manufacturing

Working with
Innovate UK



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