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MANUFACTURING REVIEW

INDUSTRY SECTORS

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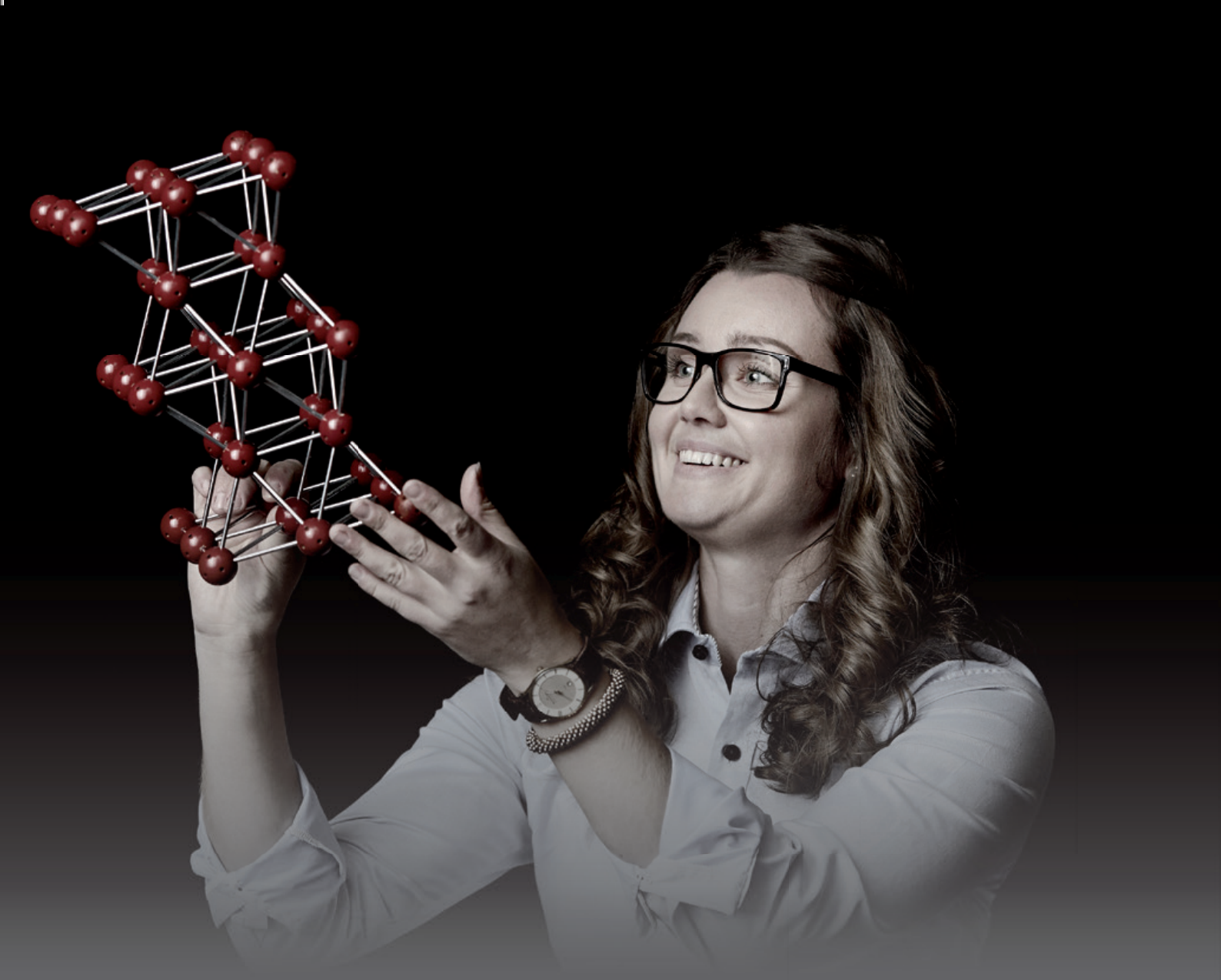

Cover images

Range Rover Evoque: Jaguar Land Rover's SUV is part of a bigger story that saw JLR in January build more cars in the UK than previous top cat Nissan. In November CEO Ralph Speth said he wants to double production to one million cars a year and push hard on electric powertrains.

JCB Hydradig: JCB's flagship 2016 model, and one of three new product launches in 2016, Hydradig offers new engineering design innovations around visibility, stability and manoeuverability, including a low-slung engine positioned between the axles. A hit with buyers, it is sold out until spring 2017.

Eurofighter Typhoon: BAE Systems won new support contracts for Typhoon and Hawk in 2016. The construction of Typhoon, Europe's largest military programme, has supported 40,000 jobs in Britain.

Prosthetic limb: Basingstoke-based Blatchford has developed the first ever prosthetic limb with integrated robotic control of the knee and foot, a system in which the parts work together like a human leg. A team led by technical director Professor Saeed Zahedi OBE FREng won the 2016 MacRobert Award.

Equator gauge: A key feature of Industry 4.0 is fast process control. The Renishaw Equator™ gauging system delivers highly repeatable, thermally insensitive, versatile and reprogrammable gauging. The integration of Equator™ within automated production cells was a notable trend in 2016.

An ABB robot at the Manufacturing Technology Centre: The seven HVM Catapult centres work with companies from all parts of the UK to help them benefit from technologies such as industrial automation. Large robots can hold big components to better automate complex machining processes.

UK MANUFACTURING REVIEW 16|17

Welcome to UKMR 2016

Do you remember January? David Cameron and Barack Obama, the UK still spiritually "in" Europe, a run of bad manufacturing output data, and a record-breaking car industry. We end the year with a vote to leave the European Union, a new prime minister and opposition leader, a Department for Business, Energy & Industrial Strategy, Donald Trump as US president-elect, a car industry carrying big concerns about the future, and with Q3 manufacturing output, post-Brexit, the best of 2016.

Most companies still have no idea what Brexit will mean. Our article on page 122 gives contrasting views from the people who matter, the makers. What is certain is that a low pound helps many exporting manufacturers and, let's hope, if it remains close to this valuation for a while, it will encourage many more firms to try exporting – something that is much harder to do than talk about. Textiles, you may be surprised to know, is a growing British export industry benefiting greatly from the Made in Britain brand – see page 110. A low pound is not great for those who buy components from Europe, I hasten to add, which is the reason that while our car industry looks healthy, for long term prosperity, Britain needs to fill the hollowed out middle and build more domestic suppliers (see page 25). A good example of how the mid-sized, high capability British company can develop is Gardner Aerospace, profiled on page 45.

I won't apologise for mentioning the darlings of British manufacturing, automotive and aerospace, first. They always grab the headlines, to the vexation of other equally worthy, less visible engineering sectors. Here, UKMR is even-handed; the pharma, food and drink, motorsport, medical and defence sectors are afforded as many pages as auto and aero. We have deliberately covered some of the hidden gems of UK industry, like textiles, space equipment and even watchmaking. In technologies, we review additive manufacturing, naturally, but also automation and robotics, photonics, metrology and advanced materials.

And there is a 32-page section devoted to digital technology in manufacturing. Industry 4.0, 4IR, Industrial Internet of Things – call it what you will; 2016 was the year this phenomenon landed with a bang – check the Google graph on page 195. Many of us, while using a smart device to order shopping or check a bank statement, are still figuring out what the digital revolution actually means to our business. What is certain is that these technologies can help companies to become more competitive, and will also change the nature of manufacturing work.

My sincere thanks to the sponsors who helped make UKMR 2016 a success; see page 251 for full acknowledgements. I hope you enjoy the Review and good luck in 2017.

Will Stirling

Editor and Publisher,
UK Manufacturing Review
2016/17

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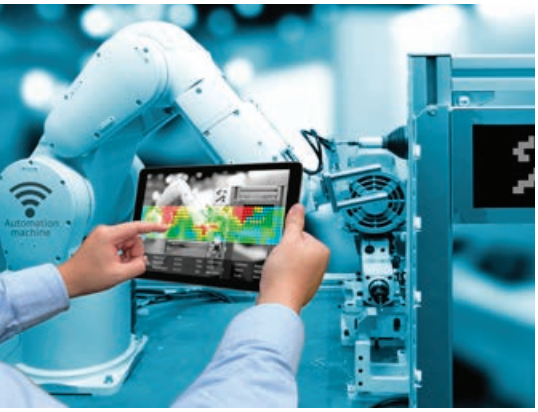

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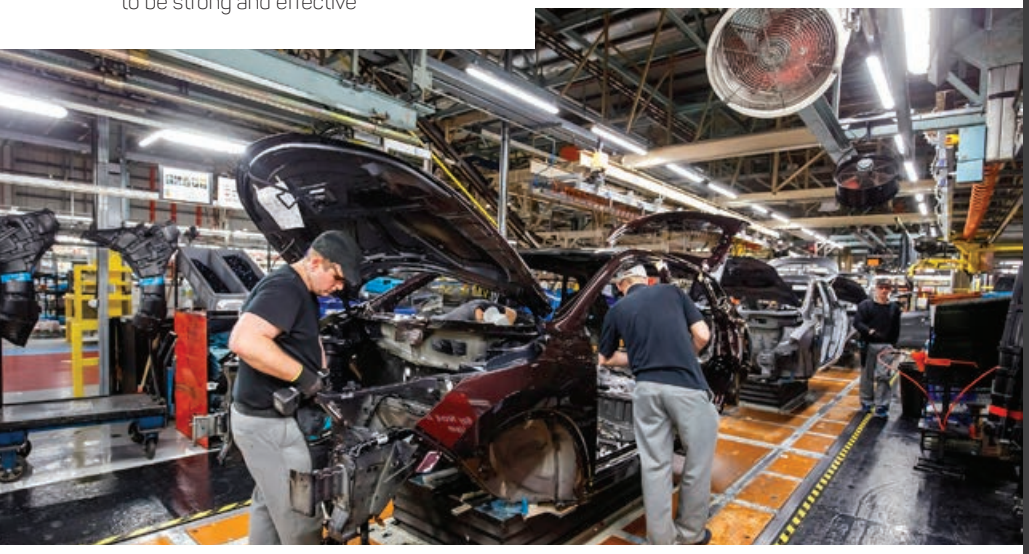

UK MANUFACTURING REVIEW 16|17

Published by Stirling Media Ltd
Cedar Studios, 49 Kings Road, Teddington, TW11 0QE
Tel +44 208 973 0920

Produced by Stirling Media Ltd

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Motion Ltd.
www.motionltd.com
Production manager/ Head of design:
Ben Gibbs, Motion Ltd
Designer and Illustrator:
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Additional design:
Burge Agency
www.burgeagency.com/

Publisher: Will Stirling
Stirling Media Ltd
will@stirlingmedialtd.com

ISBN 978-0-9956954-0-5

Printed in the UK by
Geoff Neal Group

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Photo courtesy of Jaguar Formula 1

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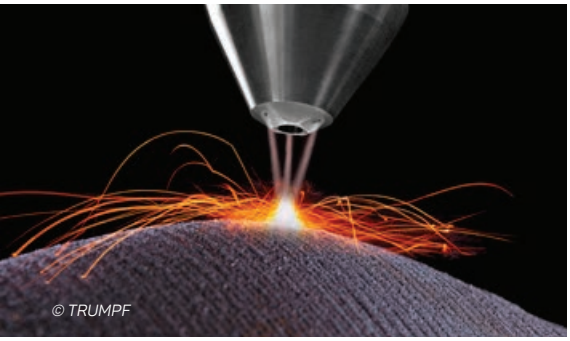
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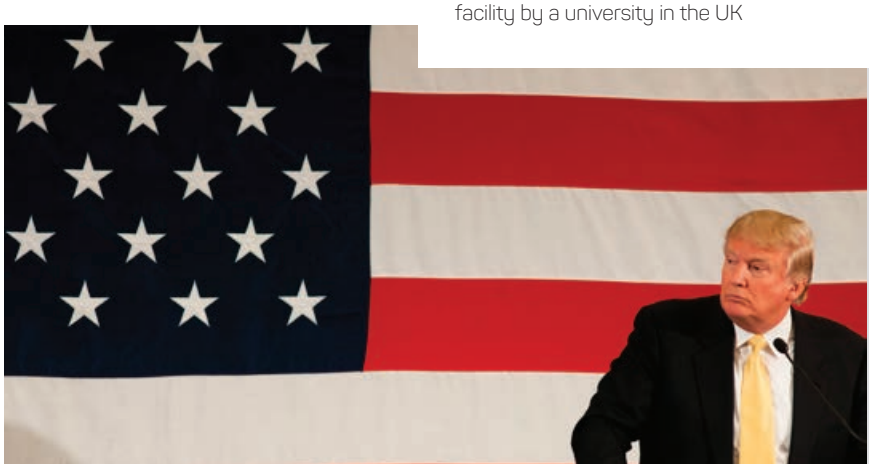

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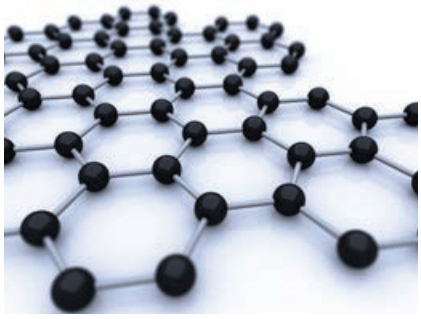

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Total value of our assets

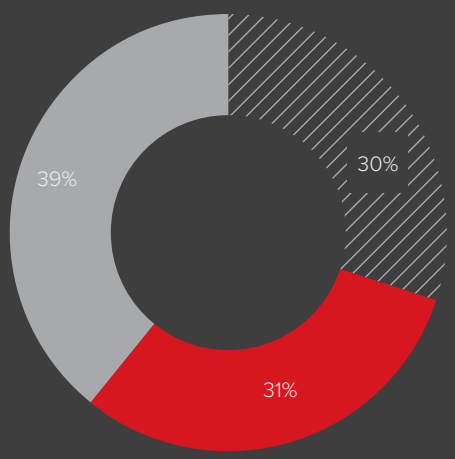
£561m

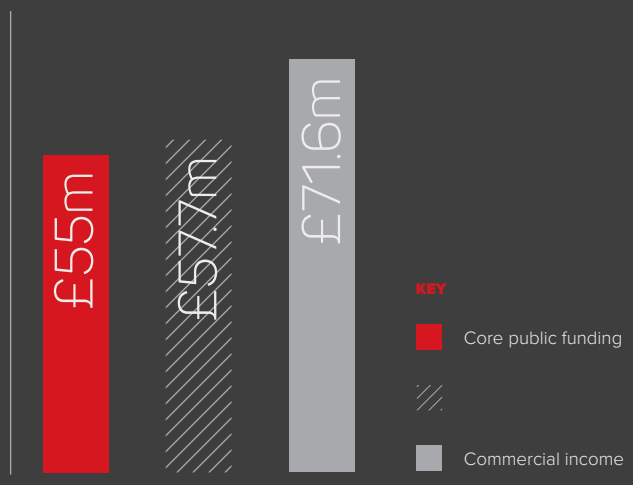
Up 15.5% from 2014-15

Investment in large capital projects

£74.5m

FUNDING BREAKDOWN





Number of employees

1,913

Number of projects

1,878

HVM catapult economic impact

£1

core public funding received

£15

net benefits to the UK economy

Source: WECD Economic Impact Evaluation study 2016. The next economic impact study is due in 2017.

Size of order book

£188m

Of which £100m is CR&D

Private sector clients

3,036

Over 56% of whom (1,701) are SMEs

Dick Elsy

CEO, The HVM Catapult

CATAPULT High Value Manufacturing

Manufacturing underpins the success of our economy. The UK is the world's 11th largest manufacturing nation, employing 2.6 million people, making up 50% of exports, and accounting for 69% of business R&D. Although this year has been very challenging for manufacturing, with economic turmoil, uncertainty regarding the EU referendum, and the steel crisis all taking their toll, UK manufacturing has shown remarkable resilience.

With global consumption expected to double by 2030, British manufacturing has the opportunity to continue to perform strongly, compete on the global stage, strengthen its export position, and grow its contribution to the national GVA, which currently stands at 9.5%. So what is key to our success?

MARKET OPPORTUNITIES

The UK is the world's second largest aerospace manufacturer and expected global demand for 27,000 passenger aircraft – worth around $3.7 trillion by 2030 – is a compelling commercial prospect. The UK automotive industry also continues to excel, particularly in the premium vehicle market. Exciting developments in nuclear energy, medical technologies and healthcare, the built environment and agri-food, are equally set to see global export opportunities for the UK.

The more digitally focused world of the 4th industrial revolution will create new business opportunities. Connected, flexible factories will respond to customer requirements and monitor products from the factory floor, right through to end-of-life. Big data will inform design and manufacturing processes. New technologies such as additive manufacturing, or 3D printing, and intelligent automation will broaden horizons.

NEW VALUE FROM THROUGH-LIFE ENGINEERING SERVICES

There is a move towards through-life engineering services, with users opting to pay for safe, cost-effective and reliable performance, rather than owning products outright. For complex, high value assets – such as aerospace engines, cars, and yellow goods, in particular – manufacturers won't just make the assets, but remain responsible for timely maintenance and ongoing improvements. This gives users more certainty whilst manufacturers gain access to a growing market of – high value – engineering services.

For the UK to capitalise on these opportunities, we need to be at the forefront of technology innovation. Fortunately the UK has an excellent process to support this. At the High Value Manufacturing Catapult, our 1,900-plus strong team of engineers, technicians and scientists work with manufacturers to bridge the gap between early stage innovation in materials, processes or products, and commercial exploitation through UK manufactured products.

There is a move towards through-life engineering services, with users opting to pay for safe, cost-effective and reliable performance, rather than owning products outright.

We have worked with more than 3,000 companies in the last 12 months. More than half were SMEs. Seeing how working with us has helped them increase market share, enter supply chains, re-shore production, build new facilities and achieve step change productivity improvements, is the biggest motivator in my job.

My second biggest motivator is the fact that government now recognises manufacturing as being key to a balanced economy. The last Comprehensive Spending Review saw government support for the HVM Catapult more than double from the original plan. This, combined with ongoing close collaboration with Innovate UK and a strong manufacturing strategy, gives me much confidence for the future. MR

Read more about the automotive industry and the HVM Catapult's first five years on pages:

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Tom Lawton

Head, BDO manufacturing

2016 has proven to be a year of huge economic change that will continue to impact the UK manufacturing sector for many years to come. There are many stories that I could pick out for this foreword, but the following four standout as the most important and impactful for the sector in the short, medium and long-term:

EU Referendum: the referendum dominated the news for the early part of the year and the impact of the Brexit vote has cast a very long shadow of uncertainty

Skills: for many years the sector has highlighted the lack of available skills and Brexit may well make this worse at least in the short term

Industry 4.0: during this year the drive towards the internet of things is gathering pace and this is impacting the UK manufacturing sector in many different ways

Industrial strategy: all of the above factors (and more) need to be considered and supported by a long-term government industrial strategy.

WITH UNCERTAINTY THERE IS ALSO OPPORTUNITY

The United Kingdom's decision to leave the European Union (Brexit) will have a profound effect on manufacturing. Immediately after the EU referendum vote, the financial markets were hit and sterling fell sharply to a 30 year low. Since then markets have started to calm and sector data since Brexit has been mostly positive (UK manufacturing PMI in October was at 54.3 with upturns in output, employment and new orders and GDP grew by 0.5% in the third quarter). But these are early days and Brexit and what it actually means to our trading relationship with the EU (and beyond) will continue to cause significant uncertainties for UK manufacturers. The depreciation of Sterling will put additional pressure on costs and therefore profit margins for manufacturers but there is a silver lining – even with increased costs the low pound should help our exporters export more and ideally start to export to the faster growing economies outside of the EU.

MAINTAINING THE RIGHT SKILLS

The availability of the right skills has been a long-term issue for the UK manufacturing sector and Brexit may have further implications on the ability of UK manufacturers to recruit both the high level engineering skills to maintain our edge in research, development and design of products particularly in the era of Industry 4.0 and the lower level (and cheaper) skills that drive large parts of the sector. This is likely to require changes in how we manage the immigration process and over the medium and long-term how we develop the right skills and education system that we need to maintain a successful manufacturing centred economy.

> "The Government should match manufacturers' long-term outlook by looking 15-20 years ahead when planning the industrial strategy"

KEEPING UP THE PACE

The pace of change towards more automation, digitisation and Industry 4.0 processes over the next five to ten years will be rapid and UK manufacturers will need to change how they do business to cope with the new digitised environment. One of the key likely implications will be the requirement to provide greater access to data through the supply chain – and this may require significant changes in IT. In addition, the drive towards automation (even in a design rich environment like the UK) will require further investment to keep up pace with customer requirements and global competitors. It is encouraging to see the Government's £400m investment in UK Catapults but in comparison to Fraunhofer Institutes, (the German equivalent), which has an annual budget of £1.9bn, the UK still seems far behind in making these critical strategic investments.

THE SECTOR NEEDS A LONG-TERM SUSTAINABLE FRAMEWORK

The creation of the Department for Business, Energy and Industrial Strategy (BEIS) is a promising sign to UK manufacturers who have sought formal recognition of a long-term strategy for industry for decades. Establishing an industrial strategy in a developed economy with a rapidly changing global perspective is complex.

The Government should match manufacturers' long-term outlook by looking 15-20 years ahead to plan an industrial strategy, avoiding the disruptions of the political cycle. This should include setting a stretching, formal target for manufacturing growth over the next five, ten and twenty years to provide the background to a sustainable industrial strategy. The programme must be steered by a dedicated manufacturing minister, able to focus on firms' needs in a way that will benefit us all. MR

Read more about Brexit and Industry 4.0 on pages:

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Kim Carr

Managing Partner, FBC Manby Bowdler

fbc manby bowdler.
SOLICITORS

Our work providing legal advice to SMEs up and down the country gives the team at FBC Manby Bowdler a good level of insight into most sectors. This year, our manufacturing specialists have seen a vast amount of activity on matters involving contract law, purchasing property, intellectual property protection, HR and employment legislation, and various mergers and acquisitions.

The Brexit vote led some clients to put plans on hold while they took stock of what leaving the EU could mean for their businesses. But this only lasted for a few weeks, and the second half of the year has been more buoyant than the first. The sector does still face challenges – access to skills, increasing productivity, uncertainty about what an EU exit really means and maintaining cashflow repeatedly come up in conversation with the manufacturers we speak to.

It's incumbent on us and other professional partners to keep abreast of any changes, understand what they mean for our clients, and ensure they get timely advice to help them maintain their competitive edge.

STRONG TRACK RECORD IN THE SECTOR

Clients choose us because we have a strong track record in their sector and add real value to their business. Manufacturers, in common with many businesses, face employment issues but more so than most industry sectors; they face constant challenges to their intellectual property, and they need to be compliant with a myriad of regulatory requirements.

This can take up valuable management hours and be a major headache for manufacturers. What we, as professional partners, can do is minimise stress, release management time, and, ultimately, allow business owners to focus on building their business.

And that appears to be what manufacturers are focused on doing – regardless of the current political landscape. Within months of the Brexit vote, UK exports were growing at a world-beating pace for the first time in a decade. The march of the manufacturers was in evidence as new overseas markets were sought for British manufactured goods.

By the end of 2016, the CBI was reporting that SME manufacturers were broadly optimistic about further increasing exports, but continued uncertainty over the value of the pound may mean that order books are not filling as fast into 2017.

Without a doubt, one of the key challenges facing manufacturers is finding the right people, with the right skills. This is not a crisis waiting to happen; this is a current crisis, which threatens not only the growth of the sector but of the economy as a whole. And once again, we are seeing manufacturers rise to the occasion by developing programmes which see employers taking the lead on training. Flagship schemes are being developed by employer-led consortiums investing in the future workforce, and we're delighted to support a number of initiatives aimed at promoting the sector as a career choice.

In summary, this year has not been devoid of its challenges for the sector, but, on balance we see a stronger sector now than at the beginning of the year, as indicated by the rise in output growth, new orders and employment. Long may it continue. MR

"Access to skills, increasing productivity, uncertainty about what an EU exit really means and maintaining cashflow repeatedly come up in conversation with the manufacturers we speak to"

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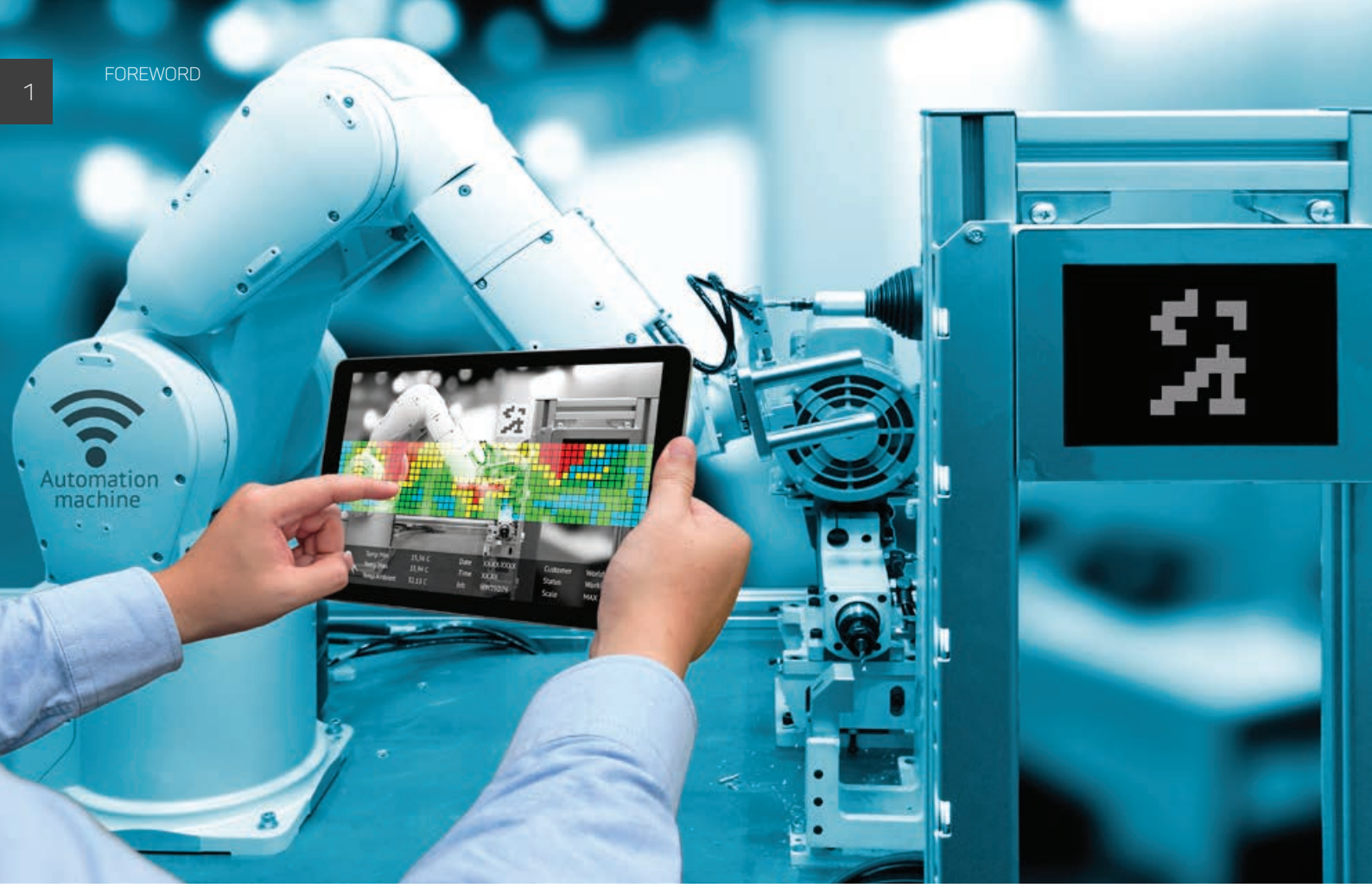

EMBRACING TOMORROW, TECHNOLOGY, AND A TEAM APPROACH

Manufacturers can achieve more, says Andrew Kinder, Infor VP of Industry & Solution Strategy.

The state of manufacturing has never been as tumultuous as it is today. New technologies, new business models, and a reignited drive to power-up are propelling manufacturers forward. Next-generation technologies and innovations, including: digitalisation, Internet of Things, data science, machine learning, virtual reality-enhanced engineering design, global supply networks, and customer-centric business models are driving a transformation. Each one of these technologies alone is a game-changer. But, together, they create a new era in manufacturing, far beyond Industry 4.0.

Moving forward in today's high pressure, highly competitive landscape takes more than just plodding perseverance and cash infusion. This is the era of creative problem-solving—not just thinking outside of the box, but redefining the box and redefining the goal. It's the Uber-effect. Instead of providing today's consumer with a better car, Uber provides access to a car, virtually any time or place, with no hassles of maintenance or storage. The famous ride-share pioneer is now worth an estimated $28 billion.

THE NEXT WAVE OF INNOVATION

This focus on the end effect, rather than just a product, is the next wave of innovation. Instead of a company manufacturing and selling air conditioning equipment for a shopping centre, they will sell conditioned air. Instead of selling animal feed, the provider will sell herd health and weight gain. Instead of selling equipment to dredge a channel, the enterprise will provide improved

trade routes for larger ships. Instead of a shoe manufacturer simply selling shoes, expect to see a buying experience that is fun, memorable, and sure to inspire more footwear purchases.

This next era, digitalised manufacturing, represents a whole-system transformation, from product design to order entry, to shipment and aftermarket service. Each link in the value chain is as critical as the next.

DIGITALISATION SUCCESSES

Digitalisation of manufacturing is already happening. There are early successes that can serve as models. Ferrari, Egbert Taylor Group, JR Watkins, Dunlop® Aircraft Tyres, and Vantage Power are European companies that have stepped up to the challenge and found innovative ways to use technology, particularly ERP solutions and cloud deployment.

"As a young engineering company, we are in an excellent position to get the most out of the cloud," says Alex Schey, CEO of Vantage Power. "That will quickly evolve as new versions of the powertrains are developed and we increase our customer base. Looking further to the future, we plan to take the data from our powertrains and feed that into the ERP so we can proactively maintain the units, and offer a cost-effective and complete managed service to our customers. Cloud will be at the heart of making all of this happen."

Egbert Taylor Group, manufacturer of waste bins, felt the need to upgrade outdated systems. "Our legacy systems were reaching the end, and as such we required an effective system that would enable us to have greater visibility of the business and its processes," says Andrew Davies, finance director of Egbert Taylor Group. "Our objectives included improving working capital management, streamlining production processes as well as integrating our quoting process into a single cloud based solution," he adds.

These are just two examples of manufacturers solving problems with the use of technology. We are not surprised by the great accomplishments of our customers. Manufacturing minds are brilliant when it comes to "making something work" and applying skills to make an improvement. In the recent past, those skills were focused on improving the same basic products. How many models of a kitchen sink or front door have we provided to consumers over the last five decades, all nearly the same? Now, finally, we have front doors that can tell us if a package arrived and a faucet that can save energy by calling for less hot water in off-peak hours.

Now, industry analysts, experts, and technology partners, like Infor, are saying think even bigger – think broader. We have the technology to help you go in whole new directions. Be customer-centric. Provide services and products. Outsmart start-ups. Be agile. Move to the cloud. Live data. Breath analytics and KPIs. Embrace data science. Value and speed will follow.

It's an exciting time in manufacturing—nothing short of a revolution. At Infor, we feel honored to play a part. We're ready. Are you? MR

"Moving forward in today's high pressure, highly competitive landscape takes more than just plodding perseverance and cash infusion"

– Andrew Kinder, VP Industry & Solutions Strategy, Infor

Read more about innovation and the digitisation of manufacturing on pages: 100 184

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National Apprenticeship Competition

23 May 2017
Cranfield University

Production of a mass transportation system on the Moon

This annual event hosted by Cranfield University invites ambitious apprentices across the engineering and manufacturing sector to demonstrate their skills and innovative ideas for manufacturing on the Moon. Working in company teams apprentices will be tasked with producing a mass transportation system suitable for manufacturing on the moon.

A team of national judges will select the finalists who are invited to showcase their models at the National Manufacturing Debate 2017.

Register a team now

www.national-apprenticeship-competition.org.uk

(Closing date for registration submission 18th December 2016)

National Manufacturing Debate (NMD)

24 May 2017
Cranfield University

For the eighth year running, this event brings together manufacturing professionals from a range of sectors to debate current challenges in the industry. NMD is designed to encourage networking and collaboration across the sector.

A full list of our speakers and programme will be available to view online shortly.

To register your interest visit

www.national-manufacturing-debate.org.uk

Professor Rajkumar Roy

Director of Manufacturing, Cranfield University

The events of June 2016 and the UK's decision to leave the European Union has led to uncertain times for manufacturing. Wherever any of us stood on the issue, what's needed now is not reflection on what has happened, or what might happen, but a bold statement of intent about how manufacturing can play a part in the UK Plc global offering.

The events of June 2016 and the UK's decision to leave the European Union has led to uncertain times for UK Manufacturing. Where ever any of us stood on the issue - what's needed now is not reflection on what has happened or what might happen but a bold statement of intent about how manufacturing can play apart in the UK PLC global offer.

Like many in industry and academia, I was delighted to see the Government re-commit to an Industrial Strategy – this is long overdue. The strategy however cannot be a top-down Government initiative, we all have our part to play in identifying and seizing on global opportunities as they emerge in a post-Brexit world.

It is vital that research and innovation are at heart of the Industrial Strategy, spearheading a UK drive to capture developing global markets. At Cranfield, we are committed to playing our part, focused within Manufacturing on delivering excellence and creating the next generation of leaders in technology and management. Cranfield Manufacturing's Executive MSc Programme and newly launched Manufacturing Director's Programme are spearheading our work to take people to the next level in manufacturing and leadership.

For the UK to triumph, we need to be bold, ambitious and brave. For manufacturing that means looking to the future, reinventing ourselves where necessary and never being afraid to re-think the way we do things.

At Cranfield, we look to create an environment where we can have those debates and test out new ideas that challenge and innovate. And we put these ideas into practice, an example of which is our new MSc in Cyber-Secure Manufacturing.

> "I was delighted to see the Government re-commit to an industrial strategy – this is long overdue"

In July, this year we launched with industrial partners a National Through-life Engineering Strategy that urged the UK to be ambitious in striving to capture this emerging global market.

Our new international symposia 'Manufacturing 2075', is dedicated to looking at the challenges of the very long-term and creating an invigorating space where industrialists, researchers, policy makers and technologists can come together and generate a common understanding of what the future could look like and how we can collaboratively best position ourselves with an optimum approach.

And of course the National Manufacturing Debate – now in its eighth year, in 2017, at Cranfield – continues to go from strength-to-strength in providing an arena where industry can come together with business, academia and government to search for common solutions to the current challenges in the UK manufacturing.

Cranfield Manufacturing is growing with significant expansion on world class academics and research facilities. In 2016 alone we have appointed 12 new academics within Cranfield Manufacturing.

Throughout this review, you will see examples of Cranfield's world-leading research and innovation, if you want to work with us in meeting the challenging of the future, then do get in touch. MR

Read more about through-life engineering on pages:

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Robert Harwood

Global Industry Director, ANSYS

Throughout 2016, the use of engineering simulation technology in product design and development continued its rapid growth. This was due to its proven ability to create value for companies, by enabling them to innovate faster, lower operational costs, accelerate new product development and achieve their sustainability goals.

Looking into 2017, this growth will continue, but three profound shifts will have an impact on the use of engineering simulation across industries. The first is the maturation of technologies under the umbrella variously called the Internet of Things, the industrial Internet and Industry 4.0. This essentially refers to the convergence of information technology (IT) and operational technology (OT). When integrated with engineering simulation capabilities, sensor and data management systems will enable the evolution of 'digital twins' which captures the behaviour not only of a product blueprint, but also of each individual product as it performs in its own operating environment.

SIMULATION UNLOCKS VALUE FOR ENGINEERS

This real world behavioral information provided by engineering simulation allows companies to unlock additional value from their assets by optimising operation and maintenance and leveraging those insights to accelerate new product development. The second shift is the emergence of integrated engineering simulation platforms that will enable broad deployment throughout an organisation. This will deliver product design and development simulation capabilities to all engineers and designers, taking simulation out of specialist silos.

And third, as new approaches to manufacturing, such as additive manufacturing and 3D printing take hold at the industrial scale, the potential for product design will expand almost infinitely. The only way that organisations will be able to explore and capitalise on these opportunities will be with fast, reliable and accurate engineering simulation.

New, more integrated engineering simulation platforms will will deliver product design and development simulation capabilities to all engineers and designers, taking simulation out of specialist silos.

The commercial pressure of innovation, cost control, reducing time to market and improved performance and quality increases by the day. Product complexity increases, competitive pressure is unrelenting and customer demand for new capabilities is insatiable.

Fortunately, engineering simulation continues to accelerate its evolution to meet these demands by enabling the digital twin, establishing an integrated enterprise platform and enabling new user communities to access the power of the technology.

2017 is the year when engineering simulation becomes more than a product development tool and establishes a foothold at the business level across the enterprise from ideation to manufacturing and operation. MR

Read more about simulation and the digitisation of manufacturing on pages:

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2016: A YEAR IN REVIEW

A year that was dominated by political turmoil in the UK, Europe and the US had a heady mix of highs and lows for the manufacturing sector. In early 2016, manufacturing activity (as measured by the Purchasing Managers' Index) broke several negative records. But later, while Brexit briefly knocked business confidence, industrial activity surged back in October and government measures to reassure Nissan – although the detail was unclear – seem to have settled nerves, with a comparatively solid finish to a rollercoaster year for the sector.

JANUARY

Record car production: The Society of Motor Manufacturers and Traders announces that more new cars were built in Britain in 2015 than in any of the past 10 years, with exports also very high. Total sales of UK-built cars rose 3.9 per cent to 1,587,677 units. (*SMMT*). But....

Makers stop marching: GDP figures for the last quarter of 2015 show manufacturing output 0.5 per cent below the level it was at when George Osborne gave his 2011 "march of the makers" Budget speech. The number of jobs in manufacturing has risen since 2011 by about 90,000, to 2.65 million, but is still below the pre-recession level. (*BBC*).

FEBRUARY

Exports forecast to slump: A British Chambers of Commerce survey of 7,500 firms finds that manufacturing fared worse than the services sector at the end of 2015 and was "close to stagnation" after export sales fell to below their pre-recession levels in 2007. Without government action to improve skills and upgrade outdated infrastructure, it says, "the UK economy could suffer negative consequences in the face of increasing global uncertainty". (*BCC*).

MARCH

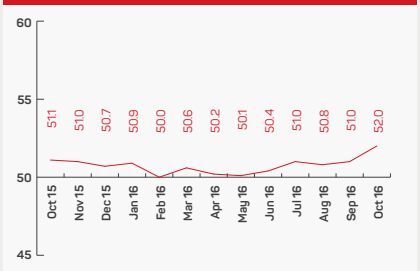
Six out of ten EEF members against Brexit: Reseach carried out for manufacturers' organisation the EEF by GfK finds 61 per cent of EEF members are in favour of remaining in EU. Opportunity to export is listed as main advantage of remaining. (*Insider Media*).

Qashqui ramps up: Production of the Nissan Qashqai in Sunderland rises, as the factory's Line 2 is modified to build more units of the mass-market crossover. It will allow Qashqai production to increase from its current level of one car every minute – or 300,000 units annually. (*Autocar*)

APRIL

Global manufacturing sector stalls: The JP Morgan-Markit global manufacturing purchasing manager's index falls 0.5 points to 50.1 in April, the second-lowest reading in the past five years. (*Business Insider*).

FLATLINE: JP MORGAN MARKIT GLOBAL MANUFACTURING PMI 2016



Doubts over 'wonder material': A parliamentary inquiry into the UK's efforts to commercialise graphene is putting the £61 million National Graphene Institute's (NGI) progress under scrutiny. The inquiry is partly prompted by allegations in *The Sunday Times* newspaper in March. These included concerns that the NGI was not doing enough to protect valuable intellectual property around graphene. (*Nature*).

Worst month in three years: Britain's factories suffer their worst month in three years in April as falling export orders and a lack of domestic demand for consumer goods squeeze manufacturing output. (*The Guardian*).

Growth in factory output has been on the slide for a year, but the manufacturing sector contracts for the first time since March 2013. Economists believe the decline will drag on GDP growth in 2016.

JUNE

Sector limps back to growth in May: Manufacturing activity rises slightly in May, raising concerns over the economy's strength before the European Union referendum. The Markit/CIPS manufacturing Purchasing Managers' Index grows to 50.1 from 49.4 in April, which had been the lowest reading since early 2013.

UK votes to Leave: Referendum reveals 51.9 per cent of the voting public want the UK to leave the European Union, sparking mayhem in British and European politics and uncertainty in business.

Steel salvation: Tata Steel completes the sale of its long products business to Greybull Capital, in a deal that will preserve 4,400 UK jobs and revive the British Steel name. The business makes products such as railway tracks and steel used in construction. The sale includes steelworks in Scunthorpe, Lincolnshire, and sites in Teesside, Workington and York. The business also employs about 400 people in France. (*The Guardian*).

JULY

SoftBank buys ARM Holdings for £24 billion: Japanese internet and telecoms firm SoftBank Group agrees to buy ARM Holdings plc, the designer of microprocessors for smartphones, for £24.3bn. The deal positions SoftBank as a player in global 'Internet of Things' market. ARM does not manufacture but licenses its semiconductor technologies to chip manufacturers. A spokesman for the Prime Minister welcomes the prospective deal as "in the national interest". (*WSJ, FT*)

Boeing and Government's big deal: The government places order for nine new maritime patrol planes from Boeing in a 10 year deal worth £3bn, and with 2,000 new jobs to be created in the UK. The deal includes building a new £100m P-8A Poseidon facility at RAF Lossiemouth plus

50 Apache attack helicopters for the British Army. Boeing says UK suppliers will receive additional bidding opportunities on Boeing programmes. (*Boeing UK*).

GSK backs Britain post-Brexit as it invests £275 million to expand its UK factories. The pharma company, whose chief executive Sir Andrew Witty openly backed the EU Remain campaign, says the UK's skilled workforce and competitive tax system helped it decide that Britain was "an attractive location" despite Brexit. GSK has invested a further £750m in new facilities over the past six years. (*BBC*)

Space Agency invests £4m in National Propulsion Test Facility: The UK Space Agency invests £4.12m in a rocketry research facility at Westcott, Bucks, a location with a strong history of propulsion research for defence and space development. Here UK researchers will test and develop space propulsion technologies. (*The Engineer*)

AUGUST

Hitachi to create 150 new jobs at North-East plant: Japan's Hitachi says it will create a further 150 jobs at its train manufacturing facility at Newton Aycliffe, County Durham. The company already employs about 500 people at the £80m site, where trains to run on lines in England and Scotland are being built. (*BBC*).

PMI shrinks to three-year low: Manufacturing activity contracts at its fastest pace for three years in July, as the Markit/CIPS PMI drops from 52.4 in June to 48.2. Pre- and post-referendum uncertainty is cited as the main reason for the fall. But for the quarter, The Office for National Statistics shows UK industrial output grew at the fastest rate for 17 years in April-to-June. Output grew 2.1 per cent compared to the first quarter of the year. (*BBC*)

SEPTEMBER

Finally, green light for Hinkley Point C nuclear power station: PM Theresa May is accused by Labour and environmental groups of back-tracking on security concerns about Chinese involvement in nuclear power as she approves the £18 billion Hinkley Point C plant. The government insists the new plant in Somerset is only being approved with "new safeguards" to ensure that China and other foreign investors could not own stakes in British nuclear plants without UK government approval. (*The Guardian*).

Bounce after Brexit: The sector bounces back strongly in August according to better-than-expected figures that boost hopes the economy will avoid a recession. The Markit PMI shows growth in Britain's factories climbed to a 10 month high after going into reverse gear following the referendum. (*Sky*).

F&D sector to create 75,000 jobs by 2021: The food & drink sector forecasts 19 per cent growth over the next five years, according to a survey by Lloyds Bank Commercial Banking, an increase of 3 per cent from last year. The survey shows that 44 per cent of food manufacturers have increased their planned investment since the Brexit vote. (*Food Manufacture*).

British tea causes a stir in China Tea growers in Britain say the 2016 crop has produced tea of exceptional quality, so good that export volumes to China and Japan have been higher than ever. (*The Times*)

Study proves link between engineering and economic development: A global study by the Centre for Economics & Business Research shows there is a strong positive correlation between the strength of engineering and economic development. The study claims it is the most comprehensive of its kind, fusing engineering data from 99 countries. Sweden tops the new Engineering Index; the UK is ranked 14th on the Index, above the US, and India and Vietnam are identified as future engineering hotspots. (Royal Academy of Engineering).

Let's talk? Apple and McLaren: Apple approaches McLaren Technology Group, the British supercar engineer and Formula One team owner, about a potential acquisition. Many read this as a sign that the iPhone maker plans to enter, and transform, the automotive industry. (*Sky*).

MG says it is to end UK car production: moves to China. MG says it will stop making cars at its Longbridge plant and will move production to China, ending manufacturing in the UK. It says in future cars would arrive "fully built, ready for distribution". MG says there will be 25 redundancies, but sales, marketing and after-sales operations would remain at the plant. (*BBC*).

OCTOBER

Jobs – lost and found:

- The UK Government commits £1.3 billion funding for Successor submarine programme
- Fracking in Lancashire is given go-ahead by government
- Thales picks UK for new plant to build "revolutionary" satellite engines
- 230 helicopter manufacturing jobs lost as GKN Yeovil plant closes
- 300 new manufacturing jobs in prospect with new 225,000 sq ft Magna International factory development, serving Jaguar Land Rover
- Bombardier to cut 7,500 more jobs through 2018, mostly in rail
- Nissan to build new models in Sunderland after post-Brexit deal

(BAE Systems, *BBC*, *The Daily Telegraph*, Unite, *Reuters*)

NOVEMBER

Autumn Statement: Outlook for wages is "dreadful" with the squeeze on pay lasting for more than 10 years, The Institute for Fiscal Studies says. Workers would earn less in real wages in 2021 than they did in 2008.

R&D push: Government will invest an additional £4.7 billion in research and development from 2017 to 2021, meaning an extra £2 billion a year by 2020. The 20 per cent increase comes after several years of flat science budgets. (Royal Society).

Electric vehicles: CEO Ralph Speth confirms Jaguar Land Rover's ambition to build electric vehicles in the UK and sets out vision to double production of the business, which could create 10,000 jobs in the West Midlands. JLR says the ambition is "dependent on overcoming infrastructure and capacity issues". (*Sky*).

Type 26 frigates work to start in summer 2017: Defence secretary Michael Fallon says the date for cutting the first steel would safeguard hundreds of skilled jobs at shipyards in Glasgow until 2035. (*BBC*).

HS2 "will open on time" in 2033: Transport Secretary Chris Grayling vows the Government's controversial £56bn high-speed rail project HS2 will be completed on time. (*BBC*).

Engineers see 2 per cent pay rise year-on-year: EEF report shows engineering graduates take home £28,000 a year on average, 22 per cent more than average graduate pay. (*www.imeche.org/news*). MR

BREXIT SPOOKS BUSINESS BUT MAKERS MARCH ON

British industry's nerve was tested to the limit by Brexit – and still is – and the UK steel industry has changed forever. But with business anticipating an overdue Industrial Strategy and sectors like auto and train making on a roll, Robert Lea's manufacturing glass is half full.

Not in recent corporate history have the words industry or industrial been so at the forefront of the English lexicon. Industry 4.0 and the digitisation of manufacturing. Industrial output and the ongoing failure of the manufacturing sector to grow or push the dial on productivity. And, of course, industrial strategy. Rescued from the wastelands of the 1970s, industrial strategy is now not only engaging smart people to define what it be might be, it has, for goodness sakes, found its way in to the title of the re-engineered Business department.

Yet the 2016 story of British industrial manufacturing ends the year where it started: people wondering what Brexit might mean.

One thing Brexit has meant is industry's cheerleader George Osborne who re-coined lines like "the march of the makers" and "for we are the builders" has gone the way of his catchphrases and left the stage.

Brexit has also meant the departure of the stewards of industrial policy such as it was, Sajid Javid and Anna Soubry. One was moved sideways after having been led a merry dance over the Tata Steel crisis (and taking an ill-advised holiday in Australia at the peak of the crisis) and the other out of government altogether exposed as an arch-Remoaner.

In their stead Brexit means DExEu, the new Department for Exiting the European Union to which business is supplicant waiting for an answer to the original question of what Brexit means for the single market; it also means a new International Trade secretary who appears to think British bosses would rather be on the golf course than signing export deals on a Friday afternoon; and Greg Clark, a new Business secretary charged with defining what industrial strategy actually means.

In amidst the year's industrial highlights – much of it in the renascent automotive industry – there has been the odd reverse.

Rolls-Royce, Britain's global engine-making champion, is on some of the most exciting aircraft manufacturing programmes in the world, yet project delays – not its fault – and some unwelcome engine failings have led to a sharp fall in share price and investor sentiment.

The aerospace and defence sector has not had a wholly happy year. Cobham oversaw the departure of both its chief executive and finance director, was forced into a rescue rights issue and unveiled an accounting scandal to boot. Meggitt and Chemring have also had their own issues, although the former's share price is flying as the year draws to a close.

Other manufacturing companies got caught in the capricious cross-winds of global trade.

A slowdown in the heavy truck markets in the US plus oil and gas industry investment remaining in the doldrums hurt Senior. Notwithstanding the crash in sterling, profits at Elementis were tarnished because of the effect on chromium production of the collapse in Russian rouble and Kazakh tenge.

Tech parts maker Laird got caught up in the slowdown in the march of Apple. The Chinese slowdown hit precision engineering champion Renishaw as it did Rolls-Royce Motor Cars and Bentley Motors, the latter heaping problems of plunging sales on its German parent Volkswagen already caught in the dock over vehicle emissions. McLaren meanwhile has got itself into pole position of being a F1 team-turned-diversifying advanced manufacturer but an alleged boardroom coup has unseated its visionary leader Ron Dennis.

And while the threat of closure still hangs over Port Talbot – a one-time £1 million-a-day lossmaking steelworks with a £14 billion pension fund millstone round its neck - the UK steel industry moves on: Scunthorpe has been renamed British Steel after Greybull Capital took it off Tata Steel's hands for £1 while Tata's other major business Rotherham and its sister works look set to join Liberty House.

While Theresa May's administration has had its critics it has got away the 3Hs: saying yes to Heathrow, Hinkley Point and HS2. Philip Hammond added a couple more in a infrastructure-rich Autumn Statement which prioritised housing and highways.

Trainmaking is also back in vogue. Bombardier in Derby is busy building more than 13 kilometres of new trains for Crossrail. Hitachi in Newton Aycliffe, close to the birthplace of the industry is delivering 600 carriages for the new intercity expresses that will come in from the west and north east into London.

Yet it is in the glow of the automotive industry in which the country is basking. Lost in the cacophony around the EU-related deal Nissan has got itself with government, is the news that a next generation Qashqai and a brand new X-Trail are coming to Sunderland. That will make the factory one of the world's super plants at the forefront of both electric and semi-autonomous car development.

At Jaguar Land Rover which is now vying annually with Nissan to see which produces more British-assembled cars, the big cat is roaring with a mainstream volume Jag, the XE, an F-Pace which has landed to rave reviews and now an I-Pace as the brand embraces electric too. For all its challenges British industry is marching and building.

Robert Lea is the Industrial Editor of The Times. MR

WHY BRITAIN NEEDS AN INDUSTRIAL STRATEGY

The government wants an industrial strategy for Britain and a Green Paper is due in December to show the detail. Two prominent figures in industry explain what such a strategy should do.

THE BUSINESS LOBBYIST

TERRY SCUOLER

chief executive, EEF

"The Chancellor's Autumn Statement was a glass half empty picture of the economic outlook, with the Office for Budget Responsibility and the Institute for Fiscal Studies not far behind. While growth is set to remain subdued as inflation bites into real income and holds down consumer spending, the picture for manufacturing from our latest indicators is more encouraging. In that respect our sector is a bellwether for the economy.

Overseas, manufacturers are seeing better prospects in their main markets. After bumping along the bottom since the end of the financial crisis, investment is slowly beginning to pick up and, while there is undoubtedly uncertainty around Brexit, the post-vote apocalyptic scenarios have not born fruit and more companies are planning to recruit in 2017.

The overall picture continues, however, to mask significant sectoral variations; some such as automotive and aerospace are continuing to power ahead, while others such as basic metals and mechanical engineering are still seeing tougher conditions.

While the prospects will remain uncertain in the near future, the downpayment the Chancellor made on a modern industrial strategy should pay dividends in the medium to long term. The focus on innovation has to be the way forward, especially on schemes that improve the commercialisation of research, while the review of the R&D tax credit is welcome recognition of its success and should allow more companies to benefit. There were also other commitments that should benefit business, including investment in the UK's digital network, better local roads, more resources for UK Export Finance and the British Business Bank.

The Government now has the opportunity to bring these pieces of the jigsaw together in a full scale modern industrial strategy. This must include four pillars: lowering the cost of doing business, delivering a more skilled and adaptable workforce, building more reliable and resilient infrastructure, and providing better support for growing businesses. By implementing such a strategy that industry recognises and, doing so across government in a joined-up manner, industry will be in prime position to improve significantly the UK's productivity performance and take full advantage of the fourth industrial revolution."

THE MANUFACTURER

LORD BAMFORD

chairman of JCB

"The UK Manufacturing Review 2016 lands on our desks at the end of a momentous year. The United Kingdom voted to leave the European Union. Theresa May has become Prime Minister and 'industrial strategy' is now high on the Government's agenda.

The fact that these two words appear in the job title of the new Secretary of State for Business, Energy and Industrial Strategy fills me with great hope. The term 'industrial strategy' means different things to different people but, as a manufacturer, I am clear about one thing: manufacturing must be at the heart of any future industrial strategy.

There are many reasons to be optimistic. Shortly after moving into 10 Downing Street, the Prime Minister stated clearly that she wanted "a proper industrial strategy to get the whole economy firing." The Autumn Statement can be our guide to its direction of travel: more innovation / R&D, better infrastructure, more housebuilding, higher productivity and a lot more support for exporters.

As manufacturers, this should be music to our ears - but only if the Government follows through on this commitment.

Manufacturers need to see tangible measures that create the conditions for them to succeed, such as capital investment allowances, R&D incentives and a focus on STEM subjects that genuinely delivers the next generation of talented engineers.

> "As manufacturers, the Industrial Strategy should be music to our ears - but only if the Government follows through on this commitment"

The key to industrial strategy is that it must be long term, so I was delighted to learn that Greg Clark MP, the new Secretary of State, came to the Midlands recently and told our carmakers that "a commitment to have an industrial strategy is to act for the long term."

As we look to the future, businesses and Government must work together to develop a long-term industrial strategy that makes Britain a leader in manufacturing and a champion of global free trade."

MANUFACTURING IN PARLIAMENT: A NEW EMPHASIS ON INDUSTRIAL STRATEGY

By Chris White, member of Parliament for Warwick and Leamington, co-chair of the All-Party Parliamentary Manufacturing Group and Member of Business, Energy and Industrial Strategy Select Committee.

THIS ARTICLE EXPLAINS:

- **Industrial strategy recognised as part of government department**
- **Prime Minister recognises importance of industrial strategy**
- **Manufacturers demand stability of legislation and in the economy**
- **Strategy must cross several Whitehall departments**
- **IS will boost national creativity and productivity**

Earlier this year I spoke on industrial strategy during the Queen's Speech Debate, and I was therefore delighted to see this all-important aspect of policy being officially recognised as part of a Government department. Following the outcome of the EU referendum, the government's renewed focus on a long-term industrial strategy can offer the stability for investment the sector needs.

Britain's post-Brexit relationship with European counterparts is a challenge for many; however, the Prime Minister has recognised the importance of industrial strategy as being central to our ongoing prosperity and our wider economic policy.

INDUSTRIAL STRATEGY CAN TRANSFORM ECONOMY

A true industrial strategy, focused on long-term stability and growth, has the potential to transform the domestic economy. There is clear demand from our manufacturers for stability, both in legislation and the economy, which can be provided by the government through drafting a clear and coherent strategy for industry over the coming years. This stability is essential, not least for the development of the high-value yet capital-intensive manufacturing where the UK is leading the world. There is a duty on these companies to invest in equipment and skills, but there is also a duty on the state to create the stable framework in which these decisions can be made.

This strategy must also encourage inward investment into the UK economy, particularly in research and development in new technologies and processes. In my own constituency, Tata's new technology centre has demonstrated the effect these investments can have, and I look forward to the headquarters opening in 2017. I also welcome the Prime Minister's commitment to increased government spending on R&D as well as the Chancellor's support in the Autumn Statement.

Chris White, MP for Warwick and Leamington, says an industrial strategy has the potential to transform the economy

> "A strategy that provides the framework for long-term stability in every aspect – macroeconomic, regulatory, and fiscally – will boost national creativity and productivity, not hinder it"

While regional schemes such as the Northern Powerhouse and the Midlands Engine have been successfully focusing minds on the potential opportunities for these areas, they must also be backed by robust policy. Infrastructure development is laudable, but this must not be piecemeal. The strategy must incentivise investment in our physical and digital infrastructure across the country to support all manufacturers and whole supply chains.

Furthermore, while the industrial strategy is to be formed in BEIS, it must also recognise that to truly have the impact needed it must stretch, cross-sectoral, through several Whitehall departments. For example, the strategy must influence the engineering and technical skills provision and education needed to train the workforce of tomorrow's high-value modern manufacturers. Clearly this includes traditional STEM subjects – and much can be done to improve their image in the UK – however it must stretch wider to non-traditional subjects such as modern languages, essential in the international world of business.

The government's new focus on a wide ranging industrial strategy, with a national cross-departmental scope is therefore hugely welcome. There is no reason that this strategy document cannot establish the kinds of long-term thinking in the UK which have long been the norm for our European counterparts.

A strategy that provides the framework for long-term stability in every aspect – macroeconomic, regulatory, and fiscally – will boost national creativity and productivity, not hinder it. MR

Sectors

Looking up the jetpipe of a BAE Systems Hawk Advanced Jet Trainer at the back of the Rolls Royce Adour 951 engine.

Adour 951 Jet Pipe, taken by Paul Heasman at RAF Valley in Anglesey, shortlisted in the amateur category of the EEF Photography Competition 2016.

AUTOMOTIVE

CAR SECTOR CHASING RECORD FINISH TO DECADE

THIS ARTICLE EXPLAINS:

- British automotive sector has enjoyed decade of growth
- Carmakers on course to beat 1972 record in 2020 by hitting 2 million vehicles
- Brexit leaves the sector vulnerable to potential tariffs
- EU key market for parts and vehicles
- Industry bolstered by Nissan decision to build new Qashqai and X-Trail in Sunderland

Britain's automotive industry is a shining light of the manufacturing sector, but carmakers are hoping Brexit will not knock growth plans off course. By Peter Marsh

Ian Malcolm says he has spent much of the past few months talking to senior German executives about why Britain has decided to leave the European Union. He says he has been "embarrassed" by what has happened. "There is a fear that after Article 50 [the treaty clause triggering the formal British exit] everything will go pear-shaped."

Malcolm is UK managing director of ElringKlinger, an automotive parts maker with its UK plant in Redcar, northeast England, which employs just under 300 people. The Germans he has been speaking to are top managers at the headquarters of his company, which is based near Stuttgart.

Similar slightly fraught conversations have been taking place in many parts of the UK car industry as companies have weighed up the referendum result.

The concern is explained by the industry's large degree of foreign ownership, and big exposure to Europe on trade. All the big six UK car makers, plus many parts makers, are owned by overseas businesses. Almost 80 per cent of British-made cars are exported, more than half of this total going to the rest of Europe. These factors make the industry – a big UK success story in recent years – especially vulnerable to post-Brexit aftershocks.

COULD INVESTMENT CLIMATE WORSEN IN UK?

Malcolm at ElringKlinger is worried that after Brexit the investment climate in Britain will worsen. That would mean the Redcar plant misses out on the sort of new capital spending it relies on for growth. Capital spending at Redcar since 2012 has totalled about £17 million, with the value of the plant's annual output growing to about £26m. Employment has expanded to just under 300, from just 80 in 2009. Products from the unit include heat shields and gaskets for engines.

On current plans, the factory's annual production will expand further to £40m by 2020 – but this, says Malcolm, "will be dependent on what happens to global economy and under Brexit".

Against this nervy backdrop, there has been one big piece of good news. In a big show of faith in the economy Japan's Nissan – the second biggest carmaker in the UK – said it would produce two new models at its Sunderland plant. The new cars are a version of the Qashqai sports utility vehicle, as

AUTO FIRMS INCREASE EFFORTS TO EXPAND THE SUPPLY CHAIN

If there is one thing that unites all the UK's big automotive companies, it is the need to boost the amount of homemade components that end up inside their vehicles. The sector's dependency on imports adds to costs and creates threats of supply chain disruptions. Britain's decision to quit the European Union could make matters worse by adding new tariffs on traded goods.

This is why any new announcements of increased investments in the car parts industry is always seized on in automotive circles as good news. In one recent positive signal, Spanish body parts company **Gestamp** said it would invest £70m in its plant in Cannock, West Midlands, to add more capacity.

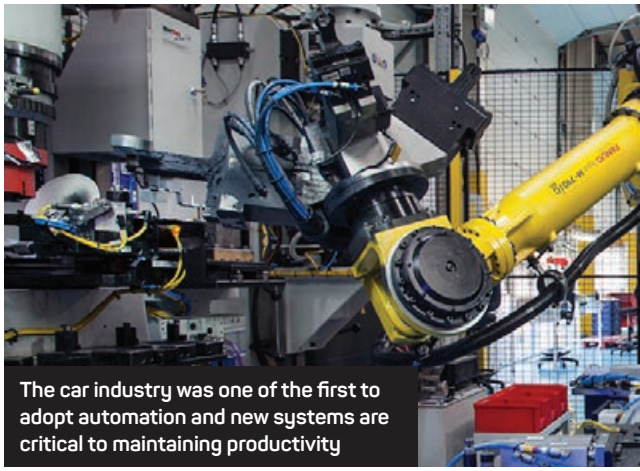
Magna of Canada, another big auto supplier, is to build a new aluminium casting facility in Telford, while **Sertec**, a British maker of body stampings, has invested £16m on new equipment at its factory in Coleshill, near Birmingham.

VTL, a Huddersfield-based maker of precision engineering components, is upbeat about the expansion possibilities in automotive. Bruno Jouan, chief executive, sees "abundant opportunities", which are improved by what he sees as an increased interest by UK manufacturers in adding automation and other advanced manufacturing techniques.

Mike Matthews is managing director of the UK arm of **Nifco**, a Japanese vehicle parts business with 600 employees at a plant in Stockton-on-Tees. "Nifco has a healthy order book and we plan to continue to grow in sales," he says.

Edward Grainger, director at castings firm **Grainger & Worrall**, says he sees good growth prospects in some of the areas where the company has a technical lead – such as making lightweight engine parts. Looking further ahead, some see a lot of opportunities in components including sensing and control equipment for new generations of driverless cars where two UK technical leaders include Coventry-based **RDM** and **Oxbotica** of Oxford.

JLR is the largest automotive employer in the country through plants such as its Wolverhampton engine factory



The car industry was one of the first to adopt automation and new systems are critical to maintaining productivity

well as another vehicle called the X-Trail.

The announcement in October 2016 is likely to mean hundreds of new jobs at the factory, which employs 7,000 people. The unit – Britain's biggest car plant – makes 500,000 cars a year, and this could rise by 20 per cent following the investment.

Nissan's decision came after prime minister Theresa May and Greg Clark, business secretary, offered assurances that the company would be protected from any negative fall-out from the Brexit vote – for instance by the government doing it all could to ensure no extra tariffs or bureaucratic obstacles to trade. The government also promised to act to safeguard the competitiveness of the industry in other ways, such as through funding for training and skills, and boosting research on electric cars.

WORRIES OVER BREXIT IN EVIDENCE

But worries over Brexit are still in evidence. Neither Nissan nor the government have said precisely what May and Clark offered the company. This makes it hard to assess whether similar concessions could be given to other car makers and suppliers. Also no one knows whether the assurances on tariffs and bureaucracy will carry any weight, since this will depend on the outcome of the negotiations over Brexit between Britain and other EU members.

It would be wrong to say no one expects anything positive for the car industry following the vote. Some think that outside the EU Britain will be in a better position to steer its own course – perhaps through providing financial support for certain parts of the auto industry that would be prohibited under Brussels rules.

Also the drop in the value of the pound has made exporting from the UK more competitive – by reducing the prices paid by foreigners for cars and other goods made in Britain.

But negative thoughts about Brexit emerged strongly from a survey of members before the referendum by the Society of Motor Manufacturers and Traders, the main business group for the sector. Almost four out of five companies said remaining in Europe would be best for them, while 59 per cent said that coming out would mean business prospects worsened.

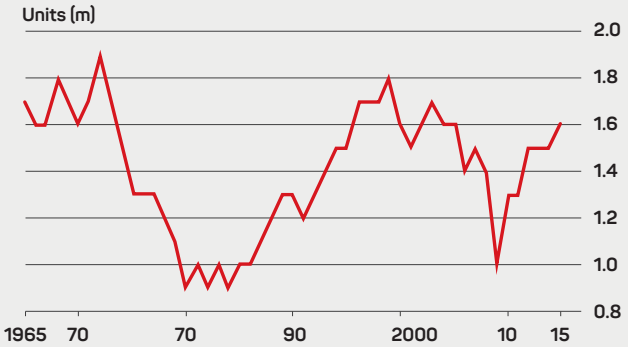
Edward Grainger, a director at Grainger & Worrall, a Shropshire-based castings manufacturer, says: "Like the vast majority of businesses, we didn't want Brexit. Any move to extricate ourselves from the EU will create instability, which is not good for any enterprise."

Paul Heard, managing director of the UK operations of Japanese parts maker Futaba, can also see the potential downside. The company employs 215 people at its plant in Derby where it makes items such as fuel pipes and body parts. Heard says the weaker pound has helped his company's profitability. But he is worried about the possibility of a "market collapse" once Brexit takes place.

A DECADE OF GROWTH

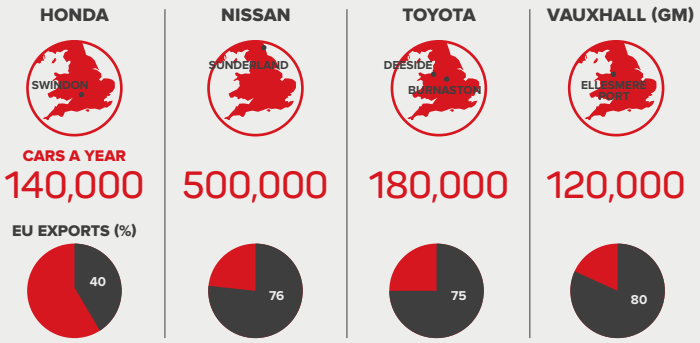
Such thoughts come after a decade of broad industry growth. Back in the early 1980s, the car industry was making just 800,000 cars a year. Production since then has doubled to 1.6m cars in 2015. The business is on course to make two million in 2020, ahead of the record of 1.9m in 1972. UK automotive manufacturing employs 169,000 people – compared to 140,000 in 2012 – although the number is well down on the 500,000 in the industry in the 1970s. Of the current total, 78,000 are in supply chain companies.

UK CAR PRODUCTION TO 2015



Source: SMMT / FT

OVERSEAS CARMAKERS' UK PLANTS



Source: Financial Times

"I am sure that [the British] will bitterly regret retirement from the EU in ten years"

Volkswagen chief executive Matthias Müller in *Handelsblatt*

Nifco makes automotive plastics at its UK base on Teesside

As well as Nissan the big six car makers include Honda and Toyota of Japan, Germany's BMW – which runs the Mini plant in Oxford – the US's General Motors, and Tata of India. The latter owns Jaguar Land Rover, the UK's biggest automotive company. JLR has three large car plants in Britain, while the others in the big six have one each. In addition, Germany's Volkswagen owns a smaller factory in Crewe making Bentley luxury vehicles, while BMW's Rolls-Royce subsidiary operates a similar site turning out high-end cars in Goodwood, West Sussex.

The car makers have been responsible for the lion's share of the investments of an estimated £17 billion which has gone into the UK automotive industry since 2010. Of this total, about £12bn has come from JLR – which employs 36,000 in the UK out of a worldwide workforce of 38,000.

Other significant spending has come from large automotive supplier groups based in the UK. Most of the world's top vehicle components businesses – including Bosch, ZF and Continental of Germany, the US's Delphi and Canada's Magna – have plants in Britain.

In the predominantly foreign-owned auto industry, there is particular concern about the impact of any new trade restrictions. Because of the single market, goods sent between Britain and the rest of the EU are currently traded without tariffs. Continental Europe accounts for more than half of UK car exports. In the post-Brexit landscape, there is a risk of new tariffs that would drive up costs. Even though it possible that the impact of extra tariffs on exports might be offset by a weaker pound, another factor is the amount of parts and materials the domestic automotive industry imports, much of this from Europe.

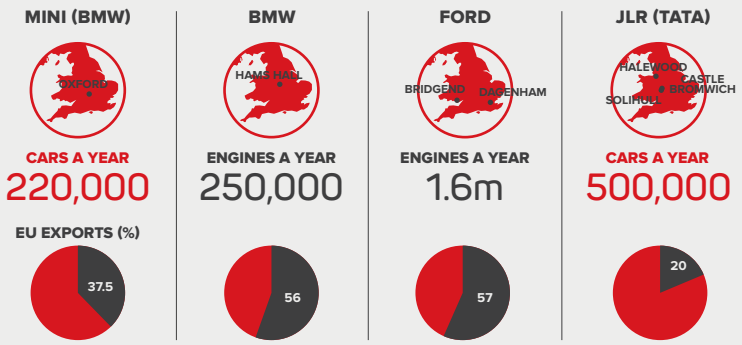
Each car coming off the assembly lines in Britain contains roughly £10,000 of materials and parts bought from outside suppliers, according to Vendigital, a consultancy. Of this total, about £8,000 is spent on imports – making the industry especially susceptible to the impact of any new tariffs.

There is yet another complication: the amount of material and parts that go back and forth between the UK and the rest of the EU during the various stages of manufacture. One example is a fuel injector for diesel lorries manufactured by Delphi. The part uses steel from continental Europe which is machined in the UK before going to Germany for special heat treatment. The injector is then assembled at Delphi's plant in Stonehouse, Gloucestershire, before being sold to truck producers in Sweden, France or Germany. If the resulting vehicle is sold in Britain, the materials in it will have crossed the Channel five times before the lorry is ever driven on the roads. If tariffs are applied at each stage, the cost could be substantial.

Stonehouse is one of Delphi's three plants in Britain where it employs 3,000 people, most of them involved with diesel injectors – a field where the company says the UK has special expertise. On the likely fallout from the referendum result Delphi is like others in the industry fairly cautious – even though it sees plenty of opportunity to expand in injectors. General Motors – which sells in the UK under the Vauxhall brand – has a big car plant in Ellesmere Port, Merseyside, while also operating a van factory in Luton. GM does not want to comment on Brexit, saying "there is too much uncertainty". Honda, which has a big plant in Swindon, is keen to stay upbeat even with Brexit. It expects to make 165,000 cars in Swindon in 2017, up from an expected 140,000 in 2016, and 119,000 in 2015.

Whatever happens in the post-Brexit world, a key factor will be the attitude of JLR, whose main factories are in Castle Bromwich and Solihull in the Midlands and Halewood on Merseyside. The company has also recently opened a big £1bn engine plant in Wolverhampton. Like other UK-based companies – Nissan being one of the leaders – JLR has also made big investments in electric car technology. Ralf Speth, JLR's chief executive, told reporters after the EU vote that he "regretted" the decision – but for the time being the company's commitment to the UK remained as before. MR

OVERSEAS CARMAKERS' UK PLANTS



Source: Financial Times

EXCEED EXPECTATIONS
WITH ADVANCED SOFTWARE SOLUTIONS FOR AUTOMOTIVE TRANSFORMATION

Infor solutions help turn disruption into a competitive advantage

HIGHLIGHTS

- **Changing consumer preferences and technological advances are creating a fundamental shift in vehicle requirements.**
- **Advanced software solutions support agile response to changing market demand.**

It's a time of unprecedented levels of transformation in the automotive industry. Not only are consumers demanding vehicles that are more fuel efficient, they are also expecting connected, smart features that enhance the driving experience.[1] These widespread changes in consumer expectations are causing a ripple effect throughout the automotive value chain, from engineering design to component procurement and shop floor assembly.

To keep pace with this rapidly evolving ecosystem, suppliers and automotive original equipment manufacturers (OEMs) need to improve their agility and become better equipped to respond to changing demands. Timing is everything. The ability to not just react to but also anticipate where the market is headed has become essential to spotting opportunities early. Only nimble organizations will survive this era of quick response.

INFOR AUTOMOTIVE BY THE NUMBERS

- **3,000+** automotive-related suppliers run Infor software.
- **100** countries are home to Infor Automotive customers.
- **80%** of the top 100 automotive suppliers use Infor software.

TIME OF TRANSFORMATION

Technology long ago became critical to success in the automotive industry, but the forces now driving this market have made strategic software investments even more critical. Managing the speed of new product introductions, the short lifecycles of high tech components, an inventory of complex systems, and multi-tiered global supply chains requires advanced systems especially tailored to the automotive industry. Not only must organizations manage day-to-day shop floor operations, they must be able to step back, analyze how change is impacting profitability, and ensure that new products and processes offer a realistic, long-term return on investment.

RIGHT SOLUTIONS

Infor Automotive solutions give manufacturers and suppliers the ability to embrace industry disruption and turn it into a strategic advantage. Purpose-built for the industry's unique needs, these solutions provide deep domain functionality and innovative features, including a highly intuitive user experience, role-based dashboards, advanced analytics and business intelligence, and collaboration tools that suppliers and OEMs need to achieve controlled, profitable transformation.

MORE RESOURCES

FERRARI CUSTOMER INNOVATION STUDY
http://www.infor.com/content/casestudies/ferrari.pdf/

INFOR AUTOMOTIVE BROCHURE
http://bit.ly/2f4t3D3

IMPROVING THE AUTOMOTIVE VALUE CHAIN
http://bit.ly/Infor-auto-valuechain

AUTOMOTIVE MANUFACTURING BUYER'S GUIDE
http://bit.ly/infor-Auto-buyguide

[1] Disruptive trends that will transform the auto industry, McKinsey Insights. http://bit.ly/1TkUgxU

WMG
THE UNIVERSITY OF WARWICK

SMART MOTOR CITY GEARS UP FOR UNCERTAIN FUTURE

Consumers are demanding the best from the automotive sector in terms of connectivity and safety

The NAIC will help position Coventry as the UK's own Motor City

THIS ARTICLE EXPLAINS:

- Automotive developing and enjoying support from government and consumers
- Alternative-fuelled vehicles now make up more than three per cent in UK
- Carmakers monitoring the effects of Brexit carefully
- The NAIC will become beacon for automotive research
- UK must retain its leading position in carmaking

The National Automotive Innovation Centre (NAIC) will be a leading light of industry as the automotive sector enters the Brexit era. By Professor Dave Greenwood.

The automotive sector continues to develop like no other and it has come a long way since the first steam-powered automobile, built in 1769 by Nicolas-Joseph Cugnot. Today, there are expectations from customers, as well as legislators, that our cars will have the latest safety features and connectivity, as well as being kind to the environment.

This year we've seen continued confidence in the sector, with the Spending Review and Budget confirming ongoing support for the Advanced Propulsion Centre, based at the University of Warwick. We've also seen the sales of alternatively-fuelled vehicles increase by 12 per cent relative to 2015. They now stand at 3.3 per cent of market share.

AUTOMOTIVE MANUFACTURERS ADJUST TO BREXIT

But what's to come? Automotive manufacturers carefully monitoring the effect of Brexit, which in the short-term has affected exchange rates. In the longer term, successful negotiations are hoped to allow for tariff-free trade with Europe, as this could otherwise damage UK competitiveness in this strategically important sector.

Whatever the future of transport might look like, one thing is for certain: automotive manufacturers can't afford to take their foot of the R&D pedal, they must continue to innovate. WMG, at the University of Warwick, is enabling the automotive sector to meet the growing demands of customers and government regulations through leading edge research in industrially relevant areas. Working collaboratively with automotive manufacturers through projects, the transfer of knowledge, enables the development or improvement of products, processes and services.

NAIC IN 2017– A BEACON FOR AUTOMOTIVE RESEARCH

Late in 2017 the National Automotive Innovation Centre will become a beacon for automotive research. A partnership between WMG, Jaguar Land Rover and Tata Motors European Technical Centre, it will foster collaboration, cohesion and cross-fertilisation of knowledge with academic and industrial R&D teams, working together using state-of-the-art equipment and facilities to develop breakthrough designs, technologies and processes. It is the largest centre of its kind in Europe and will help put Coventry firmly on the map as the 'Smart Motor City'.

At the forefront of this will be WMG's research into cleaner and smarter vehicles. A dedicated Advanced Propulsion Research Laboratory will create next generation propulsion technologies that are central to the future competitiveness of the automotive industry. The research scope will focus on the integration of internal combustion engines, hybrid and electric systems, lightweight vehicle technology and advanced automotive control systems.

Coupled with this will be the Virtual Reality Centre, which will provide immersive, simulated environments for smart and connected vehicles to support the accelerated development and adoption of advanced technologies required for next generation vehicles. Simulation can support R&D across all stages of product development, from definition to modelling and real-world application.

It's all well and good having dedicated R&D programmes, but this requires skilled staff, and through the centre the shortage of skilled R&D staff across the automotive supply chain will be addressed, developing the talent required for the demands of emerging technologies and engaging future generations of engineers.

The future of automotive will be lighter, cleaner, smarter and cheaper, and the UK needs to be seeking to retain its position within the sector – whatever the economic or political landscape may look like. MR

MADE IN THE MIDLANDS

THE ULTIMATE INDUSTRY NETWORK

30

HOST OVER 30 EVENTS A YEAR

BIGGEST REGIONAL MANUFACTURING EXHIBITION

1,000

ARTICLES UPLOADED BY MEMBERS WITHIN THE LAST YEAR

SELL OUT NETWORKING EVENTS

WE HAVE OVER 10,000 FOLLOWERS ON TWITTER

OVER 300 MEMBERS

QUARTERLY MAGAZINE DISTRIBUTED TO 5,000 MANUFACTURERS

COMPANIES THAT GENERATE OVER £4 BILLION TURNOVER

EXHIBITION IS GROWING 25% PER YEAR

MIM TV

MADE IN THE MIDLANDS TV IS GROWING IN POPULARITY

fbc manby bowdler.
SOLICITORS

Midlands manufacturers such as PP Control and Automation have a proactive approach and determination to succeed

LOCAL HEROES CLUSTER FOR GROWTH

Law firm FBC Manby Bowdler is a keen supporter of Made in the Midlands. Kim Carr, managing partner, explains why

Above: Pooling resources helps manufacturers exploit new technologies such as additive manufacturing

THIS ARTICLE EXPLAINS:

- **FBC Manby Bowdler is a Patron of Made in the Midlands**
- **Privately-run peer group for executives of manufacturing and engineering firms is a leading group in region**
- **Annual MIM exhibition has grown by 25 per cent a year**
- **Being member helps raise a firm's profile**
- **Manufacturing firms should join local cluster, says FBC**

The great thing about working alongside clients in the manufacturing sector is their proactive approach and determination to succeed. Working with businesses with a can-do attitude makes life so much easier!

There are many examples to illustrate this but the one that stands out is the peer group clusters that have formed around the country. We're proud of be a Patron of the leading group in our region, Made In The Midlands.

Made In The Midlands (MIM) is a privately-run peer group for managing directors and chief executives of manufacturing and engineering firms. The group currently has more than 330 members who generate in excess of £4 billion worth of collective turnover a year.

> "We would encourage other manufacturing firms to join their local cluster, so they too can gain access, support and advice from peers"
> **– Kim Carr**

MIM hosts some of the most well-received manufacturing events in the region. No more proof is needed than by looking at the annual Made In the Midlands exhibition, which has grown by an average of 25 per cent per year and is now the biggest regional manufacturing exhibition in the country.

Made In The Midlands also hosts sell-out networking events throughout the year at members' premises across the region. Being a MIM member helps to raise a firm's profile to the audiences that matter to them. The most engaged members actively grow their network and create partnership opportunities, while enhancing their public support of the manufacturing community.

MIM continues to strive to extend its reach to the Midlands manufacturing community. Within the last year, it has reached a landmark 10,000 Twitter followers and launched MIM TV, which sees local directors of manufacturing companies providing an insight into topical issues, their companies, and capabilities. Organisations with a similar objective and make-up exist across the country and as a trusted advisor to many Made in the Midlands members, we would encourage other manufacturing firms to join their local cluster, so they too can gain access, support and advice from peers. MR

ON THE FAST TRACK

ANSYS

Ferrari has made dramatic improvements in its racing cars' aerodynamic performance by combining computational fluid dynamics (CFD) simulation and wind-tunnel testing

Engineers at Ferrari rely on the extensive use of simulation and CFD to improve performance on race day

IN BRIEF

- Ferrari is using high performance computing and CFD
- Aerodynamics are crucial to improving performance
- CFD used to evaluate vortices of GT2 cars
- Wind tunnel testing is too time-consuming
- Ferrari engineers need simulation to drive design and performance

Ferrari engineers have extensively automated the simulation process and run many design iterations to explore the design space and improve speed, reliability and safety. It takes up to four weeks to arrange a session in the wind tunnel, while company engineers can perform more than 100 CFD simulations in the same time period.

As a result, simulation dramatically increases the number of different alternatives that can be evaluated, enabling substantial performance improvements, which have played a key role in Ferrari's many track victories. "The contribution of simulation is huge," says GT Driver Gianmaria Bruni, winner of the 2012 24 Hours of Le Mans in a Ferrari 458 Italia.

KEY ROLE OF AERODYNAMICS

Aerodynamics play a major role in the design of these cars because the shape of the upper part of a GT car body generates lift. The underbody must be designed to create downforce to increase the tires' gripping capabilities during braking and cornering, without increasing drag.

Ferrari improves downforce in GT2 cars by smoothing out the underbody, and adding diffusers at the rear, to intensify air speed and mass flow under the car. A diffuser ejects air from the underside of the car, causing an increase in velocity and a reduction in pressure of air below the car. The slower-moving air above the car generates a higher pressure, and the resulting pressure differential pushes the car onto the ground.

The process begins when the design team provides a proposed design in the form of a computer-aided design (CAD) file. An analyst then generates the surface mesh, the only part of the process that is done manually. Then an automation script takes over and executes the entire simulation process. In early stages of the process, analysts typically evaluate one proposed design at a time, scrutinising flow speed and direction, as well as pressure around the body, to understand the performance of the design and how it might be improved.

ACCELERATING THE EVOLUTION OF DESIGNS

Once analysts gain a general understanding of flow patterns and which parameters have the most impact, they set up a design of experiments (DOE) which runs tens to hundreds of simulations without user intervention. The software provides genetic algorithms to evolve a group of candidate designs toward better solutions. Ferrari engineers have used these methods to optimise the down-force in a number of areas:

- They applied CFD to evaluate vortices under the body of the GT2 cars and evolve the body design to minimise the vortice's impact
- They optimised brake cooling inlet and outlet ducts. These have a critical impact on brake performance as well as on the downforce on the car's front axle. They are designed nearly entirely with simulation
- Elsewhere, CFD analysis showed that even the side mirror's design is closely related to the shape of the engine air intake. Engineers modified the shape of the mirror to get the best performance without having a negative impact on the engine air intake.

Ferrari engineers need to perform simulations and tests as quickly, reliably and efficiently as possible to better drive style and design, ensure accuracy, and achieve performance targets. Every new racing car developed by Ferrari must rise to a new level of aerodynamic performance. The time required for wind tunnel testing makes it impossible to achieve targets within the allotted timeframes. High performance computing-based simulation solutions from ANSYS enable the Ferrari team to improve car performance faster than the competition.

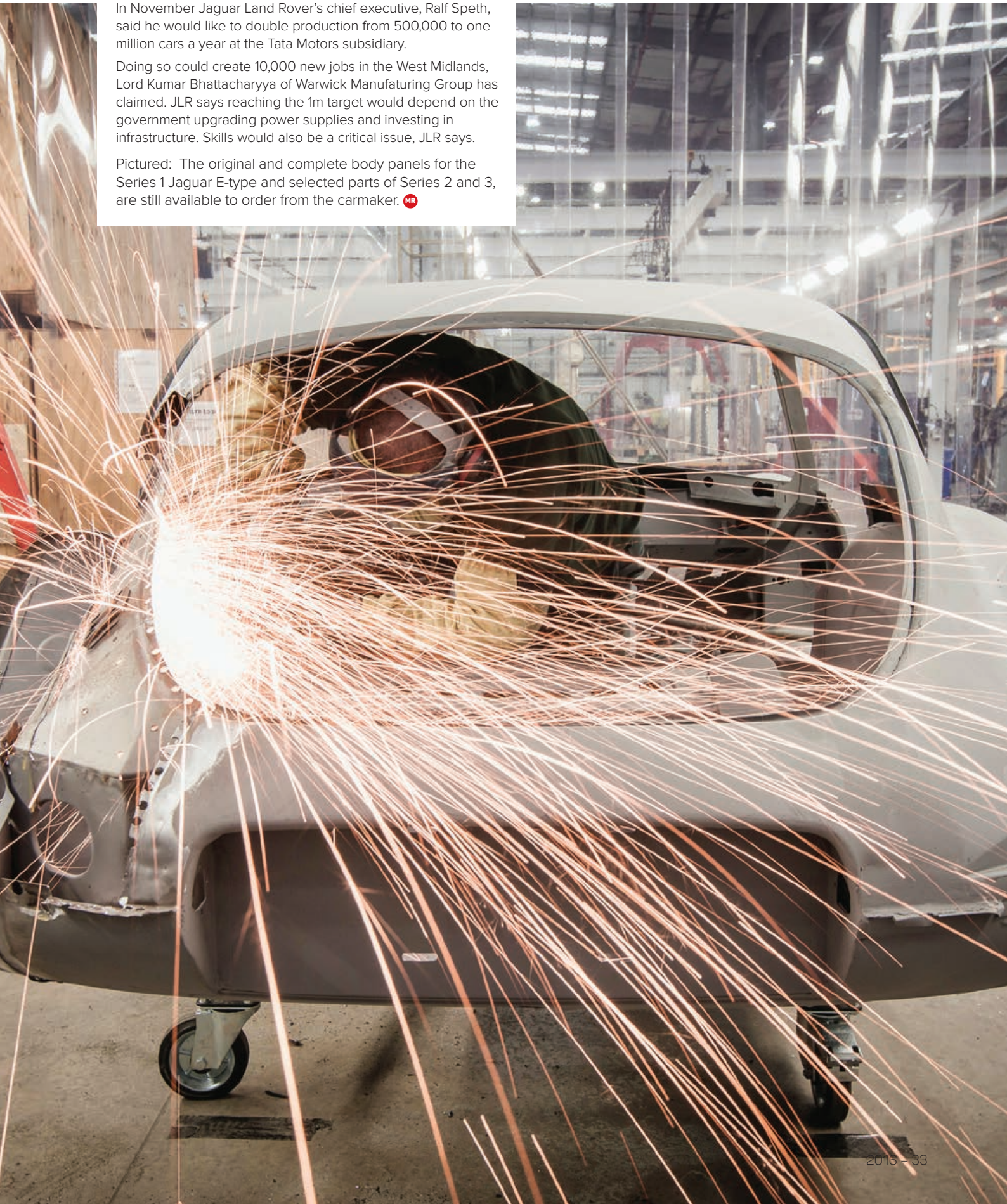
By combining CFD to evaluate and optimise the design with wind tunnel testing for verification and validation, Ferrari is able to stay at the forefront of aerodynamic performance. MR

PERFECT PANELLING FOR THE E-TYPE

In November Jaguar Land Rover's chief executive, Ralf Speth, said he would like to double production from 500,000 to one million cars a year at the Tata Motors subsidiary.

Doing so could create 10,000 new jobs in the West Midlands, Lord Kumar Bhattacharyya of Warwick Manufaturing Group has claimed. JLR says reaching the 1m target would depend on the government upgrading power supplies and investing in infrastructure. Skills would also be a critical issue, JLR says.

Pictured: The original and complete body panels for the Series 1 Jaguar E-type and selected parts of Series 2 and 3, are still available to order from the carmaker. MR



The launch of the JCB Hydradig in early 2016 has been acclaimed as a revolution in an industry more used to product evolution. The Hydradig is manufactured in Uttoxeter, Staffordshire and is now sold out until late Spring 2017

A REVOLUTION IN THE MAKING

FIVE PRODUCT DESIGN CHALLENGES FOR JCB HYDRADIG

- Visibility
- Stability
- Mobility
- Manoeuvrability
- Serviceability

JCB is a British manufacturing icon with a reputation for innovation that is well known and much deserved. However, its recent drive for product design and development is proving to be industry-changing, resulting in three market-driven product launches in the last 12 months.

JCB's distinctive yellow excavators and loaders have been a familiar sight on the streets and in the fields at home and abroad for several decades. The Staffordshire-based manufacturer of construction and agricultural equipment prides itself on 'innovation with a purpose', which is all about giving customers something different and better.

BE FIRST

In early 2016, social media channels started to light up with glimpses of a new product that was due for launch at the JCB World Headquarters in Rocester. The company hosts several launch events every year, but this pre-launch campaign looked and felt very different from anything that had gone before with an image that couldn't have been simpler.

A JCB logo mounted on a black background - with touches of JCB yellow top and bottom – alluded to a promise of a machine that no-one had ever seen before. The graphic effect of highlighting the red reflectors to look like robotic eyes added to the intrigue.

The teaser campaign called on the industry to 'Be First' but didn't make clear what 'being first' actually meant. When the product name was finally revealed as the JCB Hydradig, no-one really knew what to expect.

REVOLUTION?

Mark Anthony is Editor of Diggers and Dozers, the leading online construction industry publication. He was one of more than 80 trade journalists who attended the press launch in March. In an online article, he said that he "*approached the launch of JCB's much-lauded Hydradig concept with a degree of trepidation.*"

A veteran trade journalist, Mark had observed how JCB's "*slow-burn lead up to the launch of what it had described as a revolutionary machine had hogged social media headlines for more than a month. But that was always going to be a bold claim in a mature industry in which variations on a proven theme is the usual order of the day.*"

Mark was simply stating the obvious; in an industry better known for evolution, customers don't expect revolution. When the Hydradig was finally launched, Mark conceded that "*sadly, for a cynic like me, when the screen rose in the JCB theatre to reveal the machine in all its glory, my trepidation was replaced by admiration.*"

DIFFERENT

The JCB Hydradig is an 11-tonne wheeled excavator but it looks completely different from any excavator on the market today. So what's going on? Firstly, the engine is not where you would expect it to be, to the rear of the cab. It has been positioned in the chassis between the four wheels.

Tim Burnhope, JCB's chief innovation and growth officer, explains: "The innovation process on Hydradig started with our customers. They told us that the construction industry needed something different, particularly because machines were working a lot more in urban and congested environments."

After detailed discussions with customers and machine operators, the JCB innovation team concluded that five product attributes were critical: visibility, stability, mobility, manoeuvrability and serviceability.

VISIBILITY

Site safety is a major issue on construction sites, especially in cities and towns. The issue with traditional large excavators is that they have blind spots. The position of the engine to the rear of the cab restricts the operator's view to the ground, which poses a significant safety risk.

"So we decided to move the engine" says Tim "and relocate it into the chassis where it is out of the operator's line of sight to the ground. The Hydradig operator has superb visibility of all four wheels, which is an industry first on an 11-tonne excavator. It means the Hydradig is a safer machine to operate on site."

JCB's pre-launch teaser image

STABILITY

Relocating the engine into the chassis also means the machine is more stable. This is important because excavators don't just excavate - they are used to lift and place heavy loads on site. The lower centre of gravity on Hydradig means it can lift heavier loads 'over the side' while keeping all four wheels on the ground.

MOBILITY

Unlike traditional excavators, the JCB Hydradig doesn't need a low loader to get it to and from a site. It is the first excavator of its kind to have true mobility. It can reach a top speed of 40kph on the road, and because of its impressive 50/50 weight distribution, it doesn't 'nod' forward or backward while travelling.

MANOEUVRABILITY

On-site manoeuvrability is just as important as on-road mobility. "How a machine moves around a congested work site is critical" says Tim. "Customers judge machine performance on how well it can do the job and Hydradig's 4-wheel steer, 2-wheel steer and crab steer credentials are making a real difference."

The Hydradig's reverse steer option means the back of the machine can become the front, and vice versa. This makes it ideal for work in a single carriageway on the highway network, and because of the greatly reduced tailswing, the risk to passing traffic or pedestrians is minimised like never before.

SERVICABILITY

"Finally, there is the issue of serviceability" says Tim. "Customers and operators don't like climbing on top of machines to do daily checks. As the engine is at ground level in the Hydradig, daily checks and servicing take place at ground level. This is much safer and gwoth."

The launch of the JCB Hydradig has certainly caused quite a stir. It is JCB's most innovative solution in response to the key challenges facing the construction sector.

The JCB Hydradig is manufactured at the the company's Heavy Products factory in Uttoxeter. Around 85 people have been recruited to manufacture the new machine, including engineers, welders and assembly line employees. If you want one, it's sold out until Spring 2017, which tells you something about how well it has been received by the industry. MR

"Customers told us they needed something different for urban and congested environments"
Tim Burnhope, chief innovation and growth officer, JCB

A JCB Hydradig places a load on a city building site

LITTLE BIG MACHINE RESPONDS TO MODERN URBAN NEEDS

JCB has manufactured more than 600,000 backhoe loaders since its first one in 1953. A recent design revolution has redefined the concept to make them more suited to modern urban construction projects.

JCB has responded to the changing customer requirements in the construction sector by redesigning its classic backhoe loader product. "Customers said they needed a 'little big machine' for use in urban building projects," says Tim Burnhope, JCB's chief innovation and growth officer.

In late 2015, JCB launched the 3CX Compact – a backhoe loader that is 35% smaller than its 3CX big brother with a much smaller turning circle of just 5.8 metres on its equal sized wheels, meaning it can turn within a single carriageway. The 3CX Compact outperforms a mini excavator at digging, outperforms a compact wheeled loading shovel at loading and operates with a versatile range of tools and attachments. What's more, it can travel at 40 kilometres per hour, so it is highly mobile as well.

Tim concludes: "As more construction work takes place in confined urban environments, the 3CX Compact is the ideal mobile tool carrier solution for towns and cities. Customers are only just beginning to see the benefits of our little big machine, which is fuel-efficient, has plenty of power, and is very versatile." MR

A JCB Agri Pro Loadall with a DualTech VT transmission loads bales onto a farm trailer. The combination of highly productive precision control with high speed on-road mobility is unique in the industry.

LEADING THE FIELD

JCB is a world leader in agricultural materials handling. The launch of the JCB Loadall telescopic handler nearly 40 years ago has revolutionised how farmers move material in farmyards and fields. An innovative JCB transmission is now driving this revolution to a whole new level.

JCB launched the Loadall telescopic handler in 1977, initially to the construction sector. In 1981, the company launched its first Agri Loadall, a telescopic handler designed specifically for use in farmyards and fields.

When it was introduced to farming customers, the Agri Loadall was considered an agricultural industry first. It was a four-wheel drive telescopic handler that was truly capable of working in deep mud. The JCB Agri Loadall has since become an essential and indispensable piece of equipment on farms across the world.

JCB has recently been making innovative changes to Agri Loadalls in response to industry trends. Tim Burnhope, JCB's chief innovation and growth officer explains: "Farms have been consolidating and the size of farms has been increasing. In fact, owning multiple farms is the norm today and this has implications for machinery."

"Today's farmer or farm contractor needs to travel greater distances to get the job done. It is no longer sufficient to have a machine that is agile and highly productive in the farmyard. More than ever, farmers need versatile machinery that is highly mobile and capable of towing a heavy load from the fields back to the yard. Modern farmers and farm contractors now expect a lot more from the same machine."

THE 'EITHER/OR' COMPROMISE

One of the issues facing the industry has been the choice of transmission technology. For customers who need good acceleration and high speed for road mobility and towing, there was only one practical choice: a multispeed powershift transmission with direct drive through a lock-up torque converter.

The powershift solution delivered high productivity in bulk rehandling, high-speed trailer towing and efficient road speeds up to 40 kilometres per hour. However, powershift technology is seen as having shortcomings on smaller, repetitive rehandling operations, such as digging out a manure pile.

Hydrostatic transmissions are often seen as the better option when high tractive effort is required at low speeds, particularly

The JCB Loadall assembly line at the company's headquarters in Rocester, Staffordshire where Loadalls have been manufactured since 1977

when precise control is needed, in terms of inching forwards and backwards.

Two different transmission technologies, which epitomise the 'either/or' choice that farmers have had to make for many years. JCB decided that it wasn't right that customers had to compromise between precision control on one hand, and acceleration, speed and towing capabilities on the other.

BEST OF BOTH WORLDS

In response to customers saying they wanted the best of both worlds from an Agri Loadall, JCB innovators came up with a unique solution. They developed a brand-new JCB transmission combining powershift for fuel-efficient travelling on the open road with a hydrostatic module for high-output precision control.

Launched earlier this year, JCB's new range of Agri Pro Loadalls incorporating the all-new DualTech VT variable transmission is another industry first from the Staffordshire-based manufacturer.

DualTech VT operates as a hydrostatic from 0 – 19 kilometres per hour for maximum productivity and precision. As if by magic, it switches seamlessly to powershift mode from 19 – 40 kilometres per hour, which means the Agri Pro Loadall becomes a fuel-efficient, high performer on the open road with superb towing capabilities.

Tim Burnhope comments: "We've taken the best features of both technologies and combined them to deliver the best performance, productivity and precision. The reaction from farmers since DualTech VT was launched in our new Agri Pro Loadalls has been fantastic."

He adds: "As farms become larger and the distances between farms become greater, the new Agri Pro Loadall is JCB's answer to the growing productivity challenge in modern farming. No other manufacturer has brought together hydrostatic and powershift technologies in a single housing."

DRIVE THE REVOLUTION

The two transmission modules work seamlessly and automatically to provide great mobility, superb tractive effort and outstanding precision. The hydrostatic drive provides fine stepless speed control from standstill up to 19 kilometres per hour, so it's quiet and smooth as well as responsive and efficient. When it switches to powershift, the acceleration to 40 kilometres per hour is second to none which means that hill climbing and towing is also effortless.

The launch of DualTech VT marks the culmination of years of design and engineering effort at JCB, both in the Rocester headquarters in Staffordshire, where Loadalls are manufactured, and at JCB Transmissions in Wrexham, North Wales, where the DualTech VT was designed and is currently manufactured on a purpose-built line.

DualTech VT truly breaks with convention and has allowed JCB to take the market-leading Agri Loadall to new heights. It was born out of customers' desire for one solution, so that they would no longer have to choose between two technologies. "That's revolution, not evolution" concludes Tim. MR

FIVE YEARS IN AND ALL TARGETS EXCEEDED AT THE HIGH VALUE MANUFACTURING CATAPULT

CATAPULT High Value Manufacturing

Framing the future: the MTC in Coventry is part of the High Value Manufacturing Catapult's successful vision for British engineering

The High Value Manufacturing (HVM) Catapult has proved its worth and is now a key part of British manufacturing strategy. As the UK goes through a period of uncertainty, it will continue to generate value for the economy and help manufacturers of all sizes embrace new technology

THIS ARTICLE EXPLAINS:

- **In five years the HVM Catapult has become the go-to place for advanced manufacturing technology**
- **The HVM Catapult is the most mature of the Catapult network**
- **Every £1 of funding brings in £15 of value to the economy**
- **In the last year, more than 3,000 companies worked with the HVM Catapult.**
- **In a time of uncertainty, HVM Catapult provides constancy**

Risky, launched in a recession, and something of an experiment; the stakes were high for the High Value Manufacturing (HVM) Catapult in 2011 when it was set up to help secure a strong future for high value manufacturing in the UK.

Now, only five years on, it has established itself as the go-to place for advanced manufacturing technology in the UK and its success is proof that collaboration and intelligent risk-sharing with government can produce substantive economic rewards.

The HVM Catapult is the most mature of a network of 11 Catapults set up by Innovate UK. The Catapult programme is a collaboration between industry, academia and government set up to transform the UK's capability for innovation in specific areas, and to help drive future economic growth.

BRITISH TRACK RECORD OF SCIENTIFIC DISCOVERY

The UK has a track record of world-class scientific discovery, but all too often breakthroughs end up being commercialised overseas. Take the ground-breaking research by Oxford University scientist Stanley Whittingham some 36 years ago which led to the development of the lithium-ion battery, now the ubiquitous power source for consumer electronics and poised to be the battery of choice for our electric vehicle future. Yet the research was commercialised mainly in China and South East Asia – where the economic benefits from the $30 billion and growing global lithium-ion battery market have been secured.

The HVM Catapult and its seven centres provide the infrastructure to ensure that promising inventions can be scaled up to be manufactured in this country and to generate economic value and jobs as a result. The seven HVM Catapult centres work with companies from all parts of the country and all sectors within manufacturing to reduce the risk inherent in the process of translating early stage technology innovation into full-scale commercial production.

Each of the centres excels at specific areas of technology innovation and collectively, their capabilities span the broad spectrum of manufacturing. Companies of all sizes can access HVM Catapult's world-class facilities and expertise to scale up and prove out high-value manufacturing processes in an environment of collaborative innovation.

Since its establishment, industry has been quick to grasp the value of the offer. In 2015-16 alone, more than 3,000 paying industrial clients worked with the HVM Catapult, more than 1,850 projects were delivered, and it built an impressive £188 million order book, of which £100m was for collaborative R&D.

FACILITIES FOR SMES

The impressive new facilities on show may create the impression that the HVM Catapult only works with resource-rich, high profile large multinationals. But this is far from the truth. In fact, more than 56% of its customers in 2015-16 were SMEs. Dick Elsy, HVM Catapult chief executive, has been particularly focused on that. "We were fortunate that large manufacturers in sectors such as aerospace and automotive very quickly understood our

The seven HVM Catapult centres work with companies from all parts of the country to help them benefit from technologies such as automation

Innovation is about new applications for existing technologies rather than re-invention

offer and worked with us to establish our Catapult.

"But we are here to help businesses of all sizes, not just the big multinationals. There is well-documented evidence that innovative companies successfully grow faster, and this in turn makes our entire economy more competitive. "

The outputs look impressive, but an often-asked question is about its ultimate economic impact. An independent study in 2015 found that for every £1 of core government funding the HVM Catapult locked in £15 of value to the UK economy.

The success of HVM Catapult in the aerospace and automotive industry in particular are widely recognised, with big industrial brands such as GKN, BAE Systems and JLR bringing forward innovations that were developed with the HVM Catapult centres. In 2014, for example, Rolls-Royce opened two new production facilities in the UK based on advanced manufacturing technologies developed with the HVM Catapult.

"At the outset, we agreed seemingly ambitious business plan targets with government. Yet what the HVM Catapult has achieved in only 5 years far outperforms those original targets. It is clear that the collaboration between the centres in terms of sharing technology developments, undertaking large scale projects and collaboration on strategic priorities is producing tangible and significant benefits"

Bob Gilbert, chairman of the High Value Manufacturing Catapult

Not all manufacturing sectors have been as quick to recognise the benefits. But this is changing fast, according to Dr Phill Cartwright, chief technology officer at the HVM Catapult. "Innovation is often about new applications for technology rather than re-invention. There is tremendous opportunity for innovations that are tried and tested in one sector, being successfully adapted and applied in other sectors.

"Examples include additive manufacturing technology – of which aerospace was an early adopter – now finding seemingly limitless applications in medtech; and virtual reality – which has been used in automotive for years – is now one of many advanced manufacturing techniques being introduced in the construction industry. Because our centres work with enlightened and leading businesses of all sectors, we are uniquely placed to help adapt innovations into new applications for the benefit of industry and the economy, and it is clear that more and more businesses recognise that potential."

STAYING AHEAD OF THE CURVE

Combining public and private sector investment allows the HVM Catapult to look forward and stay ahead of the curve, conducting research and putting in place technology capability before industry demands it. Battery technology is a good example of a technology which is key to the development of electric vehicles as well as to household and grid energy storage. The newly opened Energy Innovation Centre at WMG centre HVM Catapult, at the University of Warwick, provides open access for academics and industry to scale up battery innovations. It is the only facility in Europe which covers not only battery chemistry, but the entire battery system, including electrode coating, battery cell formation and module and battery pack testing. The facility is already working with industrial players such as Nissan and JLR on aspects such as battery power, range and performance. Professor David Greenwood from WMG says: 'The lithium battery was commercialised oversees. Our facility aims to make sure that that doesn't happen again and that scientists can get all the infrastructure and support to scale up and develop their technology in this country. Early industry interest shows that we could develop a bright future for UK battery manufacture."

FIVE YEARS OF TREMENDOUS CHANGE

Five years after the establishment of the HVM Catapult, the UK has seen tremendous change. In the aftermath of the EU Referendum the country needs to determine its changing position in the global world. This is a time to rethink, agree and commit to the measures and actions that shape the composition of the UK economy and the role of manufacturing and engineering in that context. Industry will be looking for reassurance and stability amid the inevitable uncertainty.

Whatever the future holds, the UK will need to maintain and grow its world class innovation translation model to support UK companies and to act as an enduring attractant to international investment; to exploit its world-class research capability and bring new products and services to market and to drive productivity improvement in manufacturing to keep the UK globally competitive.

Now, more than ever, there is a need for constancy of purpose: the High Value Manufacturing Catapult is recognised by many as the example of such constancy. MR

CROWDED SKIES PRESSURISE SUPPLIERS IN #2 AEROSPACE NATION

Photo courtesy of Airbus

AEROSPACE

Britain does aerospace well, but could do better. In a globalised, cost-conscious supply chain, smaller firms must innovate and invest to compete. Murdo Morrison reports

THIS ARTICLE EXPLAINS:

- Britain punches above its weight in aerospace component manufacture
- Overseas competitors are eyeing Airbus wing manufacture
- Suppliers are under cost and globalisation pressures
- Aerospace Growth Partnership says big challenges remain
- China could be new aerospace superpower

When Britain's last home-grown airliner – the BAE Systems Avro RJX – departed the production line in 2001, sentimentalists warned of an industry in decline. Unlike France, Germany, and Italy, the nation whose de Havilland Comet ushered in the jet age and helped smash the sound barrier with Concorde would no longer produce its own commercial aircraft in the 21st century. A decade and a half on, their fears have proved misplaced. Even as a major global economy, the UK punches above its weight when it comes to aerospace.

Every completed Airbus may roll out of a factory in Hamburg or Toulouse, but its wing will have been assembled in Broughton, North Wales. That expertise in wing design – a legacy of the UK contribution to the original Airbus consortium through British Aerospace – is replicated in the A400M, Airbus's flagship military product, and also in the Bombardier CSeries, a 110- to 130-seat narrowbody just entering service. The Canadian company's Belfast facility is the programme's wing centre of excellence.

Meanwhile, Derby-designed Rolls-Royce engines power almost all Airbus widebodies, including latest types the A350 XWB and the A330neo. The UK's other prominent first-tier suppliers include GKN – a provider of sophisticated aerostructures to Airbus and others. BAE Systems, since moving out of the commercial airliner market, has become one of the biggest defence contractors in the world, with a major US industrial presence alongside its footprint here, and a big role in the multinational Lockheed Martin F-35 Joint Strike Fighter.

CHAIN GANG

Less visible perhaps, but producing 'beneath the hood' equipment and systems crucial to a number of commercial and military programmes are the likes of Cobham, Meggitt and Senior Aerospace, all among the biggest 100 aerospace companies by revenue. Overseas-owned groups, including Italy's Leonardo – which builds helicopters at the former Westland in Yeovil – US aerostructures manufacturer Spirit AeroSystems and France's Safran and Thales, employ tens of thousands in the UK.

A China Airlines A350 XWB. China is developing its own indigenous airliners and becoming a powerful supplier

But at the heart of the UK's aerospace industry are the hundreds of SMEs further down the supply chain. Clustered in areas such as the North-West of England, around Bristol, the east Midlands, central Scotland, Northern Ireland and the northern Home Counties, and traditionally feeding large local customers, many of these firms have in recent years been setting their horizons beyond their back yard, benefiting from R&D support and initiatives to allow them to scale up by pooling their competencies with neighbouring companies.

A recent example of that collaboration at work is in Northern Ireland, where a

Photo courtesy of Airbus

Top left: Britain has expertise in wing design and manufacture for Airbus but competitors overseas are keen to take on the work

Above: Production of the A320neo, delivered here to Pegasus Airlines, July 2016, and Boeing 737 Max are likely to continue to 2030. At some point replacements will be required

consortium called Causeway Aero made its debut at July's Farnborough air show. Made up of five family firms that traditionally supplied Bombardier in Belfast, Causeway will bid for contracts under a single brand. The thinking is that big potential customers – keen to reduce complexity by dealing with fewer suppliers – would be unlikely to deal with five different vendors. However, they might be tempted to issue a single agreement for a package of work.

The need to move up the value chain has been the narrative of aerospace industry suppliers for almost two decades, due to two major trends. Since the 1990s, the major airframers have sought to fund programmes through risk-sharing partnerships with tier-one suppliers, giving them responsibility for designing and supplying a major sub-system in return for a slice of profits. These tier-ones have, in turn, done the same with their suppliers. Those squeezed out have seen profits erode as they have been unable to compete.

FROM MEXICO TO MOROCCO

The other trend has been a globalisation of the supply chain, with producers in countries ranging from South Korea and Mexico to Poland and Morocco increasingly able to undercut and outperform their Western counterparts. As a British – or indeed French, German or US – supplier, there is no longer a guarantee that being broadly competent at what you do will secure you work from the aircraft factory down the road. Instead, you might find that the part or section you have been milling for years is now produced in Santiago or Seoul.

While UK suppliers have remained broadly competitive in recent years, there cannot be any complacency. This is something ministers have recognised in a series of industrial strategic initiatives under the Aerospace Growth Partnership between government and industry. In its latest 2016 update, Means of Ascent, the authors admit that despite the UK industry being second only to the USA in size, 39 per cent more productive than in 2010, and deriving £27 billion of its £31 billion revenues from exports, challenges remain.

Chief among these is the need to "invest even more in the next generation skills, in truly radical technologies and processes and in increased productivity and competitiveness throughout the supply chain". Companies with a position on a key airliner programme can take comfort that order books are growing, thanks to still-robust global demand as more and more people join the flying classes, but things can change quickly in aerospace.

Aerospace is not consumer electronics. Aircraft programmes are not in-and-out-of-fashion BlackBerries or iPhones. However, they are susceptible to consumer trends and macroeconomic influences. The rising fuel price in the 2000s rapidly killed off 50-seat regional jets and four-engine aircraft like the Airbus A340. After plans for a super-fast Sonic Cruiser were scrapped in the early 2000s, Boeing's all-composite, fuel-efficient 787 Dreamliner surpassed all sales expectations when it was launched just over 10 years ago.

Towards the end of that decade, Bombardier thought it had called the bluff of its rivals when it became the first manufacturer to take advantage of a new-generation, geared turbofan engine from

Below: Engine casing machined by Sheffield aerospace and nuclear supplier CW Fletcher

Far left: Bombardier intended the new CSeries to outsmart Airbus and Boeing but the narrowbody aircraft only entered service this year

Left: The UK has continued to manufacture Airbus wings, securing the latest A350 widebody programme in the late noughties

Pratt & Whitney to launch a clean-sheet narrowbody called the CSeries. It expected Airbus and Boeing to develop all-new successors to their top-selling but ageing A320 and 737 narrowbody families, something that would occupy them for a decade or more, giving the Canadians a head start in sales.

What happened illustrates the power of the duopoly. Within a year or so of each other, both Airbus and Boeing decided not to start afresh but re-engine existing offerings, with Boeing using the CFM International LEAP and Airbus the LEAP or Pratt & Whitney P1000G. With Bombardier struggling to get its CSeries to certification – it finally went into service this year – Toulouse and Seattle have racked up huge orders for their A320neo and 737 Max, so much so that both expect monthly narrowbody production to exceed 60 by the end of the decade.

While UK manufacturers – many of which supply one or both of these programmes directly or indirectly – will benefit hugely from the ramp-up, the importance of decisions such as these at the top of the supply chain shows how vulnerable national industries can be. We have dealt with how airframers and their tier one suppliers are increasingly content to shop around in a global marketplace for the best quality and service. A moment of truth for UK aerospace could come when Airbus and Boeing launch their next-generation narrowbodies.

UP FOR GRABS? ALMOST EVERYTHING

No one knows for sure when this will be. Production of the A320neo and 737 Max are likely to continue to 2030. But at some point one of the big two will announce plans for a replacement, prompting the other, almost inevitably, to follow suit. The catalyst could be a step-change in green engine technology, in materials or even aerodynamics, or simply an accumulation of scientific advances sufficient to convince one, or both, that investing in a clean-sheet design makes sense.

At that point, almost everything could be up for grabs. Airbus chief executive Tom Enders is in the midst of steering a cultural revolution at the European group, abolishing national and divisional boundaries inherited when EADS – as it was – was set up in 2000 with the merger of French, German and Spanish aerospace and defence champions, together with Airbus's UK arm. Official and informal guidelines determined allocation of workshare and stated that certain countries and entities were the centres of competence for particular technologies.

Thus, the UK has gone on designing and manufacturing Airbus wings, securing the latest programme, the A350 widebody in the late noughties. But Germany's government is convinced its companies have the expertise to wrest that work from the UK in the future, when a new programme is announced. Spain too believes its Airbus factories and suppliers have made great advances in understanding wing technology. The UK will have to go on not just delivering high-quality Airbus wings in a timely and cost-effective way, but investing in, researching and developing what comes next.

INTO THE GREAT UNKNOWN

In aerospace, as elsewhere in the economy, Brexit is the great unknown. Trade association ADS campaigned strongly for a remain vote, arguing that coming out of the EU risked British companies' access to the single market and ability to recruit talent from the rest of Europe. Now – like many industrial lobby groups – it is focusing on persuading ministers to opt for a 'soft Brexit'. Meanwhile, in the short-term, a weaker pound has given some relief to an export-driven industry most of whose products are transacted in dollars.

China is another wild card. Over the past decade China has been one of the most buoyant markets for the West's aerospace exporters – on the civil side at least – and increasingly an outsourcing centre for low-cost manufacturing. But the country has been developing its own narrowbody, the Comac C919, powered by the CFM LEAP engine and intended to compete with the A320neo and 737 Max. It is also collaborating on a widebody programme with Russia, which now has its own narrowbody powered by a Western engine, the Irkut MC-21.

Whether China or Russia can find much of a market for their aircraft outside their traditional spheres of influence is doubtful. While Brazil's Embraer was the last new player to enter the commercial airliner segment, in the 1990s, it has sensibly stuck to sub-100-seat aircraft. Bombardier's attempt to break the bigger-aircraft duopoly has at best been a limited success. And other smaller types from Russia and China – including the Sukhoi Superjet and Comac ARJ-21 – have struggled for traction.

Fast-forward 15 years and China at least could well be a new power in aerospace, with its own supply chain bypassing as much as possible UK and other Western industry – or possibly embracing those industries keen to do business with it. UK industry has had a global vision for many years – regardless of Brexit – and its continuing success will depend on broadening and balancing its customer base, and making sure it is the first-stop shop when airframers come looking for partners who have the right technologies, at the right price. MR

Read more about aerospace manufacturing on pages:

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IN FOCUS: GARDNER AEROSPACE

The story of Gardner Aerospace provides a window into how UK firms with ambition can become tier 1 aerospace and automotive suppliers to match the investment and risk-taking needs of their prime customers. Ben Hargreaves reports.


Nick Guttridge

Aerospace prime contractors want larger partners in their supply chain, companies with capacity that can be innovative, and with the financial muscle to share in the risks of new programmes.

One such British company is Gardner Aerospace, one of the aerospace industry's largest and most diverse manufacturers of machined and fabricated metal parts. Owned by private equity and management, with 1,500 staff, sales of £119 million, and sites in four coutntries, Gardner is a big, streamlined aerospace business – the kind of company that forms Britain's own "large Mittelstand" of privately owned engineering companies over £100m.

But back in 2003 Gardner was publically owned, a sprawling entity comprising numerous engineering businesses, "many of which were in poor shape", says Nick Guttridge, executive vice president for business development. The company's current management team stepped in and, backed by private equity bought 12 aerospace and automotive engineering firms. Between 2003 and the beginning of the financial crisis in 2007, the management team consolidated the businesses, selling off some elements and closing the underperforming or unviable parts. One company in Poland making automotive components was converted into a factory that also made aerospace parts. Following the financial crisis, the company was refinanced by Better Capital, and all the factories were modernised. A second manufacturing site in Poland was added through acquisition. A French group with five factories was also acquired, three of which were then shut down. Gardner also bought a small business in Bangalore, creating a group with ten modernised and consolidated sites across four countries: the UK, France, Poland, and India. Gardner Aerospace's top customer is Airbus, in Britain, and also France and Germany. The company has a "strong position" working on the new Airbus A350 programme, says Nick Guttridge. The geographical spread of the sites is a natural hedge against currency movements, while also allowing engineers to pool expertise, and transfer skilled labour. Spreading component manufacture and assembly across countries allows Gardner to compete on cost, as well as quality. "Our sales today are four to five times what they were in 2003, with not very many more people," Guttridge says. Consolidation and improving efficiencies, under chairman Nick Sanders, helped profits almost treble to £9.7m in 2015.

> "There is a huge amount of intellectual capital in what we do – but not a huge amount of intellectual property"
> **Nick Guttridge**

Management recognised that the aerospace sector in the UK was "massively fragmented". "[OEM] Customers wanted fewer, much bigger players who would be more robust, and able to withstand perturbations in the market," Guttridge says. "These suppliers needed to be able to invest in new programmes alongside the customers." Having extensive operations in "best cost" countries – India and Poland – helped keep Gardner competitive, and the business already fulfilled many legacy Airbus manufacturing protocols. Today Gardner has more sales in Germany and France than the UK.

The coalition government introduced support for aerospace by establishing the Aerospace Growth Partnership and Aerospace Technology Institute. But Guttridge says support for the aerospace sector is still greater for companies in the US, France and Italy. The focus of support in Britain tends to be on R&D and innovation, but companies like Gardner would benefit more from greater support for capital expenditure for manufacturing. "There is a huge amount of intellectual capital in what we do – but not a huge amount of intellectual property," Guttridge points out. The company needs to invest in the latest or next generation machine tools. "These things involve significant capital spend. Government could do more to help."

Brexit could prove problematic if it restricts the flow of goods and people between Britain and the EU, he adds. Like most manufacturing companies, Gardner Aerospace has challenges with getting enough skilled staff in the UK. Five per cent of its employees are apprentices. Ultimately, a lack of skilled staff could put the brakes on growth.

But Gardner is aiming high, Guttridge says. "The aerospace sector is becoming less fragmented. There is an opportunity for people with the right vision and ambition to realise substantial growth. We definitely have that in mind. We have sales of about £120 million now. We want to be substantially bigger than that." MR

GARDNER MAKES TOP TRACK

In 2016 Gardner Aerospace broke into the 12th annual Sunday Times Top Track 250 league table of Britain's private mid-market growth companies with the biggest sales, one of 13 companies in the East Midlands to feature.

Other manufacturing companies listed in the Top Track 250 this year include Alexander Dennis (£601.9m sales), Lush (£326.5m) and shoe manufacturer Doctor Martens (£235.3m).

NEWS IN BRIEF

STRATHCLYDE SCOOPS TOP PRIZE FOR UAV DETECTION SYSTEM

The University of Strathclyde has won Europe's biggest space technology innovation competition for an early detection system for unmanned aerial vehicles.

Strathclyde was the overall and regional UK winner of the European Satellite Navigation Competition (ESNC) for the low-cost 'silent outlook' system that uses low-cost sensors and satellite navigation technology for the early detection of unmanned aerial vehicles (UAVs), addressing growing concerns over public safety, security and privacy.

Out of a field of more than 500 entries from 17 countries, five UK finalists came home from the ESNC awards in Madrid with an award and the top prize of €10,000 to invest in their technology.

While collision and crash avoidance is of paramount concern when it comes to UAVs, regulators are also concerned about UAVs available in the leisure market being used to cause large-scale civilian casualties.

The Strathclyde 'silent lookout' system could be deployed as a perimeter around a football stadium or open-air concert venue, with the sensors creating a 'detection arc' at a distance that would allow authorities enough time to take appropriate action.

JJ CHURCHILL INVESTS AS AEROSPACE SALES SOAR

Nuneaton precision engineering firm JJ Churchill has made a £1.5 million investment in new technology, people and systems to meet growing aerospace industry demand.

The company is now "well placed to meet the expanding opportunities across the European supply chain for engines for the next generation aircraft", it says. The new investment includes Makino five-axis Viper CNC grinding capacity and Doosan 5-axis machining capacity, linked to advanced information-management systems, enabling the machining of complex, precision components in advanced nickel-based alloys.

The company has increased its headcount by 20 per cent this year though, like many companies across the industry, it has found that "highly-skilled engineers are a scarce resource".

JJ Churchill's aerospace sales have increased by 60 per cent in the past year. They now contribute two thirds of the company's total sales when combined with activities in the industrial gas-turbine sector.

Andrew Churchill, managing director, says: "The market for aerospace engines is seeing substantial growth, and we have invested heavily in technology, people and systems to address this demand. We are able to continue to meet the growing needs of our existing customers, while at the same time our strong reputation in the marketplace is attracting new customers and new markets within the sector. The business is on a sound footing to capitalise for the next stage of growth."

SIG HELPS UK AEROSPACE SUPPLIERS CUT COSTS

Sharing in Growth, the government-backed competitiveness improvement programme, has helped aerospace suppliers across the UK secure an average of 16 per cent cost improvements.

Sharing in Growth (SIG) is a contributor to the UK Aerospace Growth Partnership and is backed by Airbus, Boeing, BAE Systems, and Rolls-Royce. SIG chief executive Andy Page says: "We have built an integrated and bespoke four-year training and development programme that's having a real impact on productivity and competitiveness with more than 50 UK companies.

"The results speak for themselves. Half of the suppliers on the programme have secured contracts which together are worth around £1.2 billion with some 20 per cent going to direct export. The contracts equate to 1,900 UK jobs, so we are well on target to hit our ultimate objective of safeguarding 10,000 UK jobs by 2022."

Peter Lion, managing director of independent provider of interconnect systems, Rockford Components, said the support of SIG had strengthened the business, increasing efficiency and reducing manufacturing costs, and improving the company's competitiveness.

Lion says: "A reduction in labour costs, along with improved purchasing efficiencies and new marketing material, have enabled Rockford to secure some major contracts, which has led to an increased demand on our manufacturing facilities. We have grown our workforce by 30 per cent in 2016, and will continue to grow over the coming years."

TMD BENEFITS FROM SHARING IN GROWTH

TMD Technologies, the Middlesex provider of high-tech microwave and RF equipment, has won an £11 million order for a major production contract. To support the contract TMD adapted and customised a completely new area of the factory with support from Sharing in Growth (SIG).

Working closely with TMD, SiG developed a customised programme management process intended to "guarantee complete clarity of specification and availability of necessary resources". This, together with practices such as 5S, right first time, and optimised production engineering processes thanks to the SIG programme, have been "key in getting this challenging new contract off to the best possible start", TMD says.

MIDLAND WINS THREE-YEAR A380 CONTRACT

Midland Aerospace, part of the Calder Group precision engineering business, has secured a three-year production contract for a machined structures package for the A380 aircraft, won under contract from Safran Electrical & Power.

To provide a range of CNC machined and other manufactured products and services to Safran, Midland has commissioned a new five-axis DMG DMU 65FD high speed pallet-loading CNC milling machine. The contract also includes a "turnkey engineering and machine maintenance support solution" in partnership with CNC machine tool firm DMG MORI. MR

COMPOSITES SET FOR GROWTH SPURT

CATAPULT High Value Manufacturing

Composite materials allow lightweight structures in aerospace and motorsport but their potential has yet to be fully realised in other sectors. The Automotive Council identified the need to develop a supply chain to deliver Affordable Composites to the automotive sector. The High Value Manufacturing Catapult is supporting this plan with technology development and industrialisation of composites manufacturing processes.

IN BRIEF:

New Affordable Composites Group establishing high volume, cheaper composites manufacturing

Automotive composites market predicted to grow from a current value of approximately £300m to more than £3bn in 2030

Total global market could be worth £80bn

Composites should be used in construction, rail and marine

JLR, Airbus and Bombardier leading lights in UK manufacturing when it comes to composites introduction

Cars made from spot-welded steel and aircraft made from riveted aluminium employ manufacturing technologies which have served their industries well for decades. Contrary to popular belief, however, both the aerospace and automotive industries are surprisingly material-agnostic, and driven by balancing three key elements: weight, cost and functional performance.

The market drivers for emissions reduction and greater fuel efficiency have accelerated propulsion technologies, but ongoing weight reduction is needed to maximise vehicles' range, performance and payload. Whether the vehicle is fossil-fuelled, or electrically powered, keeping 'm' (mass) as low as possible in Newtonian calculations has become the norm for today's engineers. As a result, we have seen the emergence of aluminium-intensive cars and carbon fibre composite aircraft; the challenge is now to accelerate development and adoption of processes that are capable of high rate manufacturing of cost-optimised composite components and structures.

PERFORMANCE, STRENGTH AND WEIGHT

Advanced fibre composite materials score well on performance, strength and weight, but there is a challenge in terms of the cost of the material, and in the manufacturing process.

There is a lot at stake, so we need to address this challenge now. In the UK alone, the market for affordable composites for the automotive industry is predicted to grow from a current value of approximately £300m to more than £3bn in 2030, while the total global market could be worth £80bn. The HVMC has recognised this opportunity, and realising it has become one of our key projects. We've established that there is a very real appetite for affordable structural composites if we can accelerate the process and technical development , and reduce costs.

To this end we have scoped out a roadmap showing what technology and supply chain capability the UK requires to succeed in this market.

LAND OF OPPORTUNITY

Together, we have established the new 'Affordable Composites Group' (ACG). Already, through collaborative projects, we have shown at the National Composites Centre that we can produce complex forms such as vehicle floorpans – demonstrating high productivity, component integration and the weight reduction potential of using composites in automotive applications.

A programme of this scale can only be achieved through collaboration. We have brought 14 companies together with CR&D competition funding and five research partners to the tune of over £11m, supported by Innovate UK and the Office for Low Emission Vehicles. The benefits of developing supply chains that can produce composites for the automotive sector using high productivity and rate automated processes there are very obvious, and real benefits spin back into aerospace, and also into sectors such as the construction industry, rail and marine.

Photo courtesy of HVMC

The National Composites Centre in Bristol is part of an overall national strategy for new materials

The programme is not just about developing the technology, it's about giving the UK a chance to develop a valuable new supply chain for these materials. The UK was the first country to produce a carbon fibre Formula 1 car, and the first to produce a composite road car. We have a dynamic industry in the application of carbon fibre for aircraft, thanks to serious presence from Airbus, Rolls-Royce, Bombardier and their supply chains. Jaguar Cars provides a good British automotive example, transitioning from steel-based cars to the aluminium bonded and riveted construction now at the heart of the JLR brand. However, this new opportunity was not exploited as it should have been by the supply chain. As a result, much of the aluminium sheet, casting and extrusions had to be initially sourced from overseas.

We are poised to make a step change in increasing the use and maximising UK value in the next phase of automotive lightweighting if the national composites project can be made a success.

The HVMC is determined that this opportunity will not pass us by. MR

ADDITIVE MANUFACTURING – PRINTING THE FUTURE

Cranfield Univerity has some unusual additive manufacturing equipment on site and is benefiting from a technology that's also used by aerospace and defence giants

Cranfield's rolling technology development programme uses the WAAM – Wire + Arc Additive Manufacturing – process

IN BRIEF:

- AM research at Cranfield focuses on science and industry
- Wire + Arc Additive Manufacturing (WAAM) process is used
- System also used by Airbus, BAE Systems and Lockheed Martin
- HIVE centre producing large AM parts
- System has 4m x 3m x 1m working envelope

AM part made using WAAM process and produced new twin-robot 3D printer is six metres long and weighs around 300kgs

Research in additive manufacturing – the 3D printing of large-scale (metal or otherwise) parts – at Cranfield University is scientifically based but industry focused.

Additive manufacturing is a technology that produces (metal) parts quickly, cheaply and efficiently in comparison to traditional manufacturing techniques, which rely on removing material through cutting or drilling. It promises to reduce part cost by reducing material wastage and time to market, and can also enable an increase in design freedom, which potentially results in weight saving as well as facilitating the manufacture of complex assemblies formerly made of many subcomponents.

Our rolling technology development programme uses the WAAM (Wire + Arc Additive Manufacturing) process – the combination of an electric arc as heat source and wire as feedstock. It already has significant industrial partners such as Airbus, BAE Systems and Lockheed Martin.

HIVE OF ACTIVITY

With the aim of making the UK the leading technology provider in terms of transforming practice and creating a commercial option, our WAAMMat research is based around a laboratory on campus which houses a variety of laser and arc welding facilities with large-scale material handling facilities. These are equipped with nine welding robots to enable automated additive manufacturing as well as welding, and to make use of the latest quantitative analysis technologies to model arc and laser processes.

Our High Value Engineering Research Facility, also known as HiVE, has been specifically created for industrial-scale WAAM-based technology. This has a large working envelope (4m × 3m × 1m) and is equipped with a machining and rolling facility, to produce near net shape components and control microstructure, mechanical properties and residual stress, ultimately producing superior material from a structural point of view.

Cranfield's own MSc students have recently designed what could be the biggest metal 3D part ever made in one piece. Using the WAAM process and produced on our new twin-robot 3D printer, it is an incredible six metres long and weighs around 300kgs. MR

Source: unsplash.com

VANTAGE POWER TAKES CLOUD ON THE ROAD WITH INFOR

Hybrid engine innovator deploys Infor CloudSuite Industrial to drive rapid early stage growth

Based in West London, Vantage Power (VP) manufactures complete hybrid powertrains that are retrofitted to buses already on the road. By adding remote telemetry capabilities to its hybrid engine, Vantage offers customers a combination of live performance data to enable enhanced fleet management and maintenance, as well as better fuel economy and reduced emissions. Following a three-year period of intensive research and development, VP now sells its engines commercially and as a result, has entered a period of rapid growth.

Following a thorough review of the ERP market, VP selected Infor CloudSuite Industrial because of the strong manufacturing functionality of the application and the expertise demonstrated by both Infor and implementation partner Inforlogic. As a "disruptive engineering" company, VP decided to look solely at cloud-based applications. This was based on the ease of management offered by cloud technology, in particular that cloud would mean VP was always on the latest versions of the software, and that Infor would ensure security and reliable off-site access to the application.

"As a young engineering company, we are in an excellent position to get the most out of the cloud," said Alex Schey, CEO of VP. "In the first instance, that means better visibility as we implement the ERP system. That insight into our operations will quickly evolve as we develop new versions of the powertrains and increase our customer base, which means we will need to have the latest functionality to help us stay on top of our dynamic supply chain. Looking further to the future, we plan to take the data from our powertrains and feed that into the ERP system, so we can proactively maintain the units, and offer a cost-effective and complete managed service to our customers. Cloud will be at the heart of making all of this happen."

"Aggressive, disruptive companies such as VP combine so many of the hottest technologies right now," said Lisa Pope, senior vice-president, CloudSuite, Infor. "From the Internet of Things providing real time data from the buses and then 3D printed replacement parts, to the dynamic supply chain that enables the cost-effective development of refined hybrid engines, cloud technology not only underpins all of these areas, but ultimately helps drive growth for Vantage Power."

"Combining the possibilities of cloud, the manufacturing pedigree of Infor CloudSuite Industrial and the deployment expertise at Inforlogic has led to a clear choice for Vantage Power," said Chris Stock, managing director, Inforlogic. "As the company goes through aggressive growth, we look forward to supporting VP every step of the way."

Infor CloudSuite Industrial is expected to improve visibility throughout VP's supply chain, enhancing procurement as the company enters a stage of aggressive growth. The cloud-based ERP solution is also expected to help improve VP's financial reporting and give users off-site access to critical production and financial information.

ABOUT VANTAGE POWER

Vantage Power manufactures complete hybrid powertrains that retrofit buses already on the road. Coming with remote telemetry as standard, customers buses get live performance data that enables enhanced fleet management, maintenance, fuel economy, and emissions.

To learn more about Vantage Power, please visit **http://vantage-power.com/**.

About Infor: Infor builds business software for specific industries in the cloud. With 15,000 employees and over 90,000 customers in more than 170 countries, Infor software is designed for progress. To learn more, please visit **www.infor.com**

DEFENCE

DEFENCE FRONTS UP TO THE FUTURE

In November the Government confirmed that work will commence on the new generation of Royal Navy frigates, the Type 26, next summer, safeguarding up to 3,000 shipbuilding jobs in Scotland. However beyond this £8bn programme, other naval vessels may not be built solely in Scotland after a naval procurement review by Sir John Parker suggested future contracts could be shared among companies across the UK.

The UK has a large defence sector and government initiatives hold the promise of further long-term growth. But a potential second referendum on Scottish independence and Brexit will pose demanding questions. Gerrard Cowan reports

THIS ARTICLE EXPLAINS:

- Big decisions taken in defence this year, including Trident renewal
- UK is Europe's largest defence market
- Domestic industry supported by government and company initiatives that may boost long-term exports
- Brexit poses challenges – and opportunities
- Paris, Berlin and Rome value British know-how

Defence is a big, slow-moving business, where budgets are in the billions and projects can last for decades. Still, the past 12 months have witnessed a number of developments that could impact the sector for years to come.

Perhaps the single most important milestone was political. In July, the House of Commons voted to renew the Trident nuclear deterrent, giving a green light for the further development of four new nuclear-powered ballistic missile submarines: the Dreadnought class. The vote was a boost for the UK's largest defence company, BAE Systems, which will construct the boats alongside its partners, Rolls-Royce and Babcock.

EUROPE'S LARGEST DEFENCE MARKET

The Dreadnought programme underlines the importance of domestic demand to the UK's defence industrial base. The country is Europe's largest defence market, with spending of just under £41 billion in 2016, according to IHS Jane's, a provider of defence news and analysis.

Perhaps more than any other industry, defence depends on government customers, meaning that the strategic direction set by Westminster is crucial to British manufacturers. An important development this year was the publication of the Strategic Security and Defence Review in November 2015, says Paul Everitt, chief executive of ADS, an industry body for the aerospace, defence, security and space industries. While this naturally focused on national security priorities, it "identified some key themes which for us are very important", Everitt says, around work to stimulate technological innovation, for example.

DEFENCE SECTOR BY NUMBERS

UK defence sector turnover 2015:
£24 BILLION

Direct UK defence sector jobs:
142,000

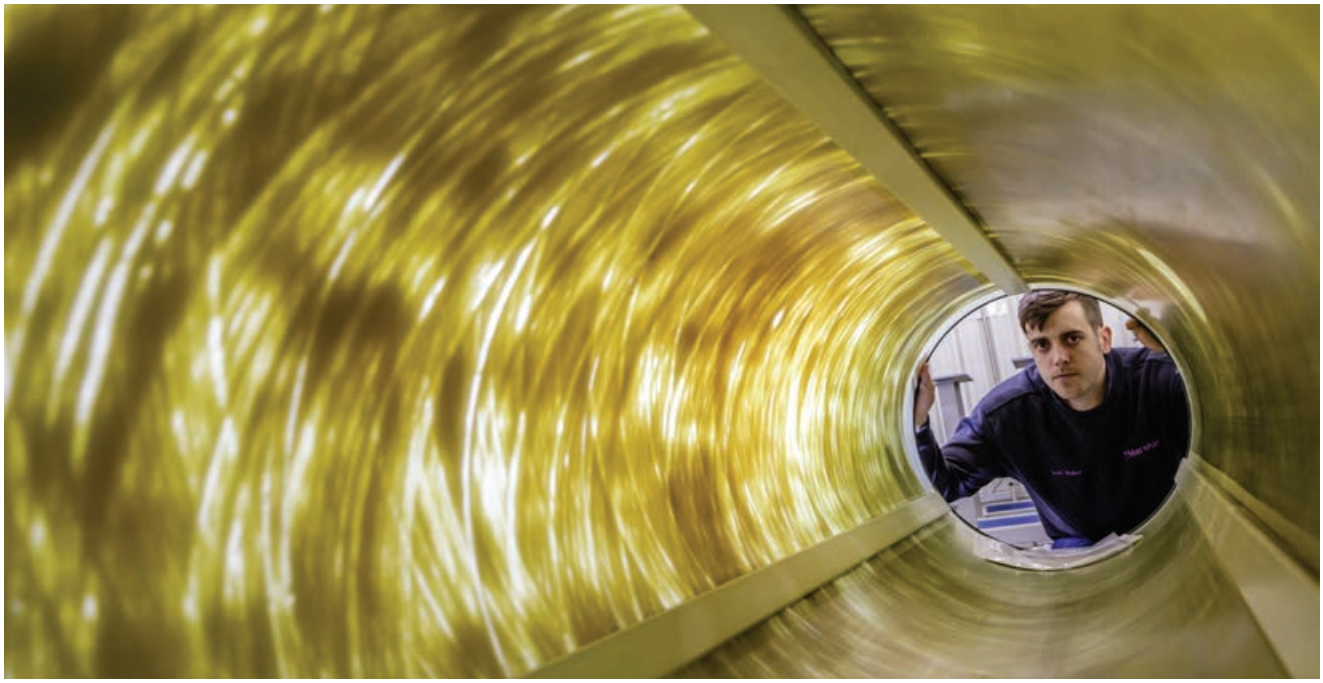
Indirect UK defence sector jobs:
111,000

Average exports 2010-2014:
£7.7 BILLION

Source: ADS

Left: Lockheed Martin UK 'looks on itself as a British company'

Below: Looking toward the future: Defence manufacturing at Marshall Aerospace



The government has sought to boost the industry in various ways through the years. The latest effort is the Defence Growth Partnership (DGP), a joint project between government and 16 major defence companies, alongside ADS, which was launched at the Farnborough Airshow in 2012. It is predominantly aimed at boosting exports through a 'Team UK' approach, with industry players and government working together to secure major deals. This work is carried out primarily through the Defence and Security Organisation (DSO), which sits within the Department of International Trade and looks to promote the UK industry overseas, and the Defence Solutions Centre, which facilitates collaboration across the sector to foster technological innovation.

The industry has broadly embraced the idea, with major players seconding staff to different elements of the partnership. There is a feeling in some quarters, however that the DGP has yet to fully click into gear. "It has taken longer to have an impact at scale than we would have liked," says Alvin Wilby, vice president of research, technical and innovation at Thales UK, a partner in the programme. While the DGP has done a good job of ramping up resources, establishing priority countries, and figuring out what a 'Team UK' approach ought to look like, it has not yet led to major export deals, Wilby says. Still, he adds that the concept represents a major cultural shift for both the industry and government: "Expecting it to have already won a couple of billion pounds may be pushing a bit too hard." If by 2018 "the UK has an extra billion or two of defence export orders, that would be a success".

NATIONAL STRATEGY FOR SHIPBUILDING

The SDSR revealed a number of other measures aimed at boosting industry. A national shipbuilding strategy is in the

works, while a Defence Innovation Initiative was launched in September, with £800 million pledged over a 10-year period to support the development of innovative defence technologies.

There is also a commitment to "refresh" defence industrial policy. There have been various efforts in this direction over the past decade. In 2005, the Labour government launched a Defence Industrial Strategy, which was followed in 2012 by the coalition government's National Security Through Technology White Paper. But the momentum behind a wide-scale industrial strategy has gained new impetus since Theresa May became Prime Minister and renamed the Department for Business, Innovation and Skills as the Department for Business, Energy and Industrial Strategy.

The DGP's predominant focus on exports contrasts with the Aerospace Growth Partnership (AGP) in the civil aerospace industry, which has a wider remit, Everitt says. The AGP has seen the establishment of the Aerospace Technology Institute (ATI), an independent body with a £3.9 billion research and development programme, funded equally by government and the aerospace industry.

"The Defence Growth Partnership has always been focused on exports, and while exports will benefit the UK economy and industry, it's only dealing with a small part of what might be an industrial strategy, whereas the Aerospace Growth Partnership is delivering a whole industrial strategy," Everitt says.

A national shipbuilding strategy is on the horizon for projects after the QE-class aircraft carriers (pictured), such as Type 26

The government's new focus on industrial strategy means there is now "a huge opportunity to develop the work that is being done within the Defence Growth Partnership, to encompass a broader industrial strategy that looks at skills and technology as well as exports", Everitt says.

A broader strategy could be helpful in addressing a shortage of job candidates with STEM skills, says Chris Owen, group business manager of Marshall Aerospace and Defence Group, which provides support to the RAF's C-130 fleet, among a number of other defence activities.

"A co-ordinated understanding of the skills shortages across advanced manufacturing in the UK, particularly in the defence, aerospace, nuclear and automotive sectors, would be helpful," he says. "A common understanding of the problem and agreed methodology for tackling it or at least a shared direction of travel would be highly welcomed."

A DEFENCE BASE OF DIFFERENT ELEMENTS

The UK's defence manufacturing base comprises many different elements. The country is prominent in aerospace, with a history of producing Tornado and Harrier aircraft, right up to work on the Eurofighter Typhoon and the F-35 Lightning II combat aircraft today. There

the British defence sector is pooling resources and expertise for future success

is also work carried out in the field of unmanned systems, as well as on a range of aerospace systems and sub-systems. Likewise, the naval sector is strong, particularly through work on the new aircraft carriers and nuclear submarines.

The UK is open to foreign-owned manufacturers, who are attracted to the large defence budget on offer. For example, the US-owned defence companies Lockheed Martin and General Dynamics are working on the Warrior Capability Sustainment Programme (WCSP) and Ajax armoured fighting vehicles from their British facilities.

Lockheed Martin's site in Ampthill, Bedfordshire, has grown quickly over the years. It now hosts 900 employees on a 64-acre site, and works across numerous areas, from ground-based air defence to the WCSP and Ajax vehicles.

It has been a big year for the UK arm of the company, says Graham Harraway, operations director at Ampthill. It has invested £12 million in a fabrication and manufacturing capability to allow it to develop, design and build turrets on site, and opened a new facility focused on this work in June.

Lockheed Martin UK "very much look upon ourselves as a British company", says Harraway, with the company registered here, and the vast majority of staff coming from the UK. However, there are advantages to being part of a US defence giant. The site has had $41 million of investment since it was established in 2006.

"We've been able to invest in both infrastructure and capital equipment, and in manufacturing as well," Harraway says.

Lockheed Martin is one link in a supply chain that has become increasingly international. European companies are also prevalent as manufacturers and suppliers. Thales, for example, operates a number of facilities across the country, and recently opened a new spacecraft electric propulsion facility in Belfast, where it also has an advanced weapons business. To a lesser degree, British companies also have holdings on the continent, notably BAE Systems through its Swedish subsidiary, BAE Systems Hägglunds.

The result of June's EU referendum raises questions for the industry looking forward, says Scott Clark, vice president of defence consulting at Frost & Sullivan. This is particularly the case for projects with a wide overseas supply chain, and which rely on imported raw materials. Any fluctuations in currency could have an impact. Additionally, Brexit has raised the prospect of a second independence referendum for Scotland, an important hub in the British defence industry.

"The big question is what happens with Brexit, and what happens with the Scottish vote, not in the short-term but probably in the medium-term, and the implications that would have for manufacturing – and shipbuilding activities," Clark says.

This cuts both ways. Harraway says the vast majority of Lockheed Martin's suppliers are UK-based, while raw materials form only a very small part of its product price. The fall in the pound is actually beneficial to the company, he said, making its exports more attractive. The company does have a handful of European partners, some of which are "quite key" to its supply chain. Harraway says it is important to avoid "hard Brexit issues, with gaps in the agreements that we have on import and export". Otherwise, he says, "we're struggling to see the downside of it from a business perspective". MR

LEAVING THE UK ISOLATED?

Exposure to international supply chains provides access to innovative technologies, says John Louth, director for defence, industries and society at the Royal United Services Institute (RUSI), a London-based thinktank. If leaving the EU makes the British industry more isolated, there could be harmful effects.

"If we get that scenario again that'll be quite problematic for the UK, especially as a lot of these sort of complex technologies aren't necessarily available in volume onshore," he suggests.

But Paris, Berlin and Rome are also likely to be considering their dependencies on UK know-how, Louth says. This could mean "the kind of deal that's done will have to enable those interdependencies to work going forward".

A broader challenge for the industry concerns the future of manufacturing itself, and how it incorporates the advances of Industry 4.0. A number of projects are underway, from investigating the potential of 3-D printing to the increasing role of automation.

A problem for the defence industry is the fact that its products have a long development time and can be in service for many decades, says Keith Jackson, chief technology officer of Meggitt PLC, a provider of components and subsystems for the aerospace, defence and energy markets. This longevity means that knowledge has to be created and retained over long periods of time, with factories and equipment being upgraded as technology advances.

The company is looking to address these demands through its Meggitt Modular Modifiable Manufacturing (M4) programme, which will capture data from the production process and the know-how and knowledge of operators to optimise long-term learning and manufacturing effectiveness.

M4 stemmed from the company's Closed Loop Adaptive Assembly Workbench (CLAAW), which guides operators through the production process while automatically keeping records through assembly. The company is currently working on a demonstrator factory that will incorporate the technologies it believes can be produced most efficiently through M4.

Still, Jackson has concerns, particularly over the company's ability to hire the kind of staff that will be needed for the project, from mechanical to analytics engineers. There is a broad need to raise awareness of manufacturing as a career path, he says. The shortage is a particular problem in the manufacturing heartlands of the Midlands.

"I think I could easily staff a project if we were based on the M4 corridor, or if we were based in Cambridge or Oxford. But that's not where much of our manufacturing industry sits. If I had to pick one thing that's the big barrier, it's that skills gap."

Read more about defence manufacturing on pages:

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CARRIER COMMAND

The Queen Elizabeth-class aircraft carriers are three times the size of the Invincible-class aircraft carriers

HMS QUEEN ELIZABETH AND HMS PRINCE OF WALES

Displacement
65,000 tonnes

Length
280 metres

Maximum beam
70 metres

Top speed
25
Knots

Range
10,000 miles

Crew
679

Huge sections of the hulls and the island structures built at yards in Glasgow and Portsmouth

CARRIER CREW

- 10,000 – number of jobs sustained in designing and constructing the QE-class carriers
- 7,000 – 8,000 jobs at the tier one shipyards in Glasgow, Rosyth, Portsmouth and Devon
- A further 2,000 – 3,000 people across the UK supply chain

Embarked forces

(up to)

921

BAE SYTEMS

is a lead member of the Aircraft Carrier Alliance, with Babcock, Thales and the UK Ministry of Defence, working to deliver the two QE-class aircraft carriers

Final assembly stages of the ships take pace in the dry dock at Rosyth, Scotland

First of class expected to be fully operational by **2020**

CARRIER ECONOMICS

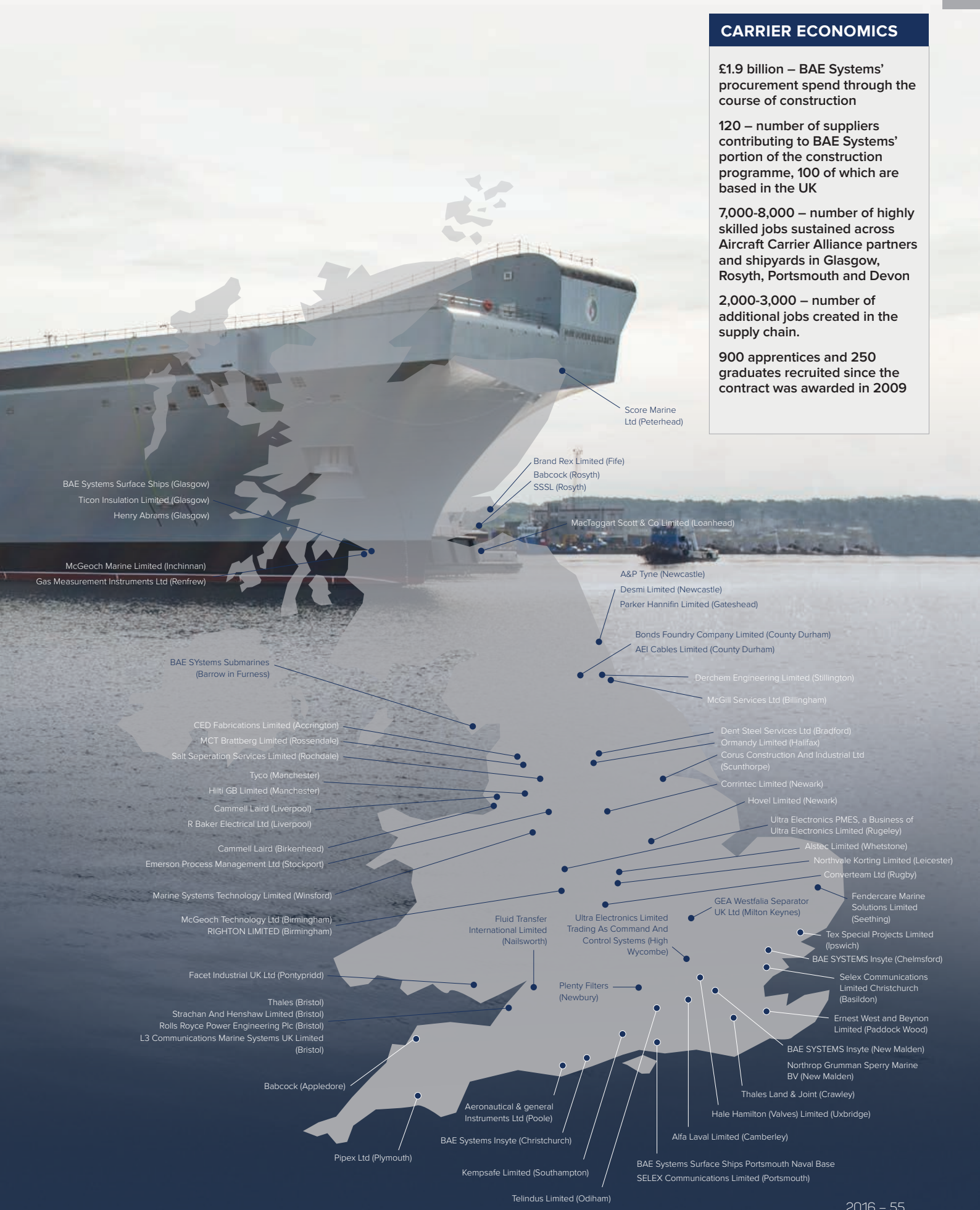
£1.9 billion – BAE Systems' procurement spend through the course of construction

120 – number of suppliers contributing to BAE Systems' portion of the construction programme, 100 of which are based in the UK

7,000-8,000 – number of highly skilled jobs sustained across Aircraft Carrier Alliance partners and shipyards in Glasgow, Rosyth, Portsmouth and Devon

2,000-3,000 – number of additional jobs created in the supply chain.

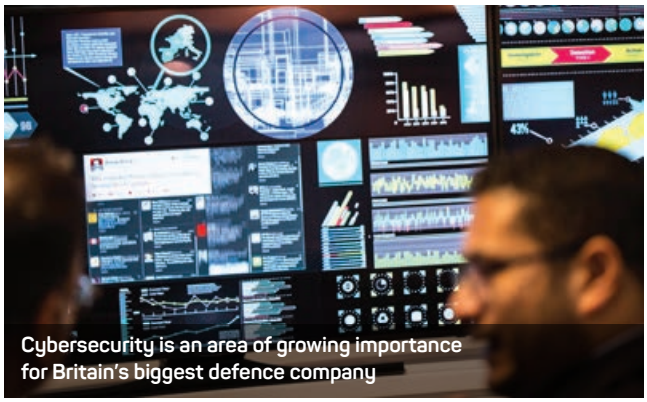
900 apprentices and 250 graduates recruited since the contract was awarded in 2009



A STEADY DRUMBEAT

BAE SYSTEMS
INSPIRED WORK

BAE Systems' UK business continues to support the land, air and maritime defence arms, as well as the emerging field of cybersecurity



Cybersecurity is an area of growing importance for Britain's biggest defence company

In 2016 BAE Systems announced new support contracts for Hawk and Typhoon (pictured)

IN BRIEF

- BAE has leading positions in air, maritime and land
- Cybersecurity is growing in importance
- F-35 Lightning II production ramping up
- New submarine programme rubber-stamped by the Government
- Company is collaborating on Challenger 2 support

BAE Systems has had a strong 2016, further strengthening its cybersecurity business in addition to its established positions as a leading global defence company in air, maritime and land.

There have been many milestones this year. Ongoing work in the air business has included continued capability upgrade work on the Eurofighter Typhoon, and the announcement of support contracts for Hawk and Typhoon. In addition the company will benefit from the United States' F-35 Joint Program Office's announcement that it had selected the UK and Australia as significant repair hubs for the global Maintenance, Repair, Overhaul & Upgrade (MRO&U) services for F-35 avionics and aircraft components.

In October, BAE Systems welcomed the Right Honourable Sir Michael Fallon MP, Secretary of State for Defence, to Barrow-in-Furness shipyard to commence the first metal-cut for the Successor programme.

This followed the UK Government's commitment of £1.3 billion funding for the Successor Submarine programme at the beginning of that month. This programme will deliver four new submarines for the Royal Navy and will replace the current Vanguard class, with the first submarine entering service in the early 2030s.

The third of the Astute class of BAE designed and manufactured submarines, *Artful*, is also now being operated by the Royal Navy. Two 65,000 tonne aircraft carriers built by the Aircraft Carrier Alliance, of which BAE is a major supplier – HMS *Queen Elizabeth* and HMS *Prince of Wales* – are expected to complete sea trials in 2017 and 2019 respectively.

Before the Farnborough Airshow in the summer, BAE also announced that its team at Samlesbury, Lancashire, had completed the 250th aft fuselage for the F-35 Lightning II programme. Manufactured on a state-of-the-art integrated assembly line, the section was equipped and rigorously tested before transport to Lockheed Martin's final assembly facility in Fort Worth, Texas, where it will be integrated with the rest of the aircraft. Jon Evans, head of F-35 Lightning II production delivery for BAE Systems, said: "Completion of the 250th aft fuselage of the F-35 Lightning II demonstrates the progress we have made and underlines our ability to deliver to the programme. Every part we produce not only benefits our own business and workforce, it also helps create work for 500 UK-based supply chain companies involved in the programme."

SAMLESBURY EXTENSION

Also in July, work began on a major expansion to the F-35 Lightning II machining facility in Samlesbury. The work will ensure the facility is prepared for the increase in production rates of the stealthy, fifth generation, multi-role combat jet. The 5,000m^2 extension will enable the facility to meet the demand of future production increase as part of the programme's schedule. It will also bring the programme's full metal machining capability in one building. The extension of the facility is expected to be completed by summer 2017, when machinery will be progressively installed to keep pace with demand. And at the beginning of the year, in a burgeoning area of the business, cybersecurity, BAE unveiled some of the biggest threats to businesses by profiling six prominent types of cybercriminal, exposing how they cause harm to companies around the globe, and providing some practical ways that companies can defend against them. The findings were built on research that demonstrates the motivations and methods of the most common types of cybercriminal with the intention of helping enterprises understand the enemies they face so they can better defend against cyber attack.

Finally, in the land business, as part of plans announced in the 2015 Strategic Defence and Security Review, BAE said it would work with General Dynamics Land Systems-UK, General Dynamics Mission Systems-International, Leonardo-Finmeccanica, Moog, QinetiQ and Safran Electronics on the Challenger 2 programme, which will form a key part of the British Army's capability through to 2035. In order to achieve this, several key systems will need to be replaced. This builds on work BAE has carried out on the Challenger 2 tank since it came into service in 1998, continuing to support the vehicle to ensure it always remains at optimal readiness. BAE has also delivered many Urgent Operational Requirements and upgrades in that time to respond to emerging threats and changing battle scenarios. MR

BAE BY NUMBERS

SALES BY DOMAIN:
Air (53 per cent)
Maritime (28 per cent)
Land (13 per cent)
Cybersecurity (6 per cent)

SALES: 2015 – £17.9 billion

SALES BY DESTINATION:
US (36 per cent)
UK (23 per cent)
Saudi Arabia (21 per cent)
Australia (3 per cent)
Other (17 per cent)

SALES BY ACTIVITY:
Military and technical services and support (42 per cent)
Platforms (37 per cent)
Electronic systems (14 per cent)
Cybersecurity (7 per cent)

EMPLOYEES: 82,500

Employees in UK: 33,800
Employees in US: 29,600
Employees in Saudi Arabia: 5,700
Employees in Australia: 3,500
Other: 9,900

Source: BAE Systems Annual Report 2015

Precision engineering is vital to the future of manufacturing in the UK

PRECISION JOB FOR CRANFIELD

University working with leading science bodies to develop precision engineered scientific and research equipment

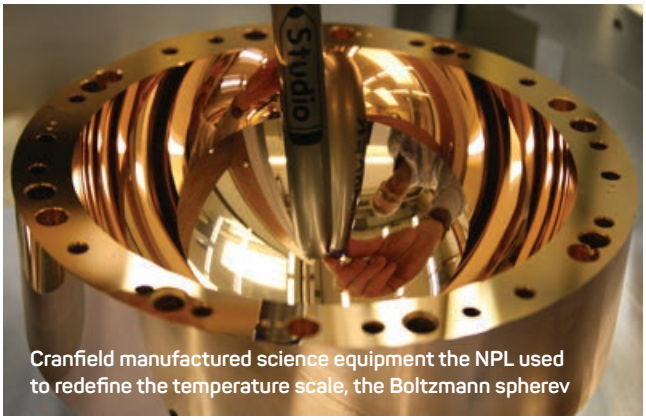
THIS ARTICLE EXPLAINS:

- Precision engineering vital to next generation products and research
- Cranfield is working with NASA, ESA and the National Physical Laboratory
- High-tech science equipment manufactured at university
- Thousands of square metres of cutting-edge laboratories at Cranfield
- Cranfield leads Centre for Innovative Manufacturing in Ultra Precision

Precision engineering is vital to fulfil the demand for ultra precision, complex components for next generation products and ongoing research and innovation.

Cranfield University works with the likes of NASA, the European Space Agency (ESA), European Organisation for Nuclear Research (CERN) and National Physical Laboratory (NPL), as well as major hi-tech manufacturers in the aerospace, medical and optoelectronics sectors.

Our research in recent years has made a significant impact across the fields of science and industry – we manufactured, measured and supplied the highly-complex MIRI (Mid Infa-Red Instrument) spectrometer mirrors for NASA's James Webb Space Telescope, the replacement for the renowned Hubble Space Telescope; we established the Ultra Precision and Structured Surfaces (UPS2) facility that manufactures large ultra precision structured drums for reel-to-reel production of advanced films; and we manufactured the science equipment that the NPL used to redefine the temperature scale, the Boltzmann sphere.



Cranfield manufactured science equipment the NPL used to redefine the temperature scale, the Boltzmann spherev

TAILOR-MADE RESEARCH FACILITIES

Unique and tailor-made research facilities in our laboratories were designed and built by our team of experienced academics and industrial engineers. There are 3,000m^2 of thermally-controlled precision, ultra precision, microengineering and surface structuring laboratories so we can validate the claimed performance capability of each of the machines we create.

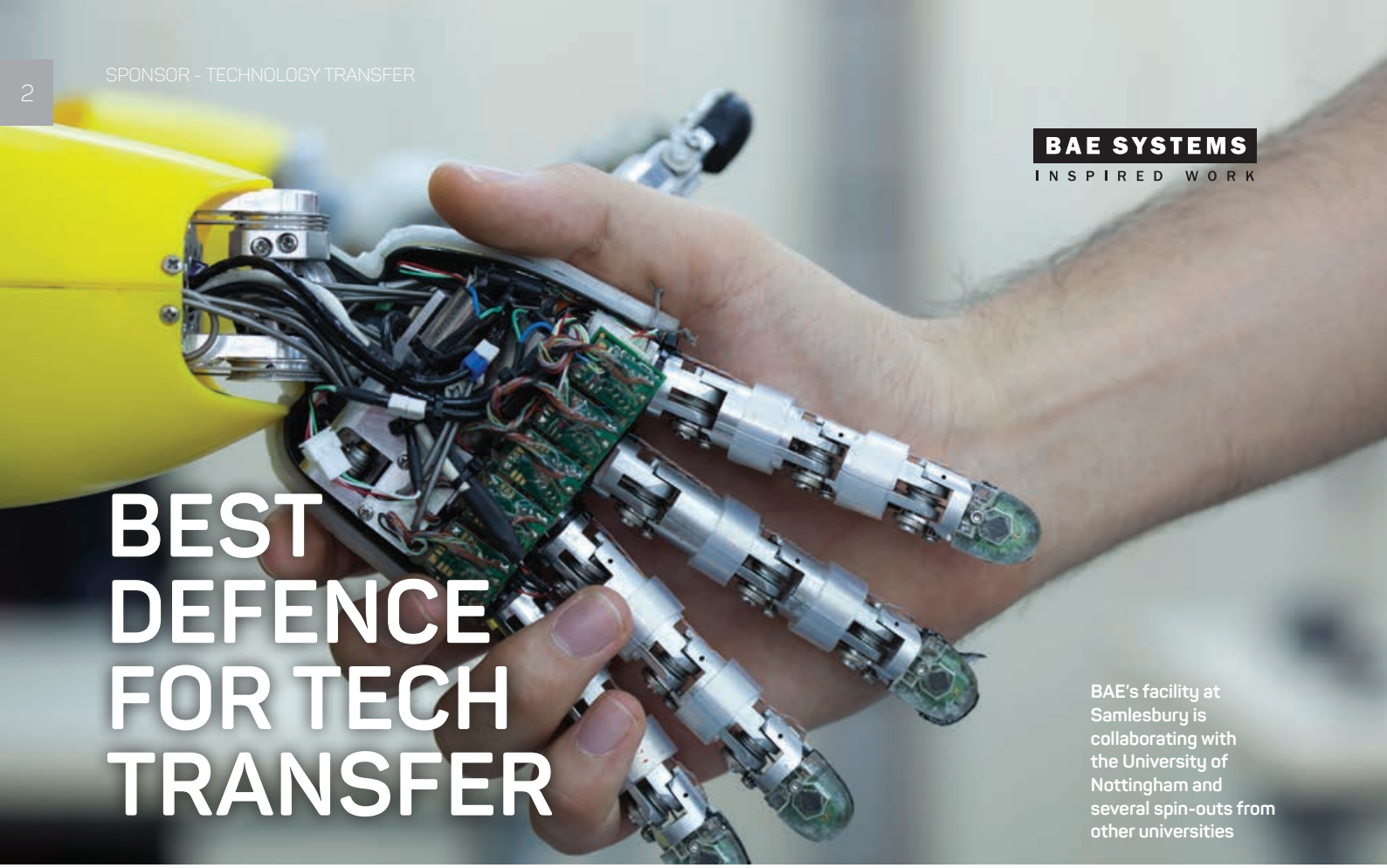
The microengineering laboratory, a 100m^2 clean environment facility, is the UK's leading specification laboratory for supply of space grade (flight approved) diamond turned optics.

The ultra-precision machining laboratory houses a range of our own developed ultra precision diamond turning machines and those from leading suppliers. It is the UK's national facility for large x-ray optics manufacture with a capacity to process optics of up to 1.5m in diameter. It is equipped with surface roughness and form measurement instruments.

The 1,000m^2 CUPE Laboratory houses ultra precision machines for a wide range of operations, as well as being the assembly area for our own self-developed research machines.

The 600m^2 Loxham Precision Laboratory houses ultra precision machines for large free form optics production, equipped to handle optics through instrumented cranes and holding devices.

We also lead the Engineering and Physical Sciences Research Council (EPSRC) Centre for Innovative Manufacturing in Ultra Precision on campus, and also input into the EPSRC Doctoral Training Centre (DTC) in Ultra Precision, both in collaboration with the University of Cambridge.



BAE SYSTEMS
INSPIRED WORK

BEST DEFENCE FOR TECH TRANSFER

BAE's facility at Samlesbury is collaborating with the University of Nottingham and several spin-outs from other universities

Andy Wright, director of strategic technology at BAE Systems, explains that the defence giant relies on SMEs and researchers in order to innovate as well as its considerable in-house resources

Andy Wright readily mounts a robust defence of the UK's record when it comes to innovation in engineering and manufacturing.

The director of strategic technology at BAE Systems argues that Britain – sometimes viewed as a nation of innovators that fails to bridge the gap between invention and the commercial exploitation of new ideas – actually does very well, particularly in the automotive and defence sectors.

Wright points to BAE's activities as Samlesbury, the company's plant in Lancashire that is carrying out its work on the F-35 Lightning II programme, as an example. The firm has a stop-go facility for making aircraft that is "world-leading", he says. There is a robotic counter-sinking capability there that improves accuracy and reduces afterwork that is not found in other businesses. Of course, Wright says, one can "always point to certain areas and say, 'they are not as good as we would like, or that are performed better in other countries'." But he adds: "If you look at UK aerospace and automotive, we are actually very innovative in terms of exploiting new technologies and ideas."

In conjunction with the University of Nottingham, Samlesbury is now looking at the introduction of cobots to work alongside shopfloor workers, with an eye on making different parts for different aircraft on one line, with reduced levels of tooling.

It is areas such as this – robots and autonomous systems for defence and automotive applications – that the UK has a high degree of know-how and manufacturing prowess, Wright offers. As another example, he says that BAE is currently working with Portsmouth's ASV on unmanned systems for marine. It is also working with a range of SME partners and academic institutions on the growing – and rapidly changing – area of cybersecurity, which has become an important part of the business. "We are not Silicon Valley, but if you look at some other areas such as pharmaceuticals manufacturing, we are world-leading," Wright says. He adds that the acquisition of predictive keyboard maker Swiftkey by Microsoft in a $250 million deal at the start of 2016 indicates the regard that British technology start-ups are held in by global tech giants.

The UK benefits, of course, from its world-class technology research base and the efforts of academia to innovate and pass on ideas to industry. "How important is university research to BAE? The short answer is: very important," Wright says. Many British universities' only peers internationally are in the US, he adds. "There are lots of universities in the UK that are at the forefront of capability." BAE's annual investments in the university system run into the millions, from autonomous systems, to advanced materials, to robots and automation. Wright adds that BAE often poses unique, and uniquely challenging, problems to researchers. "I don't come to them demanding a solution – but, rather, giving them a problem to solve. If you go in there asking for a solution, you shut down avenues of technology that are otherwise opened up."

Capturing innovation internally is carried out via a scheme called Empower, which allows BAE staff to contribute ideas for

Left: A robotic tool-change system for F-35 machining at BAE Systems Samlesbury. Increasingly the company is looking at co-notices in its manufacturing processes

Above: BAE Systems' maritime business includes the manufacture of militarised rigid-inflatable boats that can be autonomous, as well as naval ships

Below: Andy Wright, director of strategic technology at BAE Systems

new technologies. BAE will also carry out specially chosen and funded 'deep dives' into new areas. It works extensively with British SMEs such as Outsmart Insights, a ten-person spin-out from Imperial College London that specialises in crowdsourcing new technology. "People flag up technology areas that are of potential interest: these will be discussed in a quarterly digest by BAE, and in workshops we run. Occasionally something will come up that is really interesting, and then we can go deeper into it," Wright explains.

The company was working with additive manufacturing for many years before it became a mainstream technology. Today, AM parts have been certified for flight for three aircraft within the Military Air & Information business. BAE now views quantum sensing technologies as an area of particular promise overseas. So does the UK research community, which is investing hundreds of millions into quantum sensors and computing. "Will this be the next AM? We don't know – and that is part of the beauty of it," says Wright.

It is hoped, in time, that the University of Nottingham / BAE Systems trial with cobots at Samlesbury will reduce levels of tooling and increase the flexibility and productivity of the aircraft assembly lines there. The company is also trialling exoskeleton technology for arduous jobs involving people. Much has changed in the world of robotics and automation, Wright notes. "We tended to keep robots separate from people in cages. Now it is about robots working in conjunction with people, not replacing them. We are looking at some novel technologies that enhance the ability of individuals, such as exoskeletons.

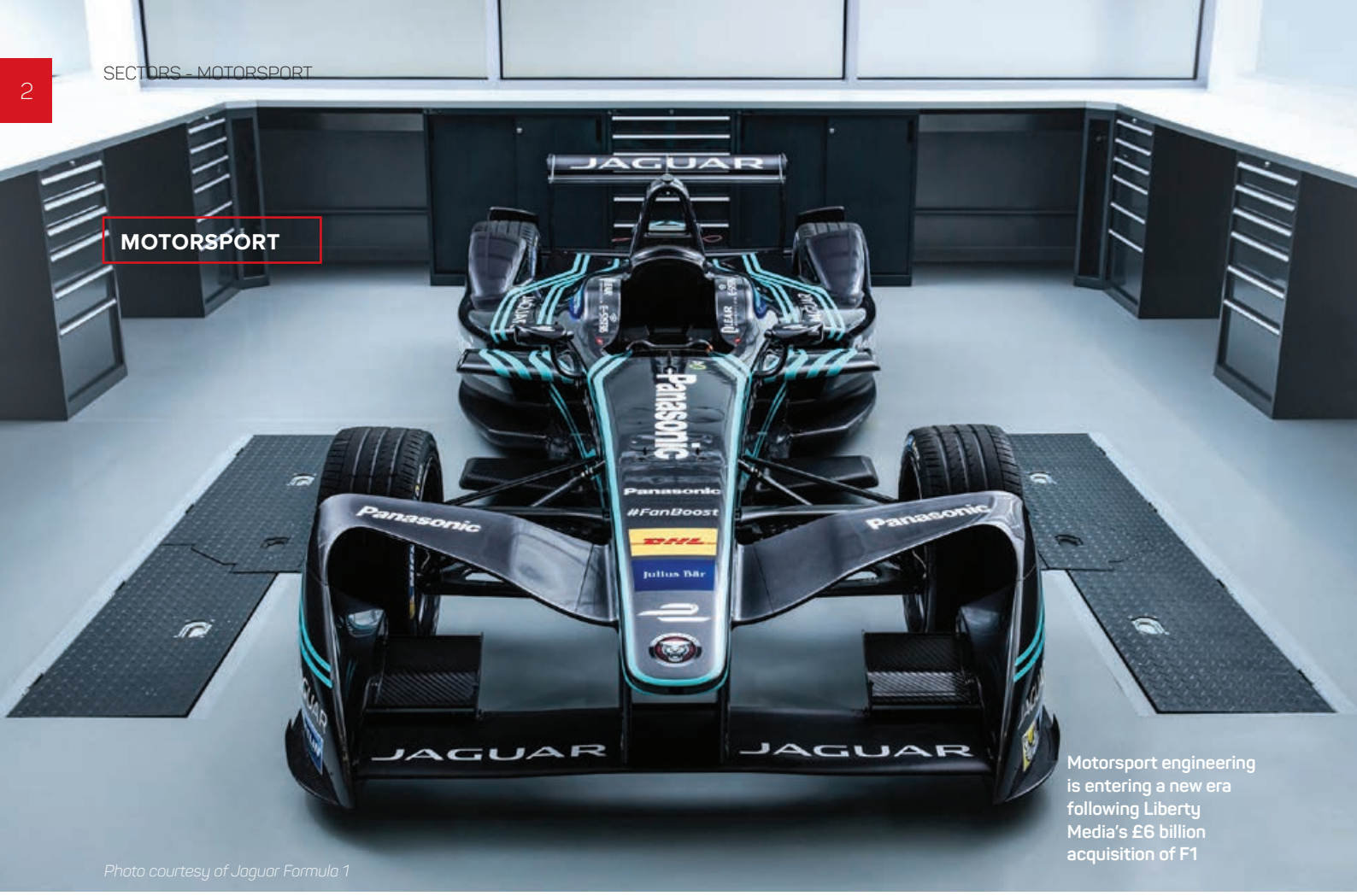
"We are trialling them in maritime, for instance, for heavy lifting on docksides."

BAE works in a range of businesses – land, maritime, air, and cybersecurity – that have different lead times and technology solutions. Information is shared across these divisions, but submarine design and manufacture evolves at different pace to cybersecurity and applied intelligence. People are crucial, however, to effective development of technology – whichever part of the business they work in. Wright says: "It is one thing to write something down about a piece of technology – it is another to understand it in-depth. So we recognise those people." BAE, while taking care to patent and protect its commercial interests, also disseminates that knowledge through the supply chain and among the academic community. "We ensure there is a greater depth of understanding in the supply chain about what we do," Wright says. "The repository of knowledge is broader than the people in our business. And there is much more sharing of information than there used to be."

Cyber security moves very quickly, and BAE works with organisations such as CyLon – Cyber London – an incubator and hub for tomorrow's cyber security companies. "We have problems, and we want to explore the solutions base very broadly. For the SME community, it means money to develop ideas, plus a potential channel to exploit them. It is a win-win." The timescales in cybersecurity are different to aerospace, but BAE has to be fleet of foot in all areas to keep up with developments.

"The way we approach research and innovation varies depending on the domain," Wright concludes. "But the fact is, working with SMEs and universities is crucial to new technology and innovation, and cuts across the whole of the business." MR

MOTORSPORT



Motorsport engineering is entering a new era following Liberty Media's £6 billion acquisition of F1

Photo courtesy of Jaguar Formula 1

THE MOTORSPORT INDUSTRY – A PROTOTYPE FOR UK MANUFACTURING?

The UK's motorsport industry is often said to be the jewel in the crown of British manufacturing. But how can the creativity, innovation and 'can do' attitude of the sector be harnessed and used as a catalyst for wider economic growth? St John White reports

THIS ARTICLE EXPLAINS:

- Motorsport industry is innovative, with a 'can do' culture
- The MIA is already facilitating technology transfer into other sectors
- Skills shortages in motorsport are chronic
- Change in ownership of F1 heralds new era
- Motorsport suppliers neglecting to protect IP

Due to its complex and diverse nature, straightforward statistics on the size of the UK motorsport industry just don't exist. However, according to research by the Motorsport Industry Association (MIA), the body that represents around 400 businesses involved in the sector, annual revenues from the sport have now reached £10.5 billion. While this figure does include income from the entertainment, advisory and service industries, approximately £5 billion comes from manufacturing anything from F1 engines to on-board fire extinguishers.

Employing more than 25,000 people in the UK, the motorsport engineering sector offers a remarkable template for other specialist sectors within manufacturing. Granted, the fact that 75 per cent of manufactured goods are exported and the industry has continued to grow at a rate of five per cent per annum despite the recent global economic downturn, is impressive. But what really stands out is the motorsport industry's ability to constantly innovate.

Fast-growing motorsport engineering firm KWSP has increased its revenues by 60 per cent for the past two years

"Motorsport is definitely part of the company's DNA, but our future growth will probably come from harnessing the full potential of horizontal innovation"

Keiron Salter

THE MOTORSPORT INDUSTRY'S DNA

This remarkable ability to develop cutting- edge technologies, season after season, is a key element of the industry's DNA that deserves more consideration, according to Chris Aylett, chief executive of the MIA.

He believes much of this success is down to the constant need for new solutions to meet sporting regulation changes and the competitive imperative. He says: "While the majority of project deadlines, in wider industries, are allowed to slip to accept technical glitches, motorsport suppliers don't have this luxury. If the car isn't ready, on time, on race day, you simply won't make it onto the grid and you won't get paid! It is this uncompromising reality that has created such as strong 'can do' culture within motorsport engineering."

Hungry for new ideas and technologies with which to bring victory, the sector has embraced the mantra of horizontal innovation more enthusiastically than others. Aylett explains: "Horizontal innovation is a new term to describe what motorsport has been doing for years; seeing which industries are pushing the technology envelope and learning from them. A typical example would be the use of computation fluid dynamics (CFD), pioneered in aerospace but subsequently adopted by F1 and the motorsport community. Interestingly, this flow of knowledge goes both ways, with technologies developed in motorsport creating valuable new revenue streams for UK manufacturers."

One such business, which has leveraged its race engineering experience to enter new markets, is Motorsport Valley-based KWSP. This fast-growing SME has increased its revenues by 60 per cent for each of the past two years and has undertaken several projects in 2016 that have used CFD and light weighting techniques first used in F1.

Kieron Salter, managing director of KWSP, says: "Motorsport is definitely part of the company's DNA, but our future growth will probably come from harnessing the full potential of horizontal innovation. This ability to think more creatively about engineering problems by employing technologies used in different sectors is what makes us different.

"While we've used our motorsport knowledge to solve problems in a range of sectors, it's not all one-way traffic. We have employed knowledge gained from other sectors to inform our problem-solving for motorsport too."

Looking ahead to 2017, Aylett believes the momentum for horizontal innovation will continue to gather pace. "We enjoy active support from our partnership with the Institute of Engineering and Technology (IET) for our work in this area, conducting key conferences and events to spread the message to the motorsport and wider manufacturing sectors in the UK."

MORE JOBS THAN SKILLED PEOPLE

Tempering this drive for growth, however, is the persistent niggle that there are more jobs in the British motorsport industry than there are skilled people. According to MIA statistics from 2013, 36 per cent of UK motorsport companies said they had vacancies they could not fill. And this situation has not improved since then.

While F1 teams talk about a lack of skilled engineers and poor job market mobility due to the rise of long-term contracts,

Photo courtesy of KWSP

Skills shortages are chronic in UK motorsport engineering, with a third of firms saying they have vacancies they cannot fill

it's further down the supply hierarchy where the challenges are most evident.

Simon Dowson is managing director at Delta Motorsport, which is based at Silverstone. He claims that being so close to the F1 epicentre is hampering his business's ability to recruit good people. "The emphasis on motorsport within university and college courses has actually created a generation of graduates who won't consider a job interview unless it's from an F1 or Le Mans team.

"Students need to broaden their thinking and consider opportunities that will challenge them and help them to develop their engineering and problem-solving skills. While 30 per cent of our work is still within motorsport, the vast majority of our income is now derived from other sectors. We need to encourage new blood into the motorsport industry, but there is more than one door."

Despite the challenges of skills shortages, the future continues to look bright for the UK motorsport industry. With a strong track record of year-on-year growth, the majority of suppliers to F1, Le Mans, WRC and NASCAR are bullish about the future.

Bridgnorth-based Grainger & Worrall, which designs and manufactures high performance castings for F1 and NASCAR, is another business that benefits from its motorsport links.

James Grainger, joint managing director of the business, says: "We count ourselves as incredibly lucky to be at the heart of such a vibrant and challenging industry. We continue to see revenues from F1 and associated motorsports grow in line with our investment in new technologies. We also see significant opportunities through the 'halo effect' such an association brings. While we have invested about £3 million in our company every year for the last five years – in CT scanning, additive manufacturing and real-time X ray technologies – this commitment to excellence has created new opportunities for us in other high performance automotive markets. "Our involvement in motorsport has acted as a springboard that has helped us win new business from a range of prestige automotive marques and diverse markets such as defence and aerospace."

The MIA's Chris Aylett is convinced the future of the industry could be even

"The majority of project deadlines, in wider industries, are allowed to slip to accept technical glitches: motorsport suppliers don't have this luxury. If the car isn't ready, on time, on race day, you simply won't make it onto the grid and you won't get paid! It is this uncompromising reality that has created such as strong 'can do' culture within motorsport engineering"

Chris Aylett, Motorsport Industry Association

more bright, if more focus was given to the export efforts of the UK supply chain. He said: "The air of uncertainty following the impact of Brexit is an unhelpful red herring. It will be, at least, three years before we leave the EU – a long time for most SMEs. In that time, there will be many changes in the wider business economy and motorsport suppliers need to be ready to benefit from those changes.

"Our export sales could increase by at least 20% in that period if, with government support, SMEs get out into the markets and take full advantage of the exceptional exchanges rates we're seeing right now. We're already an export-driven sector, so this is a golden bonus opportunity for us to drive even more growth in international markets. There's never been a better time to boost exports."

Aylett is passionate about this immediate export opportunity and wants urgent help from the new Department for International Trade to help SMEs to take advantage of this unique opportunity. "The UK is a long way from meeting the Government's optimistic target of £1 trillion of exports by 2020, but the motorsport industry is in pole position to help them do so. We're already very active in the USA, Asia and across Europe – but can achieve far more. and fast. With sensible financial support for export activity in these markets, we could double motorsport exports in the next five years."

LIBERTY MEDIA, F1 AND LIBERALISING MOTORSPORT

While Aylett's predictions may appear over-optimistic, recent developments within the wider motorsport sector provide credence to his argument.

First, the recent change in ownership of Formula 1 – with Liberty Media agreeing to acquire the rights for $8bn over the next year – will dramatically change the business.

Given the hefty price tag associated with buying the F1 race series, the new owners will want to see a speedy return on their investment. They will aim to get more fans to tune in or turn up to the events, which will necessitate a totally different business model from the current, somewhat rigid, regime.

Most industry commentators agree that the 'post-Ecclestone' model is likely to create a much more liberal market, which will be good for the motorsport industry. Moreover, while the changes to the F1 business model are good news for manufactures and suppliers, these positive effects are widely expected to cascade to other corners of the sport such as Le Mans and other high profile series.

Secondly, the growing appreciation of motorsport in fast-growing countries such as China and India provides a huge opportunity for the UK's motorsport industry. As Aylett comments: "Just think about it; collectively these countries account for around half of the population of the world and yet market penetration for motorsport is miniscule currently. The demand for our engineering and expertise is there – we simply need to understand these markets better and start engaging with them now."

While emerging export markets offer new opportunities for UK motorsport suppliers, there are also potential threats, according to David Preece, a specialist in intellectual property (IP) at law firm FBC Manby Bowdler.

His work, predominantly with Midlands-based manufacturers, has highlighted the issue of intellectual property and its protection as a business asset. He said: "As a hotbed of innovation and talent, the motorsport industry is remarkably impassive when it comes to protecting its own IP.

"Be it genuine ignorance of the scope of IP or the assumption that their technology is automatically covered, the fact remains that too few motorsport suppliers are protecting their intellectual property. This low awareness and use of IP protection could also be down to the industry's incredible pace – meaning that engineers are often onto next season's developments, giving them little time to consider the IP that may reside in technologies that were implemented last season."

He concluded: "Given the dynamic nature of the motorsport industry, and the potential for future overseas growth, we're urging management teams to put IP onto the agenda for 2017. Without it, your business could lose out in terms of income and more importantly reputation, should it transpire that inferior counterfeit versions of your product are being illegally manufactured."

It is clear that the UK motorsport industry is doing a lot of things right. Innovating, sharing technologies across sectors, exporting UK engineered products and acting as a best practice model for many high value manufacturers. While the new government reassesses its industry strategy in the light of Brexit, it would do well to consider which niches within UK industry are in pole position, such as motorsport, which are ready to give them support to maximise their commercial opportunity. MR

UK MOTORSPORT INDUSTRY BY NUMBERS

£9 BILLION
annual turnover

4,500
companies involved in the UK motorsport and engineering industry

87 PER CENT
of these firms export their products or services

Average motorsport R&D spend is
25 PER CENT
of turnover

Read more about motorsport manufacturing on pages:
64
193

REARVIEW MIRROR

Top motorsport manufacturers look back on 2016

NEWS IN BRIEF

"Titan has enjoyed 20 per cent growth this year, with the main areas of growth occurring from motorsport and automotive projects. In addition, we've been busy investing in new products and services including a new range of engine products, carbon fibre production parts, and a whole vehicle engineering project"

Zoe Timbrell, marketing manager, Titan

"The business is still embryonic, but has shown impressive growth since its foundation. Starting with one project, the creation of the Jaguar C-X75 hybrid supercar, the business now has more than 40 projects on the go with approximately 20 different customers. The business now employs around 200 people, double the figure of two years ago. It has reported revenues of £21 million for the first six months of 2016, double the figure for the same period in 2015"

Paul McNamara, technical director, Williams Advanced Engineering

"2016 has been a very successful year for Prodrive both in motorsport and with our advanced technology clients in the automotive, aerospace and marine sectors. Our focus now turns to 2017 and the Land Rover BAR entry in the Americas Cup. If our technology can contribute to bringing the trophy home to Great Britain, we will be celebrating as if we had won the cup ourselves"

David Richards, chairman, Prodrive

"2016 has seen the highest level of investment into research and development in the company's history, as we develop new safety products for new categories and markets. The world governing body of motorsports' commitment to make the sport ever more spectacular and safer pushes our business to be even more innovative and dynamic. Over the last year, we've seen a 10 to 15 per cent increase in revenues from motorsport, taking on three extra people, which represents a 9 per cent increase in staffing levels"

Jim Morris, managing director, Lifeline Fire & Safety Systems

"In 2016 we launched our latest family of gearboxes, developed for that exclusive segment of the global car market focused on ultra-high performance supercars. The P1227 series has been developed to meet the growing need for lightweight, power-dense electric vehicle propulsion systems. These developments will help further boost the company's burgeoning exports, which have increased year-on-year to currently account for an impressive 77 per cent of our sales turnover"

James Setter, head of Xtrac's automotive & engineering business unit

"Despite the economic uncertainties of the last 12 months, we've seen continued demand for our race simulators, both here in the UK and overseas. Simulation is no longer the preserve of F1 drivers – so we're optimistic about 2017 and beyond"

Darren Turner, founder and CEO, Base Performance Simulators

"Over the next five years we will see more changes in the automotive world than in the last three decades. The FIA Formula E championship will enable us to engineer and test our advanced technologies under extreme performance conditions. We will apply this vital knowledge as part of our real world development. At Jaguar Land Rover we employ 9,000 engineers and the team will draw on these engineers to extract data and push the boundaries of electric technology in a race environment"

Nick Rogers, executive director, product engineering at Jaguar Land Rover

"Having won the six-year tender for chassis component supply to the BTCC, we introduced a new kit for 2016 which has broken lap records, reduced weight and improved reliability. Uptake by more than 80 per cent of the grid was achieved by us going that extra mile in terms of customer support. Elsewhere, our Chevrolet Cruze World touring car has won races against the factory backed competition as well as proving very reliable. This positive ethos has also enabled us to expand into new sectors such as automotive, classic restoration and defence"

Simon Holloway, commercial director, RML

"While we have invested about £3m in our company every year for the last five years this commitment to excellence has created new opportunities for us in other high performance automotive markets. Our involvement in motorsport has acted as a springboard that has helped us win new business from a range of prestige automotive marques and diverse markets such as defence and aerospace"

James Grainger, joint managing director, Grainger & Worrall MR

OFF-ROAD POWER

The British Touring Car Championship has attracted millions of fans since its inception in 1958. The concentration of UK motorsports engineering irms serving BTTC and Formula One, dubbed 'Motorsport Valley' to the cluster of firms based around the Midlands and Oxfordshire.

These companies supply cutting-edge technology to F1 and dominate the design and manufacture of components used in the majority of the world's racing categories today.

Shropshire's Grainger & Worrall provides high quality castings to motorsport and automotive

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John McDonnell MP, Shadow Chancellor of the Exchequer


Martin Wolf CBE, Associate Editor and Chief Economics Commentator at the Financial Times


Alison Rose, CEO Commercial and Private Banking, NatWest


Vicky Pryce, Economist, Board Member at Centre for Economics and Business Research


Jo Malone MBE, Entrepreneur


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- The Conference will take place just weeks ahead of the expected decision to trigger article 50, putting the UK on the road to leaving the EU – This is your chance to influence senior decision makers and have your say.
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Automation is dishing up solutions for food and drink but uptake of robotics is sluggish in the sector

FOOD & DRINK

EU VOTE CHILLS OUT FOOD AND DRINK

The shadow cast by exit from the EU has chilled much of the cost-sensitive food and drink industry, while many exporters have been bolstered by the weaker pound. Meanwhile, consumer enthusiasm for high-protein, sports nutrition and free-from is creating opportunities for start-ups, SMEs and larger businesses alike. By Paul Gander

THIS ARTICLE EXPLAINS:

- Brexit a real concern for food and drink sector
- Third of workforce made up of non-UK EU nationals
- Manufacturers call on the Government to ensure workers are retained
- Skills gap looming for food and drink
- Automation making some progress in sector

If there was trepidation in the UK food and drink sector before the June 2016 EU referendum, the result left even more uncertainty in its wake.

Food & Drink Federation (FDF) competitiveness director Angela Coleshill says: "Our recent survey on the impacts of the EU referendum showed that 70 per cent of businesses are now less confident about the UK's business environment. The main concerns for manufacturers were increasing ingredient prices, a drop in profit margins and worries about the future status of non-UK EU workers."

As she points out, the drop in the value of the pound from the summer onwards might have allowed UK exports to become more competitive, but it also triggered a significant rise in the price of essential imported ingredients such as nuts, spices and cocoa. For many manufacturers, the impact of any new restrictions on immigration from other EU member states could be dramatic.

"As an industry, we employ almost 116,000 non-UK EU nationals who make up 29 per cent of our sector's

workforce," says Coleshill. "Firstly, we need clarity on the future status of these employees to ensure they have the right to remain once the UK has left the EU. Secondly, the government must develop a new migration policy that ensures food and drink manufacturers have continued access to the workers it needs."

In November, the Association of Labour Providers, representing agencies providing temporary labour up and down the supply chain, said the labour shortage was the worst it had been for 12 years, affecting agriculture and logistics as well as manufacturing.

The problem for the industry is not only that it is disproportionately dependent on overseas labour in general but that it is, simultaneously, suffering from a chronic shortage of industry-specific skills. "We have a looming skills gap, and will need 130,000 new recruits by 2024," Coleshill points out. "While we are making a concerted effort to develop home-grown talent through ambitious graduate and apprenticeship programmes, EU workers provide a highly-valued solution to that skills gap."

ON THE ACQUISITION TRAIL

Surprisingly, perhaps, the uncertainties around Brexit did not kill off merger and acquisition (M&A) activity in the food and drink sector. Head of the food team at Rollits solicitors, Julian Wild, highlights the unsettling effects of the referendum result. "These have created a climate where business owners are saying that, if we are going to sell, we had better get on and do it," he explains. "At the same time, purchasers sitting on a mountain of cash earning no interest have decided that M&A is the way forward."

Examples included premium crisps brand Tyrrells, which was sold by owner Investcorp to Amplify Snack Brands for £300 million: three times what the Bahrain-based investment company paid for the brand just three years ago. The sale to a US company demonstrates the continued interest of foreign investors and brand-owners in the UK industry. The second half of 2016 saw the sale of well-known poultry brand-owner Bernard Matthews to the owner of the 2 Sisters manufacturing operation, Ranjit Singh Boparan.

Yogurt producer Lancashire Farm Dairies is expecting to benefit from increasing sales of drinks such as its Lassi range once the sugar tax comes into force

THE MARMITE EFFECT

October 2016 saw a high-profile stand-off between two of the biggest players in food manufacture and retail respectively: Unilever and Tesco.

The Brexit-driven drop in the pound's value had prompted Unilever to push for a 10 per cent increase in prices for many of its food and other brands, including Marmite and PG Tips tea. When Tesco refused to make the change, Unilever stopped supplying the retailer.

In this case, the multinational brand-owner blinked first, agreeing to resume supply to Tesco. But within days, Morrisons had upped its own in-store prices of Marmite by 12.5% per cent, and industry insiders predicted that higher costs associated with imported ingredients would continue to have an impact on manufacturers and the retailers they supply.

Julian Wild, head of the food team at law firm Rollits, comments: "In food we are heading into a period of significant inflation, which the retailers will try to resist – but can't, despite Tesco's temporary success with Unilever."

Wild says: "Tyrrells ticks nearly all the right boxes, except for health: good quality, premium, snacking, fast growth, good profitability, a focus on export, international potential and a recognised brand. Rare businesses like that will always sell for a multiple of turnover rather than profit."

He described the Bernard Matthews deal as being at "the opposite end of the spectrum". "This is a very traditional turkey business with a brand which is quite dated, with complex vertical integration, which went through a failed turnaround, ran out of cash – and was about to go bust, with a big pension liability," he says.

GRADUAL INTRODUCTION OF ROBOTS

The introduction of robotics, like automation more generally, into the food and drink industry has been a gradual – and at times rather half-hearted – process. But 2016 saw a significant step forward with the launch of the Automated Processing Robotic Ingredient Loading (APRIL) system, developed by OAL and installed for the first time at the National Centre for Food Manufacturing (NCFM) at the University of Lincoln's Holbeach campus.

"What we are trying to do is employ the robot for materials handling, mixing, blending, homogenisation, cooling and so on," says OAL managing director Harry Norman. This contrasts with typical food industry use of robots to date which, with rare exceptions, has focused on end-of-line operations such as palletising.

One billion litres a year: Arla's vast fresh milk facility at Aylesbury has the ability to process one billion litres a year. It is the world's largest dairy operation of its kind and was built to support Arla's long-term strategy to increase the volume of milk being processed in the UK and support Arla's significant growth plans for its largest market

Used on a large scale, the robots move product to and from the different processes, including OAL's own steam infusion heat process. "Traditionally, all the different pieces of equipment would be linked together in a relatively inflexible way," says Norman. "We're trying to make it flexible and programmable."

"With existing processes, most of the equipment tends to be used relatively inefficiently," says Norman. "Overall Equipment Effectiveness (OEE) in chilled foods can be as low as 30 per cent. What's more, while ingredient wastage in a traditional, batch production process might run at around 5-9 per cent; with APRIL, the typical figure is more likely to be 1-2 per cent."

Steve Osborn, principal consultant at innovation and technology scouting partnership Aurora Ceres, says: "The marketplace wants more products, more variety and less processing for those products. The way to do this is to go back to a batch process where the robot is almost like a chef looking after each product."

He adds: "Manufacturers are only able to start thinking about taking this approach in conjunction with Industry 4.0 and the Internet of Things (IoT), with the uplift in productivity it is likely to bring."

Meanwhile, the NCFM's head of research Mark Swainson puts the APRIL development in the context of a wider shift in attitudes towards robotics in the industry. "It is to do with the reducing price of the technology and its increasing user-friendliness, but also to do with challenges around efficiency and productivity, labour availability and the National Living Wage (NLW)," he says.

"The marketplace wants more products, more variety and less processing for those products. The way to do this is to go back to a batch process where the robot is almost like a chef looking after each product."

The NLW came into force in April 2016 and was expected to hit smaller businesses and the horticulture segment especially hard. It is no coincidence that one of the NCFM's projects has centred on the robotic harvesting of broccoli, assisted by machine vision. Another area of innovation in robotics has been the collaborative robot, or 'cobot', which, unlike traditional systems, allows workers to operate in the same space, protected by sophisticated vision and sensing. The last couple of years have seen cobots enter the mainstream. This year, for example, Fanuc launched its 35 kilogram-payload CR35iA system.

Robotic handling is already accounting for significant capital expenditure in food and drink. In the summer of 2016, 2 Sisters Group announced a £45m investment in robotic poultry processing at its Scunthorpe site, increasing the factory's capacity by a third and taking it to 2.4m birds a week.

INVESTMENT AND INNOVATION

But investment is not restricted to the largest operations. Yogurt producer Lancashire Farm Dairies this year took delivery of new fermentation and filling plant for drinking

yogurts worth £1.5m. Managing director Azhar Zouq says: "We can expand still further, if demand continues to rise. The market for drinking yogurts has already improved compared with, say, five years ago, and overlaps areas such as protein milk drinks, skyr drinks, as well as products such as lassi, ayran and kefir."

Zouq specifically links this opportunity with regulatory and consumer trends. "With the sugar tax due to take effect from 2018, and with consumer tastes shifting, we believe that drinking yogurts will constitute a growth area for us."

Fruit juices and milk-based drinks are due to be exempt from the levy, but it is expected to have an impact on sales of other types of soft drink. Mintel research during 2016 quoted 53 per cent of carbonated soft drink consumers in the UK saying they would cut back or stop drinking these products if the 'sugar tax' put prices up by 24p per litre.

Meanwhile, many high-profile brands are already moving into the low-sugar and sugar-free area, with launches during 2016 including AG Barr's Irn-Bru XTRA, and Lucozade Zero, the latter backed by a £5m advertising campaign. Advertising also took the trend towards high-protein products into the mainstream when Arla Foods built confidently on the single flavoured quark-based product launched in its protein dairy range just a year earlier.

"Our initial focus was on a gym and fitness audience," says Arla Protein brand manager Steph Barker. "But as protein has become a trend in everyday life, the range has evolved into drinks, snack pots and cottage cheese. The move to a wider audience was confirmed in October 2016 with the first Arla Protein TV advert."

Most commentators agree that many of the negative effects of pre-Brexit uncertainty. alongside the positive impact for exporters of the pound's lower value, will continue into 2017. Coleshill at the FDF says: "Our recent survey showed that some companies are delaying investment, particularly due to exchange rate volatility, and there are certainly concerns for the future, with uncertainty regarding the terms [to be] negotiated for the UK's EU exit."

In certain key areas, though, investment is going ahead. Norman at OAL says that his company's APRIL system of robotics-led batch production will see the opening of its first installation on the greenfield site of an undisclosed manufacturer during 2017. Robotics and wider automation will constitute a growing slice of capital investment elsewhere as the affordability and availability of labour decrease.

But while life may be harder for those reliant on overseas supplies of labour or raw materials, expect to see more foreign acquisitions. "With the currency at such a low, the UK has become a really attractive place to buy into," says Wild at Rollits.

In terms of products, 2017 will see continued innovation in areas such as free-from and high-protein. Arla Foods, for example, says it has plans to expand its protein range still further during 2017.

As the 2018 horizon approaches for the UK's first levy on high-sugar soft drinks, activity in reduced-sugar and sugar-free alternatives will increase still further, with the availability of heathier options becoming a growing differentiator for brand-owners and retailers alike. MR

MINIMISING PROCESSING FOR DRINKS AND 'BAKERY'

Steve Osborn, commercial director at innovation and technology scouting company Aurora Ceres, rightly identifies consumer interest in reduced processing, and, potentially, enhanced nutrition, as an important trend.

As he explains, high-pressure processing (HPP) has already had a strong influence on the beverage sector, despite continued severe limitations on the global availability of this technology. Early in 2016, Aurora Ceres broke the news that it was helping to develop a cold process technology in a very different sector: baked goods.

ColdBake is based on combined innovation in the areas of processing and formulation. A honeycomb-type matrix can be produced at temperatures typically close to that of the human body, while importantly preserving the benefits of key functional or nutritional ingredients or possibly, for example, medication for kids.

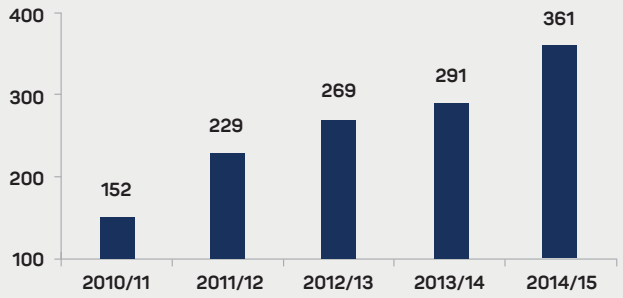
But Osborn says: "We have been working to find partners with which to commercialise ColdBake this year. But unfortunately, it seems easier to invest in products, because they are tangible, while investment in a fledgling technology is often seen as a high-risk strategy."

Read more about food and drink manufacturing on pages: 74 120

HOT CATEGORIES IN FOOD AND DRINK

NEWS IN BRIEF

NUMBERS OF NEW MICRO-BREWERIES



Source: HMRC/UHY)

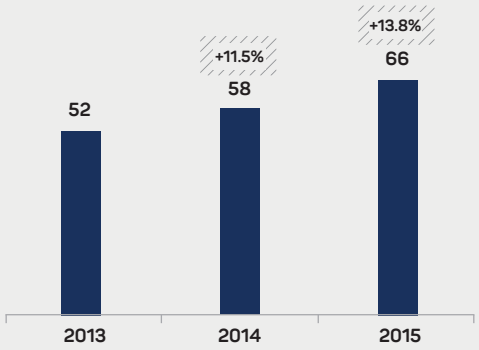
CRAFT BEERS

- Reporting on HMRC applications to open new breweries, accountancy firm UHY notes a near-trebling in the five years from 2009/10
- The year 2013/14 to 2014/15 alone saw a 24 per cent increase in new openings
- The Small Breweries Relief Scheme, introduced in 2002, offers tax relief for businesses brewing less than 10.6 million pints annually, says UHY
- Research by Mintel shows that 59 per cent of those buying alcoholic drinks say that industry needs to define what is meant by 'craft drinks', while 30 per cent say they themselves do not understand what the term means
- In July 2016, the Society of Independent Brewers launched its 'Assured Independent British Craft Brewer' marque in an effort to anchor the sub-category firmly to 'small brewers rather than large corporations'.

SPORTS NUTRITION

- The amount UK consumers spent on sports nutrition products rose by 27 per cent between 2013 and 2015, from £52m to £66m, according to Mintel
- 24 per cent of all consumers, and 42 per cent of those aged 16-24, consumed a sports nutrition product during the second quarter of 2016
- 31 per cent of consumers with household incomes of £50K or over used a sports nutrition product during the same period
- 64 per cent of those in the £50K-plus income bracket say they exercise for 30 minutes more than once a week, the same proportion as for 16-24-year-olds; 50% of the general population make the same claim
- The number of food and drink products launched with a high-protein claim rose by 97 per cent between 2014 and 2015, and by a staggering 498 per cent between 2010 and 2015.

VALUE SALES AND ANNUAL RATES OF GROWTH OF SPORTS NUTRITION FOOD AND DRINK THROUGH SELECTED RETAILERS, 2013-15



FREE-FROM FOODS

- UK sales of free-from foods are forecast to grow 13 per cent in the year to 2016 to reach £531m, up from £470m in 2015, says Mintel. It predicts sales to reach £673m by 2020
- In the second half of 2015, 33 per cent of UK consumers bought or consumed free-from products, with 22 per cent specifying gluten-free, 19 per cent dairy substitutes, such as soya cheese or milk, 16 per cent wheat-free and 16 per cent lactose-free
- Growth is set to continue, with 48 per cent of those consuming or buying these products saying they are likely to consume more of them over the current year
- 27 per cent of consumers say that they or someone in their household avoids certain foods as part of a general 'healthy' lifestyle, as opposed to 16 per cent who link avoidance to an allergy or intolerance
- The health 'halo' around these products is not unconditional, with 54 per cent of those consuming free-from saying they would stop if they thought those products were less healthy (for example, higher in fat or sugar) than the standard alternative. MR

VALUE RETAIL SALES OF FREE-FROM FOODS IN THE UK, 2010-20

	Total £m	Index	Percentage Annual change
2010	221	47	na
2011	244	52	+10.4
2012	271	58	+11.1
2013	317	67	+17.0
2014	380	81	+19.9
2015 (est)	470	100	+23.7
2016 (fore)	531	113	+12.9
2017 (fore)	564	120	+6.3
2018 (fore)	600	128	+6.3
2019 (fore)	636	135	+6.1
2020 (fore)	673	143	+5.8

Source: Mintel

A FRESH APPROACH TO TECHNOLOGY

J.R. Watkins saves over half a million dollars by choosing Infor CloudSuite Food & Beverage

infor™

HIGHLIGHTS

- Natural apothecary firm improves operations with the upgrade to cloud-based ERP system.
- Company eliminates $210,000+ in hardware refresh costs and bolsters IT footprint.

Since 1868, J.R. Watkins has been America's natural apothecary manufacturer, offering diverse lines of personal care, home care, remedies, and gourmet extracts and spices. After a decision to shift the business model to focus on large retail and wholesale customers, the company sought to modernise its aging IT portfolio to optimise speed to delivery for its customers, while also maintaining heightened quality management.

By selecting Infor CloudSuite Food & Beverage, powered by Infor M3, the company was able to achieve a noticeable improvement in functionality and performance value that allows them to better manage everything from procurement to manufacturing to distribution. By upgrading from the existing on-premises enterprise resource planning (ERP) system to a cloud-based model, J.R. Watkins was able to enhance daily operation without sacrificing business continuity.

RAPID IMPLEMENTATION PERIOD

In addition to benefiting from a rapid implementation period and staying significantly under budget, the move to the cloud eliminated more than $210,000 in hardware refresh costs, and saved almost $320,000 in technical IT resources that support the Infor applications.

"Before upgrading to Infor CloudSuite, J.R. Watkins relied upon a heavily patched and modified ERP, which while capable, had become difficult to manage with age. By upgrading to a cloud-based solution, they are better able to improve certain processes while reducing the ongoing costs of an on-premises deployment, J.R Watkins has significantly bolstered their IT footprint through this implementation, and the core benefits should significantly improve process value and generate a strong return on investment." says Mike Edgett, industry & solution strategy director, process manufacturing, Infor. MR

SAVINGS AT J.R. WATKINS THANKS TO INFOR SYSTEM

$212,529–Eliminated in hardware refresh costs, including servers, virtual environments and racks

$61,342–Eliminated in database administration costs

$318,548–Saved in technical IT resources that support the Infor applications, including database administrators and systems/OS/server administration

$208,428–Saved in upgrade costs, thanks to cloud deployment

"The total cost of ownership study we did with Infor's Value Engineering team allowed us to create a very convincing business case that demonstrated how going to the cloud would save us a lot of capital cash and a lot on the expense side as well.

We saved about a half-million dollars by choosing Infor CloudSuite Food & Beverage. Without our engagement with Infor's Value Engineering, we would have likely never moved to the cloud."

Scott Iverson,
IT Director, J.R. Watkins

About Infor: Infor builds business software for specific industries in the cloud. With 15,000 employees and over 90,000 customers in more than 170 countries, Infor software is designed for progress. To learn more, please visit **www.infor.com**

In association with

THE INFOR FOOD AND BEVERAGE ROUNDTABLE

COMPLIANCE, TRACEABILITY AND SUSTAINABILITY

From left to right: Greg Woodhead, Simon Roberts, Jennifer Douglas, Andrew Dalziel, Nimisha Raja, Robert Lucas, Gavin Milligan, Neil Lloyd, James Sage, Chris Pooles, Ian Bamford, Philip Green, Ruth Harknett, Tim Robinson, Jen Harley, Will Stirling

Andrew Dalziel (chair), senior director responsible for industry and solution strategy, Infor

Will Stirling, Stirling Media

Chris Pooles, BDO, head of the manufacturing team for the Thames Valley

Greg Woodhead, British Bakels, product development manager

Simons Roberts, Roberts Bakery

Neil Lloyd, FBC Manby Bowdler, sales director

Julian Hunt, Coca-Cola Enterprises, head of public affairs and communications

Ian Bamford, commercial director for the Centre for Industrial Sustainability

Ruth Harknett, Infor, marketing director

Gavin Milligan, William Jackson Food Group, group sustainability director

Philip Green, British Bakels, chief information officer

Jennifer Douglas, Jacobs Douwe Egberts, business development and planning manager

Tim Robinson, Lantmännen Unibake UK, managing director

Dr Helen Munday, Food and Drink Federation, chief scientist

Jen Harley, Infor, UK marketing manager

James Sage, FBC Manby Bowdler, partner and head of corporate

Nimisha Raja, Nim's Fruit Crisps, owner

Rob Lucas, British Bakels, chief financial officer

Will Stirling: In terms of compliance and traceability, there was a horsemeat scandal in 2013 – and then a lot more focus on labelling, traceability, and problems regarding food.

What are your opinions on labelling? Are there changes coming, and are they positive? Are you aware of the Food Information Consumers' legislation? I am not even sure whether that will still apply when we trigger Article 50.

Dr Helen Munday (HM): Helen Munday, Food and Drink Federation: The Food Information To Consumers Legislation – for the majority of companies – came in nearly two years ago. It's the smaller companies, those that didn't previously provide nutrition information on-pack, that it is just starting to apply to. I assume most of the companies around this table will already have adapted their labels in response to its requirements. For the first time, there was mandatory nutrition labelling. From a UK perspective, we led the world in providing nutrition information on-pack. You might have assumed nutrition labelling was already mandatory. We were having discussions about front of pack labelling and various other things well over a decade ago. But if you picked up a product you might have seen there was actually nutrition labelling.

So, who knew that you didn't have to


Helen Munday, Food and Drink Federation


James Sage, FBC Manby Bowdler


Jennifer Douglas, Jacobs Douwe Egberts


Robert Lucas, British Bakels

have nutrition labelling? But you didn't, until two years ago. Now even the smaller companies need to have it. There was a different way of labelling allergens. Instead of pulling them out in a separate box, you made them bold, or italicised them. For a lot of people, the Food Information To Consumers Legislation is standardising information on-pack. There wasn't too much guidance for companies making the changes, actually. It used to come from Defra, which is the body responsible for that. But the Food and Drink Federation often takes responsibility for providing guidance where it doesn't exist elsewhere, in this case on providing food information to consumers.

WS: And are small companies doing this now?

HM: Well, they certainly should be as the December implementation deadline is fast approaching. Theoretically, if you do not comply in time, the trading standards officer, or someone like that, will pick you up on it. Usually you would get a bit of friendly advice to help you implement the required changes.

James Sage (JS): A lot of our clients are smaller than the companies around the table. They are terrified by these new regulations... So they are on the lookout all the time, and trying to make sure they are ahead of the game. They don't want bad publicity, and in terms of the people they are supplying, the auditing is very stringent.

WS: Is there a sense of fear of being punished, and the penalties stemming from the horsemeat scandal? Can it be traced back to that?

JS: I think it is more general. At a time when it is difficult to get a new customer, the last thing you want to do is lose one because you've failed to comply with some regulations.

Nimisha Raja (NR): Generally, I don't think people are scared, but we had someone from trading standards visit a few weeks ago. It made me a bit paranoid, but they were just sharing information. We had a two-hour meeting. What they pointed out was, 'we're not here to shut you down, we just need to guide you'.

One thing that came to light is that we claim to be gluten-free. In fact, we are gluten-free. They said you can only claim to be gluten-free if you extract gluten from the product, not if you are naturally gluten-free. Which is difficult – because all of our consumers say, 'why didn't you tell us you are gluten free?' We are naturally good.

HM: The guidance is about to change again. The Food Standards Agency look after this area of trying to standardise the way gluten is talked about. So we used to be able to say, 'non-gluten containing ingredient, for example' – but you can say gluten-free, as you say, if it's below 20 parts per million. But there are rules around that. The gluten bit is really very tricky.

NR: There's lots of help there. It's not something to be scared of.

JS: People do ask about these things. They know they've got to, or they will lose the contract. Compliance is very important.

Greg Woodhead (GW): Many food companies are moving into 'neutra-ceuticals'. It's not just the ingredients on the label, but the claims they are making for the product; it used to be you had Vitamin C on the label, an ingredient. But if you're saying Vitamin C counts for these health benefits, that's a whole different thing.

Rob Lucas (RL): The nutritional and health thing has been one of the biggest changes for the food industry. That has really changed the way a lot of manufacturers do product, and communicate in the market. Every health claim has to be proved, under European standards. And in order to do that, you have to produce a dossier. If you are not able to provide sufficient evidence to prove it, then you are not able to make the claim.

HM: There are some things like probiotics, which you would have thought would be a proven health claim, that have never really managed to prove the cause and effect. You may see the word 'probiotic' appearing in general third party articles but on a


Simon Roberts, Roberts Bakery

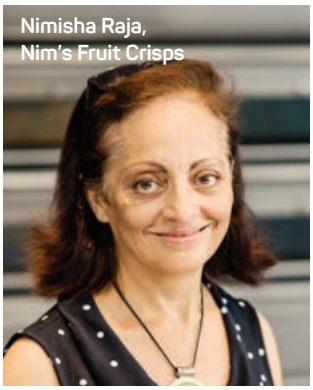
label it is an unapproved health claim. The claims need to be proven. The argument is that this protects consumers – if a product doesn't do what it is suggesting, then this fact needs to be in the public domain. We also have the opportunity when we look at regulations to ask whether the standards were set too high. We now don't know what our relationship with EFSA will be, either. That's the European body with the experts that evaluate health claims and other regulations. No one really expected there to be so few health claims approved, but the process is arduous, costly and slow and on a number of occasions has also been unsuccessful.

GW: The standards are really high, and the burden of proof is set at a judicial level. But they are a reaction to what in certain parts of the EU was a very lax attitude. The pendulum has swung, but it swung a long way the other way. Maybe it will swing back.

HM: If you look at a packet of breakfast cereal, for instance, you will see plenty of claims there, nutritionally, that are very long-lived, and have proven efficacy.

WS: But is the overall sense that in terms of labelling and transparency bureaucracy is higher now? Are not the EU and the FSA piling on unnecessary bureaucracy?
HM: It is well-intentioned.

Andrew Dalziel (AD): If you look in the US at what the FDA is doing, it is similar, and it is around health impacts. Looking at what the ingredients might do – if there's anything that could affect the consumer, cause cancer, for example, or even just obesity.


Nimisha Raja, Nim's Fruit Crisps


Andrew Dalziel, Infor

NR: That doesn't leave much room on the back of the pack to tell your wonderful story.

GW: The costs required to get health labelling approved are vast. Once you've done it, it is open for everyone to make that claim, so unless you are applying for a claim for a product that you patent, or it is something only you know how to make, the incentive to get it registered is rather small. It also limits it to quite large companies. For smaller manufacturers it is difficult to take on the cost. That is why you see proof of health benefits on breakfast cereals. But this is a grey area. It's very easy to claim all sorts of benefits about your products.

NR: Consumers are a lot more informed now. And I think government has a responsibility to protect them.

HM: It's good for consumer confidence that there are standards for nutrition claims. It's good that there are standards for how you reduce fat or sugar, and what you can say. Because if you were only reducing it by 3%, and saying it is 'lower fat', it's pretty random. It is just where you set the bar.

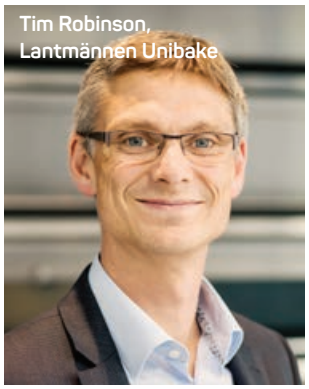
WS: There's only a limited amount of real estate on a piece of food labelling.

NR: If you are exporting, you have to have a lot of labels, which can be a problem. The nutritional values need to be there in every language.

WS: If you are currently in the EU, you are printing seven languages on a standard label now. If you are exporting to jurisdictions outside the EU, presumably you need a different set of labels for each one?

NR: Depending on the export volumes, you would have to.

Jennifer Douglas (JD): But you look to harmonise packaging and inventory where you can. You look where you can standardise on language and labelling, because it is a challenge to include everything when the packaging is small.


Tim Robinson, Lantmännen Unibake


Greg Woodhead, British Bakels


Philip Green, British Bakels


Jen Harley, Infor

AD: You also need to know that all the ingredients are legal in a country. Are you getting flagged up on this ingredient or that ingredient? In terms of supply, it becomes quite complex to manage – all the recipes, all the labelling. It can cause problems.

Ian Bamford (IB): Do any of you get involved with and how far back you go with traceability? We're just embarking on research looking at the business model and finance risk implications changing some of the fundamental protein feed-stocks that feed into the supply chain. When you think about what is in the food and drink supply chain do you go as far back as the feedstock used by farmers?

JD: There are plenty of products where traceability goes all the way back through the supply chain.

JS: Some companies use that as a competitive advantage.

IB: One of the things we are looking at is whether block chain technology that underpins Bit coins might enable us to get far better understanding and verification throughout supply chains.

NR: We make crisps out of fruit. We buy from a supplier and it up to them to have traceability. We don't go all the way back to the farm. It is up to our suppliers to have responsibility for where the product is sourced from. Although, for marketing purposes, we might say 'we buy from this farm'.

WS: So the balance of responsibility lies with you, even though you are in a supply chain.

NR: It is my responsibility to make sure they are responsible, and that they are accredited. And we need to check on that regularly.

GW: That's not forgetting, of course, that Horsegate was the result of deliberate fraud. Since then, the focus has had to be different. There was a presumption of innocence in the past, and there is now, as it were, a presumption of guilt – which has changed what we are expected to do.

RL: Since Horsegate there is much greater level of risk assessment in the supply chain.

JS: But it is a chore to do it. Are you doing it because you're being forced to do it? Or can you turn it into a differentiator? In that case you can provide more information to the consumer to generate trust.

HM: We are working on a lot of guides for our members on food authenticity. We also have one on spices and seasonings, because they are particularly difficult supply chains. Although the horsemeat incident obviously had nothing to do with seasoning and spices, there have been a few issues in the past. The supply chains are global and they are complex, meaning companies have a have risk assessment to identify potential problems. Trade associations and manufacturers are working a lot more closely with the Food Standards Agency. There is a rise in scanning. You can divert the problem before it occurs.

NR: Unless I am on the shopfloor making the product myself every day, I need to be confident that everyone else is following the rules, and that things aren't getting through that shouldn't do. I find it quite comforting that if I achieve this level of traceability, hygiene, and everything else that's involved, we have a product that is trouble-free.

JD: We have to do traceability. It's an important thing, but how can we turn it into a business tool that helps us drive efficiencies in the supply chain? I think we need to look at it as a need, but also an opportunity.

RL: One thing about our industry that marks it out as different is that we don't believe, as a matter of course, that regulation should be reduced. Regulation provides an absolute benchmark that protects consumers. It's always interesting


Chris Pooles, BDO


Julian Hunt, Coca-Cola Enterprises


Gavin Milligan, William Jackson Food Group

in that when you ask people in the food industry what rules you want to get rid, 9 times out of 10 they say 'we don't want to get rid of any of the rules; but can you give us time to absorb the last set, before introducing new ones?'

GW: There is a great deal of stuff blamed on the EU that would have happened at national level anyway. The interesting thing for us is what happens in the two years before Article 50 is triggered. What does that mean for all the regulations we work to? Food regulations, and things that are set as a common benchmark across Europe.

Gavin Milligan (GM): We are going to be trading in a global market: We are not going to suddenly drop all the standards that underpin the quality of the food that we sell. So we have to work to those standards, whatever we may call them, and come what may.

Julian Hunt (JH): I am not sure people would want them to change. For us as a European group, working to commons standards within a legislative framework relieves a huge bureaucratic burden. If we were to operate to different standards to our sister companies, it would be really difficult.

HM: It's all very well people saying: 'we need to do away with nutty European regulations'. There are some standards that are unique to Britain that are very demanding. We have to put some nutrients in bread, and you don't have to do that anywhere else in Europe. It is unique to us.

NR: Isn't that why the British food industry is so well regarded globally?

HM: People say it is the safest country in the world to eat food.

WS: Could we make more of the label, 'Made in Britain?

GM: If there are products that you associate with Scotland, such as whisky, then branding it as Scottish is useful for marketing. If you start wrapping 'Scottishness' around some other categories, then it doesn't work so well. If you talk to people in other parts of the world, they will say that Britishness implies quality. So there is some value there, I think, but you need to do it with care.

HM: If you want to proudly say, 'this is British' because it will reinforce the quality of the product, there is nothing stopping you doing that now, as long as you can substantiate it of course!

GM: We have Jackson's Champion Yorkshire bread, which sells well in Yorkshire partly because it is made in Yorkshire. The Yorkshireness may not necessarily travel beyond the boundaries of Yorkshire but it still sells in other parts of the country because it tastes nice.

WS: If we move the conversation on to sustainability goals, which are important to all companies.... is it hard to balance sustainability with keeping customers happy, and business demands?

JH: There is a core sense that sustainability is the right way to go. It makes business sense, it is right for your employees, it is right for your suppliers. There are measurable, hard business reasons why is it the right thing to do. Increasingly it is about aligning your agenda with customers, and making sure you move in the same direction they do with shoppers and consumers. It is about a whole raft of things we do as a business. The consumer piece is quite tricky, actually.

For some products it is very clear why people choose one product over another: I am thinking Fair Trade, and some of the other indicators. On coffee it is really important, for other categories less so. We look at everything from water usage, to packaging, to energy consumption. The CO2 footprint of our packaging, through to our people, through to our suppliers. It is increasingly important for those of us in the trade and for shoppers. We're on the Dow Jones Sustainability Index, which is a pretty good indication you are doing the right things.

GW: There are some major international brands that are choosing to remove palm oil from their products. When we are asked to supply those solutions it is our responsibility to support them. The reasons for doing it are legion. Palm oil is undoubtedly having an effect, and it is the responsibility of the food and drink industry to have a wider view on our choices globally – it is good for food and drink, and personal care too. I've been in the food industry long enough to see when hydrogenated fats were banned, and there was a wholesale move to palm oil in the European food industry. So we moved from what was a dubious, scientific, health problem, to an environmental problem.

WS: Palm oil seems to have come off the radar somewhat. It has come off the public radar.

GM: It coincided with other things that were closer to home. I think that's pushed it off front pages: food waste being a case in point. It is waiting to explode again.

GW: The food industry is petrified to speak up on it. We are restricted on what we can say. No one speaks up, because no one can break ranks.

WS: Is it hard to communicate what you are doing in terms of sustainability?

JH: We wouldn't necessarily communicate things on pack. We have PlantPET, a renewable plastic. The issue is what do consumers really want? What is going to motivate them? It's not going to be messages on the pack, but if you go on social media, and look at what we do generally and the way we communicate, particularly digitally, there is a lot going on.

We have a particular thing with social networks, and media, and connectivity to consumers. Everything happens so much more quickly. In 1985 at the launch of new Coke in America, it took six weeks to take them off the shelves and go back to Coca Cola Classic. That is six hours today. And that is the difference.

JD: There are certain brands where we play on their sustainability and their heritage. That is a key part of it: it's more about the beans and the origin of the beans, and the sustainable supply chain, and we talk about that. For some other brands we don't talk about the sustainability parts as much: they target indulgence, or other things. But in terms of coffee, there is a consumer expectation of a certain level of sustainability. These days are you Fairtrade? or Rainforest Alliance? has become back of pack, and we've seen that changing. There is more of an expectation now that you are doing that.

HM: Sustainability is very multi-faceted: at one level it's consumer-facing. At one level, it's the bottom line. You save a lot of money by using less energy, and using less packaging. And many companies have got a lot further to go in terms of carbon, water, energy, and packaging waste.
JH: What makes it onto the front page, however, will be driven by the people who produce the front pages.

WS: There was a great example of food on the front page when the IMechE did its report on food waste. Fifty per cent of food is wasted – they did the maths.

JH: I think people need to look at the maths a bit more closely, because it's not 50%. A commonly accepted figure is more like a third. The baseline will move on. The focus in the developed world is on food waste in the home.

WS: In terms of the supply chain, and sustainability, does anyone else want to contribute? Tim, you're in the Bakel supply chain...

Tim Robinson (TR): We are indeed. I would just add that it's the right thing to do, but it does slow the pace of innovation. We have teams in place to do it as professionally and quickly as possible, but there is bureaucracy. There isn't as much time to do innovation, but that doesn't mean it shouldn't be in place – sustainability is a fact of life. We all operate within that environment. I come from a business that is a B2B brand. We find that our sustainability agenda is far more an owner push, rather than a consumer pull. There are a lot of sound economic reasons for what we call sustainability. It is not in conflict with the bottom line. But we do a lot of private level retail, and one of the things I find interesting is how little of that agenda sits with private label retail.

AD: That is where you start to look at sustainability across the value chain. They are so many people having inputs into it, and they all have to work together to be more transparent and visible – rather than a supply chain where you are just pushing it forward. Rather than just price negotiation you have those values, and you have to think about transparency through the supply chain.

GW: We are all working on this agenda. And not merrily rubbing our hands at waste. It is a systemic issue. And consumers are part of the system, as much as we are.

WS: What effect will Brexit have in exporting, and importing ingredients?

TR: If you source your raw materials from the EU there are going to be cost implications. You are going to be hit with costs immediately. Everyone is affected. Do the customers take the price hit, or do retailers take it?

JH: At the moment, all we have is a different reason for currency volatility. I would look at the 170 countries in the world that aren't in the EU, and whether they are getting on.

JD: We are going to wait and see. And whatever it is, we are going to work around it. There will be new markets opening up.

JH: We do need to remember that the UK is smaller than the EU, although relatively wealthy. The rest of the world is not just going to dance to our tune.

FOOD COMPLIANCE, TRACEABILITY AND SAFETY IN 2016/17

Summary by Andrew Dalziel, Infor

"As we enter 2017, compliance and traceability need to remain a Boardroom topic for UK food & beverage companies, as the number of UK food recalls appears to be still running high after an increase of 78% in 2015 .
Adhering to ever-more stringent food labelling regulations and correctly declaring ingredients, allergens, additives, nutritional information, etc. is paramount. The big question for many companies is what will happen to UK regulations post-Brexit? Will the UK regulations drift apart from the EU, meaning another set of rules and greater labeling complexity? Should the worst happen, executing a rapid recall is vital and this demands having the right technology, processes and training in place. In the era of Digital Transformation, consumers can find out about food safety issues faster than in the past, which can be a challenge or an advantage depending on how companies harness the latest technologies to protect the consumer and their brands."

THE FOOD AND DRINK SECTOR

Accounts for 16% of total manufacturing turnover, making it the largest manufacturing sector

There are many pressures bearing down on food and drink manufacturers within the UK. From supermarket pricing pressures and debates about the reformulation of food to be healthier, to the challenge of finding skilled people to maintain the workforce as more employees retire in the next 10 years.

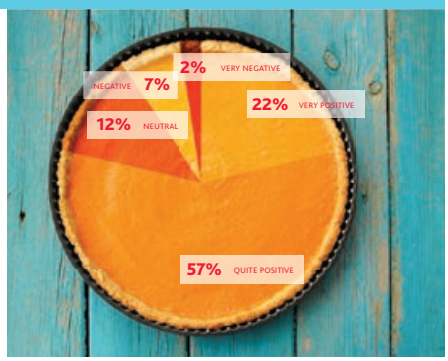
But Britain's food and drink industry has tremendous opportunities and is known for its new product innovation by companies of all sizes. Food companies can grow quickly and the industry is a vibrant source of mergers and acquisitions.

BDO recently partnered with the Institution of Mechanical Engineers (IMechE) to analyse the sentiment, challenges and changing macro landscape for UK companies operating in the food and drink industry. Below are some of the findings from our survey and you can download the full report at: https://www.bdo.co.uk/en-gb/insights/industries/manufacturing/the-food-and-drink-report-2016

GROWTH AND PROSPECTS

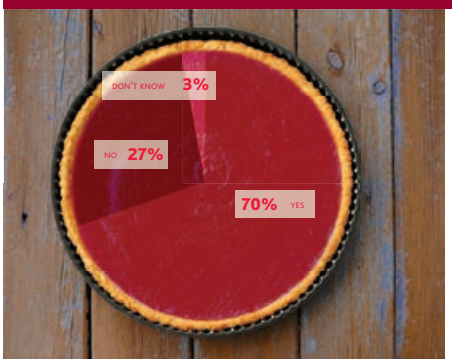
HOW POSITIVE DO YOU FEEL ABOUT THE FUTURE OF THE FOOD AND DRINK INDUSTRY IN BRITAIN?

Manufacturing companies are characteristically conservative in their outlook, so it was very encouraging to see that 79% of companies surveyed were either positive or very positive about the prospects for the UK food and drink industry.



KEY CHALLENGES

IS YOUR ORGANISATION EXPERIENCING DIFFICULTIES IN RECRUITING THE SKILLS AND PEOPLE IT REQUIRES?



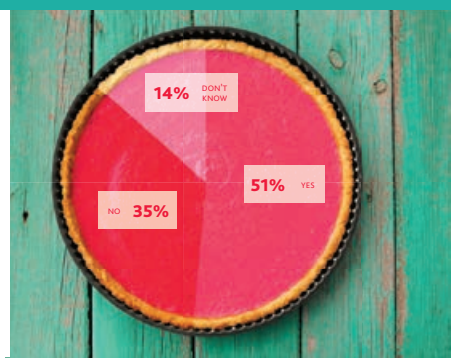
Recruitment in the food and drink industry for many companies is still a big challenge.

70% of those surveyed said they were experiencing difficulties in recruiting the skilled people they require and is highlighted as the second highest key challenge being faced in the next year.

INNOVATION AND AUTOMATION

IS YOUR COMPANY INCREASING ITS INVESTMENT IN PROCESS AUTOMATION FOR FOOD AND DRINK PRODUCTION?

Automation is a hot topic in the manufacturing sector as a whole and 51% of food and drink manufacturers surveyed said their company was increasing its investment.



RAISING PRICES, GROWING CUSTOMERS

86% of firms expect revenue growth of up to 20% in the next year

26% of respondents said they would need to increase prices for customers to offset the cost of the National Living Wage

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THE NEW NECESSITY
SUPPLY CHAIN EXECUTIVES SHIFT FOCUS FROM SURVIVING TO THRIVING

Today, manufacturers are flourishing— or failing—by their supply chain strategies

Can you estimate how much of the information that companies need to run their businesses sits outside of their own software systems, what would you say? Zero? 20%? 50%?

Experts estimate that the number is actually 80%. Eighty percent of the data[1] that companies need to serve customers effectively sits not within their own four walls, but with their partners, from suppliers and freight forwarders to customs expediters and financers. This new reality, brought about by an increasingly global, connected, and "I want it now" consumer-driven economy, means that companies no longer compete based on the quality of their own products and services alone. Their destinies are tied to the performance of their networks.

Change brings opportunity, and it's arrived in the form of connected supply chain networks. Cloud technology is powering networks that give businesses an essential ingredient for success—real-time visibility. Instead of massive blind spots between the shipment and arrival of goods, progress can be tracked all along the way. Instead of multiple versions of orders residing in each trading partner's system, a single version can be kept up to date at all times. Suppliers have visibility into customers' manufacturing schedules so they can plan accordingly. Manufacturers have visibility into suppliers' operations, so they can find alternatives if their needs can't be met.

The benefits are far reaching. In just one example, a major provider of high-tech electronics has saved millions of dollars in working capital by using its supply chain network to track the location of goods in transit and transfer ownership to its customers far earlier than was previously possible—even before those goods have been removed from their shipping container.

One thing is clear: The connected economy is here to stay. Those businesses that can continually adapt and map the best course for navigating it stand to put some significant distance between themselves and the competition.

A MODERN SUPPLY NETWORK SOLUTION

Infor and GT Nexus, an Infor company, deliver a global commerce cloud that gives manufacturers unprecedented supply chain visibility to control and optimize production, goods in transit and at rest. The combination of Infor CloudSuite applications and the GT Nexus cloud represent the future of multi-enterprise manufacturing and commerce. These solutions help manufacturers speed delivery, improve efficiency, and prevent unnecessary delays. MR

[1] Ten Ways Big Data Is Revolutionizing Supply Chain Management, Forbes http://bit.ly/2fY7Dbx

GT NEXUS™
an Infor® company

SUPPLY CHAIN STATUS

- **75%** of large manufacturing and retail executives say digital transformation of the supply chain is "important or very important."
- **48%** admit that "traditional" methods such as phone, fax, and email are still the dominant ways to interact with supply chain partners.
- **Only 23%** of respondents say that the majority of data from the extended supply chain is analyzed and used for decision making.

"The Current and Future State of Digital Supply Chain Transformation," GT Nexus and Capgemini Consulting, 2016. http://bit.ly/1Syi1gV

MORE RESOURCES

MOVING BEYOND THE VALUE CHAIN
http://bit.ly/Infor-SCM-network

THE CURRENT AND FUTURE STATE OF DIGITAL SUPPLY CHAIN TRANSFORMATION REPORT
http://bit.ly/Infor-SCM-Research

PROFITABLE SUPPLY CHAIN WITH CUSTOMER AND EVENT-DRIVEN OPTIMIZATION, ABERDEEN REPORT
http://bit.ly/Infor-SCM-eventdriven

THE ROLE OF SALES AND OPERATIONS PLANNING (S&OP) IN MODERN MANUFACTURING INFOGRAPHIC:
http://bit.ly/Infor-SCM-graphic

About Infor: Infor builds business software for specific industries in the cloud. With 15,000 employees and over 90,000 customers in more than 170 countries, Infor software is designed for progress. To learn more, please visit **www.infor.com**

Greybull Capital purchased Tata Steel's Long Products Division and relaunched it as British Steel

SAVING GRACES

STEEL & METALS

After a torrid time in 2015, this year offered new hope for Britain's beleaguered steel industry, and automotive continued to embrace aluminium. Meanwhile, the metals industry opened up a new channel to government, reports Andy Sandford

THIS ARTICLE EXPLAINS:

- Steel plant rescued from oblivion
- Millions of cars to be aluminium-intensive
- Tata Europe back in profit
- Metals industry calls on government for help
- No time for complacency for steel

After the plant closures, job losses and bleak outlook of 2015's steel crisis, 2016 was marked by new owners for large parts of Tata's steel business, businesses being saved from administration, and jobs being saved or created. In the aluminium sector, the automotive industry's undiminished appetite for lightweighting was still the driving force.

Having been unable to find a buyer last year, Tata sold its Long Products Europe business to Greybull Capital. The business, which was launched at the beginning of June as British Steel, includes the 4.5 million tonne capacity integrated iron and steel works at Scunthorpe, and mills in Teesside and France. In September, British Steel announced that it expected to return to profit for the financial year ending in March 2017. In its first 100 days it had invested more than £20m in its coke ovens, gasholders and basic oxygen plant, and taken on 270 new employees, including 48 apprentices.

Two plants that were closed by Tata in 2015, the Dalziel and Clydebridge rolling mills, were purchased by Liberty House and brought back into production. Liberty House says it plans to grow its business through both acquisition and organic growth. It plans to install electric arc furnace capacity in the UK to produce liquid steel from UK-sourced scrap and expand downstream operations.

Working with sister companies, its strategy is to power the plants by building small power stations to produce renewable energy from tidal lagoons, waste-to-energy plant, and biomass.

A 9MW biofuel plant has been commissioned in Newport where the company plans to create a 2m-tonne capacity steelmaking plant next to its rolling mill, and it has acquired an electric arc furnace from the former Thamesteel operation in Sheerness.

Tata is still in the process of finding a buyer for its speciality steel division in Stocksbridge and its pipe mills in Hartlepool. It is also in continuing discussions with Thyssen Krupp to explore options for strategic collaboration through a potential joint venture.

Tata announced in September that its European operations were back into the black, thanks to the weaker pound, stronger steel prices, the impact of restructuring in the UK – and stronger performance in its Netherlands operations.

IS THE CRISIS OVER?

So is the steel crisis over? Gareth Stace, director of trade body UK Steel, warns against complacency.

"The price of steel globally has increased a bit, from a very low level, but is it sustainable? Fundamentally, nothing has changed. Global overcapacity is still there, and potentially growing."

A year ago UK Steel asked the Government to take action in five areas: energy, business rates, trade, procurement, and on environmental deadlines.

Says Stace: "They took almost immediate action on environmental deadlines. On trade, we saw the Government moving from always voting against trade defence instruments within Europe to actually voting in favour and sometimes driving the debate – so that was a great change.

"On energy, yes, we have the Energy Intensive Industries compensation package, which saves the industry anything from £80 million to £100 million.


The Jaguar XE was the first car to use JLR's specially developed recycled aluminium alloy

But even with the compensation, we are still paying £17/MW hour more for our energy than, say, Germany. And on business rates the Government has done nothing.

"So we still face costs our competitors don't face – and there is a long way to go on procurement."

LIGHTWEIGHT STRUCTURES

The big stories in the aluminium sector are very much focused on the development and manufacture of lightweight components for the automotive sector.

In April, Jaguar Land Rover (JLR) reported that in the first full year of sales of its XE model, closed loop recycling of process scrap had allowed it to bring 50,000 tonnes of reclaimed aluminium back into the production process. The structural grade of recycled aluminium used, developed in conjunction with Novelis, is now also used in the lightweight pressed aluminium bodies of Jaguar's XF and F-PACE models.

Aluminium is not restricted to pressed parts. To meet JLR's demand for advanced lightweight castings, Magna Interna-

THE METALS INDUSTRY IN FIGURES

7.5M TONNES – estimated UK steel production in 2016, the lowest ever

RS. 578 CRORES (APPROXIMATELY £67M) – Tata Europe loss in final quarter of 2015-2016 financial year

RS. 856 CRORES (APPROXIMATELY £99M) – Tata Europe profit in the first quarter of 2016-2017 financial year

2025 – year by which 25m new cars will be aluminium-intensive

50,000 TONNES – the amount of aluminium reclaimed by Jaguar Land Rover through closed loop recycling since launch of XE

13% – year-on-year increase in demand for steel from the automotive sector in the UK

60% – percentage of steel used in first half of 2016 imported from outside the UK

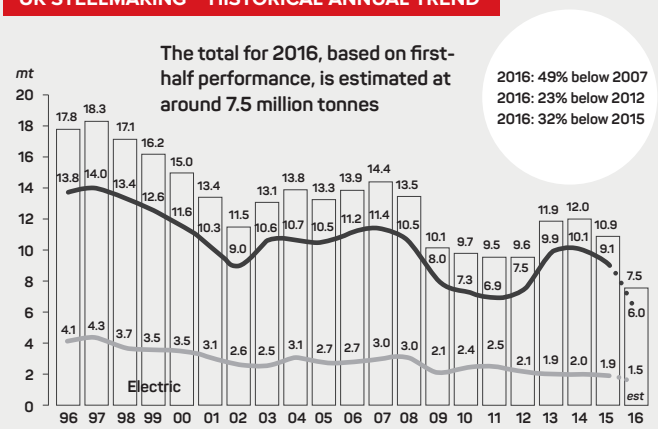
21 – average number of employees of companies in the UK metals sector

£46,700 – gross value added by each employee in the UK metals sector – 50% more than the UK average

4.5M TONNES – the annual capacity of British Steel's Scunthorpe steelworks

98% – percentage of rails Network Rail lays in the UK manufactured at British Steel's Scunthorpe plant

UK STEELMAKING – HISTORICAL ANNUAL TREND



UK DEMAND – HISTORICAL QUARTERLY TREND UP TO Q1 AND Q2 2016

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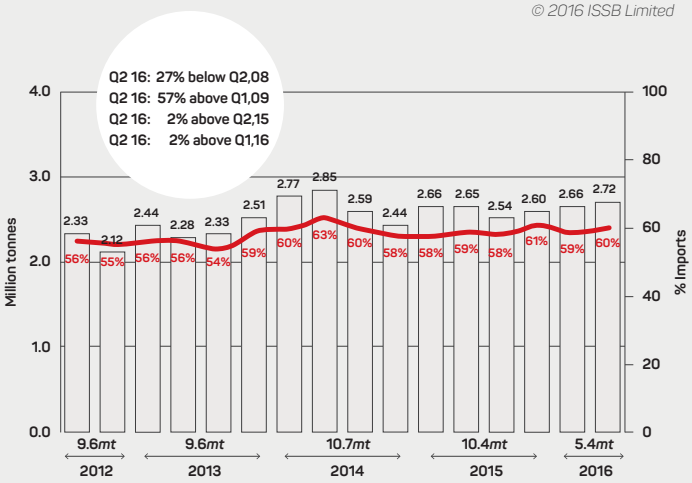
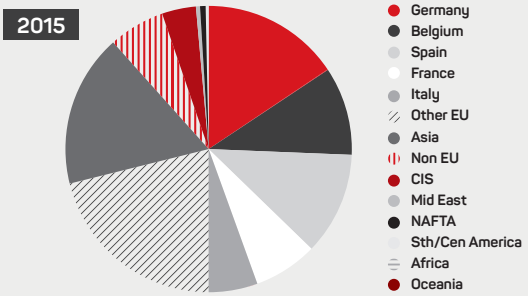
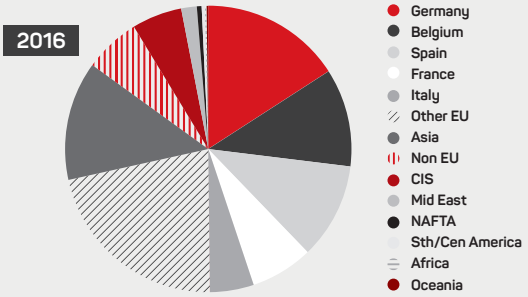


UK DEMAND BY BROAD PRODUCT CATEGORY

January-June 2015 and January-June 2016



TOTAL IMPORTS 3130kt
EU 28: 71% RoW: 29%



TOTAL IMPORTS 3209kt
EU 28: 72% RoW: 28%

Source: International Steel Statistics Bureau

Network Rail is one of the key customers of British Steel

tional announced that it was to build a new 225,000 sq ft facility in Telford. The plant will use Magna's high-pressure vacuum die casting process to produce a number of advanced lightweight aluminium castings for all-aluminium and multi-material vehicle architectures.

In October, Impression Technologies opened the first production line to use its patented Hot Form Quench (HFQ) process. This is a deep drawing process that can form lightweight, high-strength, complex aluminium parts, optimised for strength and weight, at high production rates.

The £3m line is currently configured to produce 250,000 parts a year for development, low-volume production, training and prove out. Suitably modified, it could be configured for the high-volume production of 2m parts a year. Impression Technologies has already secured a number of high-profile automotive customers, including Aston Martin, which utilises HFQ parts on its new DB11 model.

CHANNELS TO GOVERNMENT

The drama of last year's steel crisis rather overshadowed what should have been a big moment for the sector: the launch by the Metals Forum of its Industrial Strategy for Metals. Now some of the forum's proposals are being put into practice, most importantly the setting up of the UK Metals Council that creates a direct channel between the industry and the Government.

The Council meetings bring together representatives from the 10 trade associations that make up the Metals Forum, the Minister of State, civil servants and the chairs of five working groups – Supply Chain, Skills & Training, Sustainability and the Circular Economy, R&D, and Innovation and Communication.

UK Metals council manager Giles Willson says: "The idea is that Government wants to talk to the people who are actually working in industry through the trade associations. What we will talk about are common issues where the interests of the 10 trade

The Advanced Metal Casting Centre at Brunel University has industrial-scale aluminium casting and extrusion processes

UNDER NEW MANAGEMENT IN 2016

- Former Caparo steel and engineering businesses, including Accles and Pollock and Hub Le Bas, purchased from administration by Liberty House
- Dalziel and Clydebridge rolling mills acquired by Liberty House from Tata Steel
- Tata Long Products division purchased for a nominal sum by Greybull Capital from Tata Steel and renamed British Steel
- Wind tower and pylon manufacturing equipment acquired by Liberty House from former Mabey Bridge Renewables factory in Chepstow
- Wrexham Wire created by management buyout from administrators of Caparo Wire – £1.2m since invested in new high-carbon wire drawing line
- Kiveton Park Steel, which manufactures bright drawn steel and wire, mainly for the automotive industry, purchased from administration by Henry Dickinson, managing director of Norton Aluminium
- Ball Corporation acquires Rexam plc for $6.1bn, making it the largest manufacturer of beverage cans in the world

associations intersect. It is very much a partnership with government to see what the issues are, so that we can work through them together."

In parallel to the Metals Council there is also a sector-specific Steel Council, and one of its tasks is to look at the longer term vision.

Gareth Stace says: "In the longer term, if the Government just tackles the short term things and then leaves the sector as it is, then potentially we will come back to crisis in the future."

One thing the Steel Council is working on with the Department for Business, Energy and Industrial Strategy (BEIS) is a capacity capability study. This is looking at where the demand for steel is in the UK and Europe, now and in the future: what sort of products and what types of steel is the demand for, whether the UK is a player in that market and if not, could we or should we be?

Stace says: "It is basically asking the question, 'why aren't we in markets that we potentially should be in?' What are the barriers preventing us from doing so, and are there barriers that government can have an influence on? Let's look at a number of selected products, and understand if we can break down those barriers and increase our market share.

"It is not necessarily a roadmap for the sector. It is about government working with industry to say you have an ambition, we too have an ambition; let's work together to achieve it."

NO DISRUPTION, PLEASE: WE'RE BREXITING

No prediction for the future state of the metals industry would be complete without considering the implications of Brexit. Talking to the Aluminium Federation, the key concerns are that nothing is done to disrupt the intrinsically international nature of the industry, that access to skilled labour is maintained, that any trade deals don't allow unfair competition – and that the Government doesn't lose sight of existing issues such as the cost of energy.

And what does Brexit mean for the steel sector? "In terms of international trade," says Stace, "steel as a sector may be in a slightly fortunate position because even when we leave the EU, importing into Europe, the US and others is still going to be zero tariff for us. The problem, I think, will be non-tariff barriers, and the issue will be addressing them."

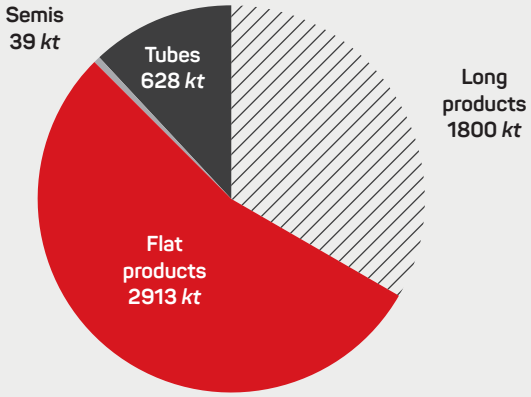
He is also concerned about the UK's lack of expertise in developing its own trade defence mechanisms and tariffs – and what happens to the 37 EU tariffs relating to steel that are currently in place.

Brexit and energy price concerns aside, the aluminium industry as a whole looks set to continue to thrive, while the positive impact of the UK Metals Council should start to become more obvious across the whole industry.

And steel? Taking on board all his previous caveats, Gareth Stace says: "If the steel price stays where it is, or even goes up a bit, if the short-term measures do their job, and if all the stakeholders involved in the capacity and capability study are fully engaged, open-minded, and willing to work through it, then there is no reason why the steel sector in the UK doesn't have a bright future, where it can invest, grow and innovate." MR

Parts made using the Hot Form Quench process from Impression Technologies are used in the new Aston Martin DB11

UK DEMAND - PRODUCT GROUPS



Source: International Steel Statistics Bureau

RESEARCH & DEVELOPMENT

- A new facility at Brunel University, the Advanced Metal Casting Centre (AMCC), will help speed up the development of lightweight, high-performance aluminium alloys for the automotive and rail industries. The AMCC is managed by Brunel University, Jaguar Land Rover and Constellium, and provides industrial-scale aluminium casting and extrusion equipment
- A £600,000 custom-built steel foundry at AMRC Castings, part of the University of Sheffield's Advanced Manufacturing Research Centre (AMRC) with Boeing, comprises two Inductotherm air melting induction furnaces, with a combined 2.8-tonne melt capacity, able to produce cast parts with a finished weight of up to 1,300kg
- A new £4m facility, The Royce Translational Centre, to be built next to the Advanced Manufacturing Research Centre, will offer manufacturing companies the opportunity to adopt next-generation technology to produce and process metal powders

Read more about steel and metals manufacturing on pages:

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300 DEBATE A BLUEPRINT FOR GROWTH

EIGHT KEY FACTORS REQUIRED FOR ACCELERATING UK MANUFACTURING GROWTH

1. Better manufacturing leadership
2. Improved employee engagement
3. Increased investment in technology (Industry 4•0)
4. Greater focus on improving productivity
5. More ambition from SME manufacturing businesses
6. More women in manufacturing
7. Government sponsored UK manufacturing strategy which is sector specific
8. Government support in promoting manufacturing

2016 marked the seventh year of the National Manufacturing Debate hosted by Cranfield University, which continues to go from strength-to-strength. This year, a packed auditorium of over 300 delegates from industry, academia and business gathered to discuss "How can UK Manufacturing Growth match the best of the G7?"

At the debate, Professor Rajkumar Roy, Director of Manufacturing at Cranfield University revealed research by Cranfield University that demonstrated the impact of manufacturing on the UK economy as a whole was likely to be undervalued by £50billion.

Anna Soubry MP, the then Minister for Small Business, Industry and Enterprise spoke about the importance of manufacturing to UK industry and the potential of the emergence of big data, the internet of things, new materials, pioneering flexible manufacturing processes, automation, robotics and additive manufacturing offered the opportunity to further improve performance, "the fourth industrial revolution is beginning and should be exploited" she said.

Looking to manufacturing in the future, Hamid Mughal Global Director of Manufacturing at Rolls-Royce suggested that with resource constraints, environmental issues and a growing global population, manufacturing will become as strategically important as defence. The ability to design and make for a country's own people will become very important.

SME's were also well represented with Grant Jamieson, Managing Director of Winkworth Machinery pointing out the large role they had paly in the UK economy and urging the Government to do more to support them.

Other key speakers at the 2016 National Manufacturing Debate included Terry Scuoler - CEO of EEF, Anna Leach - Head of Economic Analysis at the CBI and Dr Phill Cartwright – Chief Technology Officer at the High Value Manufacturing Catapult.

In what will be its eight year the National Manufacturing Debate continues to be a key date in the manufacturing calendar in 2017. MR

MORE RESOURCES

The full report of the 2016 National Manufacturing Debate and information and booking details for 2017 are available from **www.national-manufacturing-debate.org.uk**

PLASTICS IN GOOD RECOVERY

PLASTICS

Despite the concerns of the green lobby, plastics are ubiquitous and the sector – recycling aside – is in good health. Hamish Champ reports

Photo courtesy of SMMT

Plastics are in demand in automotive but skills are a concern for the sector

THIS ARTICLE EXPLAINS:

- Imports of injection moulding machines to the UK at all time high
- Sales of plastics industry ancillary equipment also up
- Automation has increased productivity and cut costs
- Plastics sought in automotive for lighter, stronger parts
- Polymer banknotes introduced for first time

Plastic. Environmentalists see it as a modern day scourge, clogging up both land and sea with its wayward presence. Others argue that without the varieties of plastic used in everyday products, the modern day would have a hard time keeping up.

Materials such as polypropylene, polystyrene, polyethylene, from ABS to polyamide, have a myriad of uses; parts in the cars we drive and the airplanes we fly in; the packaging that thousands of retail products come in; healthcare devices and equipment; construction products; electrical goods, and computers. The list is extensive.

The plastics sector has largely recovered from the industrial downturn of 2009, following the banking crisis of the previous year, which among other key end markets severely curtailed activity in the automotive arena. The bellwether for the industry is the amount of equipment imported into the UK – since little large machinery is produced domestically anymore. The latest figures available for imports of injection moulding machines – the workhorse of the sector – registered an all-time high in 2015, according to the Polymer Machinery Manufacturers and Distributors Association (PMMDA), at 643 units. UK sales of 'ancillary' equipment – heaters, coolers, sorting and storage systems, and so on – and robotics were also "significantly up", the PMMDA said.

Photo courtesy of SMMT

Sales of injection moulding and other plastics manufacturing equipment are at record levels

The use of automation has increased, according to industry insiders, helping to increase productivity and cut costs in the plastics processing sector, although observations were largely anecdotal. Injection moulding machines sold with robots attached were proving more popular with processors since they had become easier to program and are simpler to integrate. The skillset to carry out re-programming was increasingly within the customer's own capabilities, industry figures noted.

The PMMDA meanwhile described as "encouraging" the level of investment going into new machinery, citing the automotive effect, while the desire on the part of UK processors to produce larger parts closer to the location of their customer base was also regarded as a contributory factor in the industry's fortunes. Even the uncertainty caused by the vote in June to leave the European Union failed to dampen the spirits of many of the country's machinery suppliers, although a number did argue that it was too soon to assess the impact of Brexit with any certainty.

IN RUDE HEALTH

For now, with high quality design techniques, impressive facilities and an adaptable workforce, the UK plastics industry is in rude health, due in part to rising consumer spending and certainly thanks to the improving situation of the domestic automotive sector, which according to the Society of Motor Manufacturers and Traders was producing a new car every 16 seconds in the middle of 2016. UK-based car manufacturers like Nissan and Jaguar Land Rover (JLR) produced more cars than ever for enthusiastic export and domestic markets and such firms sought ways to make their vehicles more fuel efficient and environmentally-friendly. Plastic consolidated its position as a sought-after material to develop lighter, stronger parts in a growing number of areas, from side panels and support structures, to 'under the hood' applications. Companies like Stockton-on-Tees' Nifco UK have

Materials such as polypropylene, polystyrene, polyethylene, ABS, and polyamide have a myriad of uses

Environmentalists remain concerned about the impact of plastics on ecosystems

developed strong supply links with automotive firms in the North East of England, while JLR's growth curve in the Midlands – which has seen the carmaker plough more than £600 million into its plants in the region – has helped local suppliers on what has traditionally been plastics' home turf.

In the wake of the VW diesel emissions scandal, companies have scrambled to produce applications that will stand up to the test, literally; Nottinghamshire-based Tsubakimoto UK, a manufacturer of automotive timing chain systems, has developed low-friction timing system parts made from Stanyl TW371 PA46 polyamide, supplied by DSM Engineering Plastics, for the latest generation of petrol engines. The grade had previously been TW341, but DSM developed a new grade with improved friction performance, providing benefits including lower CO2 emissions and better fuel economy.

Technological progress also moved apace in the medical sector – in particular 3D printing – and led the charge in advancing patient care. One example was to be found at London's Kings College Hospital, where specialists integrated 3D printing technology into a treatment for complex cranio-maxillofacial disfigurement. Using a Stratasys Objet Eden250 3D printer, the hospital converts 2D CT scans of the patient into replica 3D-printed models for its face and jaw neurosurgery. Surgeons can effectively practice on such models, highlighting potentially problematic areas before actual surgery. Dr Muhamad Hatamleh says: "In the case of skull meningioma, where there is a tumour growing in the skull, the surgeon needs to remove the tumour and restore the skull in the same surgery. Producing a 3D model of the skull with the tumour enables our surgeons to clearly visualise the outcome of the surgery before it is performed, and make better decisions accordingly."

Despite such cutting-edge developments, the industry did not have everything its own way. The plastics recycling sector saw a number of corporate failures, some of them high profile in nature. Another big issue facing the plastics industry is its ongoing skills gap. To an extent, the industry has been its own worst enemy; poor promotion of manufacturing and apprenticeships was said to be behind the shortage of skills, at least according to a report published by the BPF. A survey of the federation's members found that many had problems recruiting young staff, with the negative perception of plastics being partly to blame, while education was also said to be a factor. A lack of advanced polymer engineering courses available across the UK's university system was also deemed a major headache for the long-term development of skilled employees, while the BPF's research revealed a perceived lack of government support as another factor. But Julie Harrison, a STEM consultant, warned the industry to do more to engage with young people, highlighting their activities in schools and colleges.

As the government launched its ambition to create three million apprenticeships, Louth-based technical compounder Luxus and plastic pipe maker Polypipe launched a compounding polymer apprenticeship scheme to help bridge the skills gap. The pair's new scheme, which saw three youngsters start a two-year multi-site programme in polymer processing, was part of the government's 'Trailblazer Apprenticeship Standards' initiative, launched in 2016.

TIME FOR 4.0

The plastics industry should be doing more to embrace Industry 4.0, according to Scott Crowther, innovation manager on the SME team at Warwick Manufacturing Group at the University of Warwick. He calls on small manufacturing firms in the UK plastics industry to embrace 'Industry 4.0' – the 'fourth industrial revolution', or 4IR – and use data by linking various systems together in order to predict changes in production performance and make better use of production and other linked

PLASTICS INDUSTRY BY NUMBERS

- UK plastics industry comprises approximately 6,200 firms
- Those firms employ between 170,000 and 180,000 people
- According to the sector's main trade body, the British Plastics Federation (BPF), the industry turns over approximately £23.5bn annually
- Around 3.3 million tonnes of plastics material is processed into finished goods by more than 5,000 manufacturers, with output accounting for around 7% of UK industrial activity

2016 IN BRIEF

- Mike Boswell, chairman of the taskforce set up by the British Plastics Federation on Brexit, says the EU is "highly significant to the plastics sector". "It is essential that the UK has an orderly exit from the European Union for the health of our important sector," he says.
- Wrap, the recycling charity, said local authorities, the recycling sector and the wider supply chain had made "significant improvements" towards creating a circular economy for plastics. Since 2009 there had been a 50% rise in the recycling of plastic packaging, aided by the introduction of mixed plastics collections
- An English stationery retailer grabbed the headlines by handing out free plastic carrier bags, despite customers being required to pay a 5p charge. The Card Factory got around the charge by giving out bags that had had their handles cut off. The ruse was legitimate, according to the Department for Environment, Food & Rural Affairs
- The government agreed to ban microbeads in personal care products such as shampoo and cosmetics. The proposal, which was backed by environmental groups and the UK plastics industry in the guise of the BPF, is likely to become law in 2017, and follows a wide-ranging public consultation
- Plasgran invested £1.7m in a new compounding line. The Cambridgeshire-based recycler said the move would double its capacity to 36,000 tonnes a year. Acknowledging the problems facing the recycling sector, Plasgran managing director Mark Roberts says firms can capture sales provided they invest wisely and are commercially astute when buying polymer

facilities. "In a way there's nothing new about pulling data from machines; we've been doing it for decades. But the ever-increasing technology power and the reducing cost means it is accessible and affordable," he says.

While some firms had been able to grow organically in 2016, others added to their operations by way of acquisitions. Nowhere was this activity more prevalent than in the packaging sector. One of the biggest deals of the year in the UK was RPC Group's move to buy British Polythene Industries – which makes film for agricultural and horticultural markets – for £261m. The deal was the latest in a series of acquisitions by RPC, which has sought to broaden its portfolio and position itself across packaging and engineering activities. Previously a player predominant in the rigid packaging market, RPC chief executive Pim Vervaat said the acquisition represented a "compelling strategic opportunity to enter the European polythene films market through an established platform". The price being paid by RPC was a 30% premium to BPI's share price at the time of the offer.

In a move that put plastics at the forefront of the consumer's consciousness, the Bank of England also issued its first plastic currency in the form of the polymer £5 note. Featuring Sir Winston Churchill, the note was made by Cumbria-based Innovia – albeit at its Australian plant, due to capacity issues at its UK facility. The plastic fiver will last two-and-a-half times longer than the paper/cotton version, can withstand being submerged in water, and is rip-proof. A new plastic £10 note will come into circulation in 2017, with the next generation £20 – also plastic – the year after that, replacing the cotton/paper variants which will eventually cease to be legal tender. Scotland has had plastic notes in circulation for a while, as have a number of other countries, such as Australia and Canada.

Meanwhile, the BPF launched a special committee to highlight the sector's interests as the UK prepares to walk away from the EU. The BPF also published a report outlining its aspirations from the forthcoming negotiations with Brussels, namely free access to the single market; access to skills, with the emphasis on apprentices, engineers and technicians; maintaining and developing legislation compatible with the EU, and support for innovation and overseas business development. MR

TOUGH TIMES FOR RECYCLED PLASTICS

The slump in the oil price has adversely affected recycling

This year saw a number of casualties in the UK plastics recycling industry, prompted – some argue – by the spectacular slump in the price of oil, a situation which rendered the use of recycled material more expensive than virgin polymer. High profile failures included Euro Closed Loop, formerly known as Closed Loop, a Dagenham-based facility which reprocessed tonnes of post-consumer waste plastic milk bottles. The company had reportedly been losing more than £300,000 a week at one stage.

Industry representatives denied reports in the trade media that the plastics recycling sector was in crisis; instead they pointed to companies that had overstretched themselves and in so doing had failed to match their commercial ambitions with an appropriate level of investment. While the market was unstable, minimising yield losses and ensuring feedstock was of the best possible quality were contributory factors to a business' success. Biffa Polymers' commercial manager Chris Hanlon says firms in the sector "should be buoyed by the fact that we are seeing the highest ever demand for recycled high-density polyethylene, and that that demand is set to continue on its upward trajectory". Biffa Polymers announced it plans to invest £6.5m in a new recycling line at its Redcar plant, more than doubling the firm's output of rHDPE, and allowing for more material to be re-processed in the UK.

European legislation also threatens to throw a spanner in the recycling works, according to Axion Polymers' director Keith Freegard. He warns that European laws on pollutants could act against the interests of recycling end-of-life materials and there were real fears that completely banning certain substances, even when they were present in miniscule amounts, could see valuable plastic resources diverted to landfill.

"If we're truly going to achieve a sustainable position for recycling in the transition to a circular economy, then surely a pragmatic approach needs to be taken to ensure we are not jeopardising that vision for the sake of a 'toxic-free' Europe," Freegard adds.

Read more about plastics manufacturing on pages:

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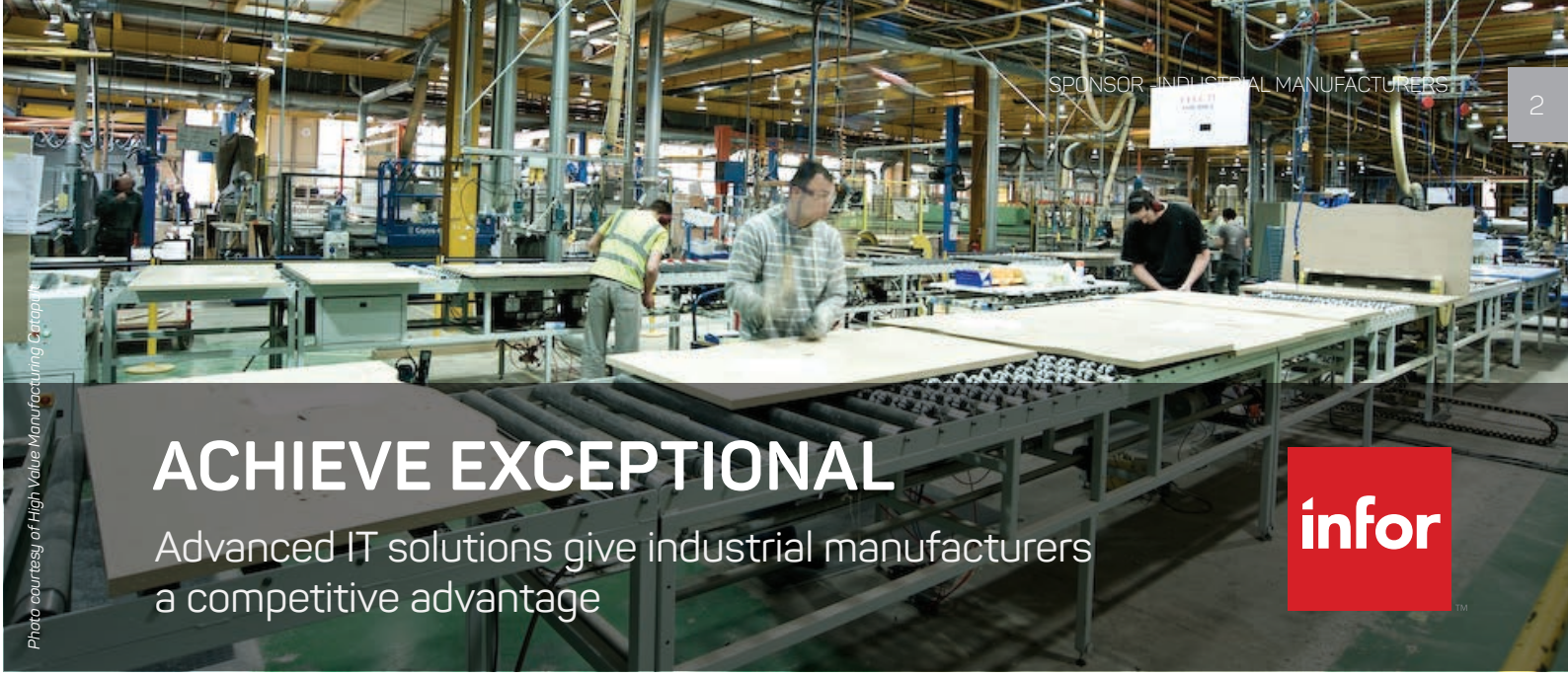

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73%

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of European manufacturers are using or plan to use cloud ERP [2]

[1] IDC: "Business Decision making in the Factory of the Future" an IDC infobrief sponsored by Infor, Nov. 2015.

[2] IDC: Moving toward information centric processes, an IDC Infobrief sponsored by Infor, March 2016

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SMART PLASTICS | BY LEE HIBBERT

SMART PLASTICS FOR A MORE CONNECTED FUTURE

igus

igus is helping to underpin the emergence of more networked factories by embedding sensing, monitoring and communication capability in its range of cables, linear bearings and energy chains.

As intelligent 'factories of the future' become a reality, connectivity is being applied across the shop-floor like never before. As a result, there is a growing demand for Internet of Things-ready components to improve networking across manufacturing operations.

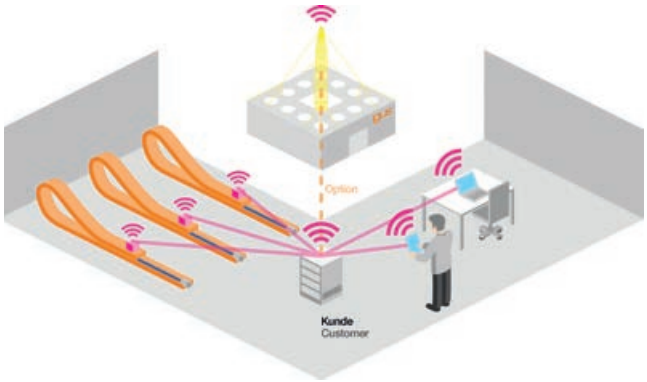
This trend is being met by igus, the Northamptonshire-based maker of cables, linear bearings and energy chains, which has started to embed real intelligence in its products through the addition of sensing, monitoring and communication capability. This new functionality means igus' products can play a more central role in IoT systems, enabling customers to improve the efficiency and productivity of their plants.

"The IoT is driving enormous changes across the manufacturing sector," says Matthew Aldridge, managing director at igus. "Previously, sophisticated sensing and data analytics was restricted to high-end, big-ticket pieces of equipment like aero-engines. But the benefits of IoT-based systems are now being realised throughout the industrial landscape, as companies realise the value of having clearer visibility of their assets."

In terms of definition, the IoT refers to networks encompassing the use of standard Internet Protocol technologies to connect people, processes and products to enable new cyber-physical systems. In an industrial context, these connections exist mainly to improve the efficiency of production facilities.

The 'things' can be a long list of systems and machines that can be fitted with sensors which record real-world data around pressure, temperature, vibration and acoustics. This data, combined with sophisticated analytics, can be used to reveal patterns and problems within factories, or with

Matthew Aldridge, igus



The isense family of products consists of various intelligent sensors and monitoring modules

equipment out in the field. The IoT will therefore help companies capture and analyse data, warning of potential problems before they happen. The tracking of patterns to indicate failure would be an enabler of condition based modelling, unleashing the potential of a truly predictive maintenance regime.

igus motion plastics are already used extensively worldwide throughout industry and everyday life in moving applications. Thanks to extensive testing in its 2,750m^2 test lab in Cologne, igus' engineers are able to accurately predict the service life of its products, offering reliability guarantees. Smart plastics represent the next step for the more connected 'factories of the future', where automated condition monitoring and predictive maintenance will help improve reliability and reduce maintenance costs.

In terms of operation, igus' cables, chains and linear bearings constantly monitor themselves, providing performance data and early warning of critical wear. The products are equipped with a range of sensing technologies and monitoring modules, called isense, which allows local data collection and analysis. A communications module, called icom, takes the data from the machines and transmits it to customers' IT infrastructure or a data cloud.

This approach can be used to measure wear in chains and linear bearings via RFID sensors. The RFID sensors work in pairs, one positioned under the other. Under normal operation, the moving part passes through and triggers both sensors. When the bottom sensor is destroyed, at 80% wear, only one RFID chip registers and an alert is made. Other sensing technologies include a strain gauge to monitor push/pull forces, a potentiometer to detect breakages, and a device that measures the electrical properties of cables to check their lifetime.

"isense continuously monitors the service life of an e-chain, cable or linear guide via measurements and calculations using the parameters of the user's system," says Aldridge. "These measurements are referenced against aggregated test data from our test laboratory to reliably predict smooth functioning in real-world operation. Alerts are sent when measured values exceed thresholds, allowing timely maintenance or replacement."

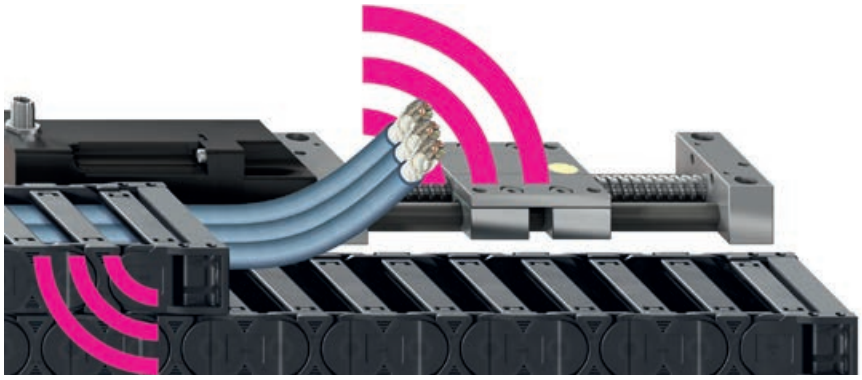
Data can also be optionally shared with the igus data centre, opening up additional possibilities for customised service life calculation and optimisation of business processes, including maintenance commissioning, spare parts ordering and just-in-time delivery. In this way, electronic intelligence lowers maintenance costs even further and increases plant availability.

"This takes the black art out of maintenance, and turns it into a science," says Aldridge.

. "We have real life data about chains, cables and bearings and can compare that to data built up over the years to give proactive advice and supply parts just before they fail. We can reduce maintenance costs, prevent premature replacement and eliminate unplanned downtime, it will have a big impact on financial performance. This will maximise the life of the products and the efficiency of the equipment, saving time."

> "This takes the black art out of maintenance, and turns it into a science"
>
> *Matthew Aldridge, igus managing director*

Aldridge says that the data will also enable the igus engineers to give design advice, such as if bearings need spacing out more. "These are real life products based on existing products we've been selling for years, with added intelligence," he said. "We already outlast a metal chain. We also analyse stroke rate and other engineering data when we supply a product to give an estimated lifetime. But monitoring all the time allows us to take into account the specifics of an application, for example customers often modify equipment after it is installed." MR



e-chains, cables and linear bearings have become smart as igus helps to usher in the fourth industrial revolution

There is a demand for world-class prosthetics for amputees, but can the market supply?

Photo © Chas. A. Blatchford & Sons Ltd

MEDICAL ENGINEERING

ENGINEERING MAKES MOVES ON THE BODY

Biomedical engineering is growing rapidly and now encompasses everything from prosthetic limbs to stents and drug delivery tools. But can engineers keep up with demand for the latest technology? John Pullin reports

Engineering is a large part of healthcare these days, and biomedical engineering is a big industrial sector and a growing focus for research in universities and elsewhere. But putting figures on it is well-nigh impossible. In some estimates, there's a worldwide market of between $150 and $170 million a year for 'medical devices', but then it's far from clear what the definition of these devices is.

THIS ARTICLE EXPLAINS:

- Human body is now an engineering subject
- Technology-led healthcare is accelerating
- Demand for world-class prosthetics for amputees
- New biomedical engineering hub for London
- Similarities between needs of disabled and ageing people

Does it include engineered structures that go inside or alongside the body, such as heart valves, stents and prosthetic limbs? Does it include measuring and monitoring equipment? Imaging systems? Drug delivery tools? That there is a trend towards engineering-derived healthcare is undeniable: it's about procedures, processes and products derived from engineering as much as medical science and pharmaceuticals. But it's very hard to pin down in terms of numbers: it defies standard industrial classifications, and NHS budgets are masterclasses in blurred categories.

What is incontrovertible is that it is quite a long way from the early years of the National Health Service, and that the change to technology-led healthcare has really accelerated in recent years. Biomedical engineering at the beginning was about a few boxes, instruments and dials used to measure and monitor: they provided data for better informed decisions about which pharmaceutical or manual surgical procedure to pursue. Prosthetics and orthotics, replacement and assistive technologies, had improved since Victorian times, but were still basic, impersonal and uncomfortable.

The technology acceleration of the past 20 years within biomedical engineering parallels that in other parts of engineering and manufacturing in its use of computer-based technologies and software. But the big change has been attitudinal: seeing biology and the human body as fit subjects to be 'engineered' – in the same way we've long accepted that manufactured products such as cars can be engineered and optimised.

Anthony Bull, professor of bioengineering at Imperial College London, is bringing together biomedical research teams

BORROWING FROM MANUFACTURING

Some of the technologies are directly borrowing from manufacturing. For example, the imaging systems that track the progress of a stent through the arteries have cousins employed in monitoring and inspection in food factories to spot the walnut whip with no walnut or in steel mills to detect hidden flaws inside billet and bar. Simulation technologies used to model the ride and handling of a car involve breaking down complex motions into fine detail for analysis, and it's a very similar way of working that has produced huge advances in understanding of human locomotion for better design of prosthetics. Cyber-physical systems that combine hardware and software, computer-aided design and analysis, automation and robotics – all these broad-ranging technologies have application in biomedical engineering.

The boom in biomedical engineering has created a new profession that sits between engineering and traditional medical disciplines and uses knowledge from both. "When we started our undergraduate degree programme at Imperial College back in 2002 we were only the second course in biomedical engineering in the UK," says Anthony Bull, professor of bioengineering at the London-based university. "Now I think there are 22 universities offering undergrad degrees."

Research funding has piled into this area and the opportunities to innovate have been immense. 'Healthcare technologies' has been a major 'theme' for the Engineering and Physical Sciences Research Council since 2011 and there have been substantial investments in centres of excellence in medical engineering by the Wellcome Trust charity.

All of this has been fuelled by broader societal trends – actually, whether they are trends as such or merely intractable mega-problems is not clear. One of these is sometimes referred to as the 'demographic timebomb': the success of medicine and technology in prolonging life is creating a surge in the numbers of elderly people, outstripping the capacity of healthcare systems to provide care and treatment and outrunning also the capability of the economically-active to pay for it.

Photo Imperial College

Imperial College London is a bio-engineering pioneer

AWARD-WINNING PROSTHETICS

The Linx development team with Professor Saeed Zahedi (front left)

Biomedical engineering took the UK's top prize for innovation in 2016, with the Royal Academy of Engineering's MacRobert Award won by Professor Saeed Zahedi and his research team at Blatchford for the development of the Linx, a full prosthetic limb that combines both an ankle and a knee joint and that senses changes in terrain and activity and adapts its behaviour to suit.

People who have lost limbs suffer constantly from pains particularly at the interface with the remaining limb and more generally in the lower back. Some of that pain has been alleviated by work Blatchford and others have done over many years to analyse and model the action of joints; the development of the Echelon hydraulic ankle – for which Blatchford was a MacRobert finalist in 2010 – came after years of observation and measurement of how human feet tackle different surfaces and terrain, some of which flatly contradicted the previous consensus.

Linx takes the Echelon work on a phase by combining two joints and using sensors that adapt the limb's approach to different types of ground, gradient and pace of activity. Blatchford sees the development not as the culmination but rather as the beginning of a new phase of work in which dynamic sensors are deployed to personalise prosthetics to the individual wearer.

But Linx has also faced an uphill struggle in another respect. The device is more expensive than a conventional prosthetic and the NHS in England has so far ruled it is too expensive for general use, so most applications have been outside the UK, though Scotland has a more positive view. Cost reduction is a primary aim of the MovAid project Blatchford is leading, but the company is confident also that lifetime costs that take into account fewer return visits for patients and much less pain relief will persuade authorities that Linx is economic in the longer term.

Photo Imperial College

The opportunities for innovation in biomedicine are immense

Advanced economies such as the UK are in great need of innovation, not just in the treatments available, but also in the delivery of them as demand for both products and services exceeds supply.

> The human body is seen as a fit subject to be 'engineered' – in the same way we've long accepted that manufactured products such as cars can be engineered and optimised

GREAT EXPECTATIONS

A second societal trend/mega-problem is that of expectation. Some of that relates to demography: we expect to live longer, but we expect also to live well for longer. So where 20 years ago you had to be the Queen Mother to get a hip replacement in advanced old age, now we all expect one. But Professor Saeed Zahedi, technical director at the award-winning prosthetics company Blatchford, sees this expectation coming from a new angle: UK success at London and Rio Paralympics, he says, has created demand among young amputees for the world-class technology that wins medals. "They see people running 100m in 10.8s and they know that if they have the blades they can start running too, and the government says, 'Yes' – but somehow it doesn't quite happen. We need to straighten the flow."

Across UK engineering and manufacturing, the big events of 2016 and 2017 are in terms of the Brexit vote and the long economic and trade shadows that seem likely to come from it. Biomedical engineering is not immune from the consequences and Professor Zahedi at Blatchford says he is concerned for the future collaborative projects with EU-based partners. He says, not entirely in jest, that with a research team of around 30 people, relocation to a more congenial place might not be that difficult.

In practice, that might be true of rather a lot of the UK biomedical engineering sector. UK research has come up with many of the ideas, especially in technologies such as medical imaging, that have been exploited by big-name global groups such as Siemens, which has a strong UK presence. But much of the UK medical devices industry is composed of smaller companies, with the notable exception of Smith & Nephew; that may reflect the newness of the business and the research origins of companies, but may also be a concern for the long-term in uncertain times.

NEW ENGINEERING HUB FOR 2018

Both Professor Bull at Imperial College and Professor Zahedi at Blatchford are leading projects that are intended to have the effect of "straightening the flow" on innovation within the sector and perhaps also enhancing the industrial base.

At Imperial, Professor Bull is heading the engineering input into a Biomedical Engineering Hub at the new White City campus that has attracted the single largest philanthropic donation – £40 million – in the university's history. The Hub, due to open in 2018, will bring together into a single building the engineers, scientists and medics: "This co-location is fundamental," he says. "We'll be putting together research groups some of which are already collaborating across multiple sites, but they'll now be in the same building."

More than that, the Hub will have a clinical facility "where we'll be able to conduct clinical studies and do small interventional procedures". What Professor Bull is aiming for is what he terms "a new translation route" to take innovative processes and procedures directly into patients. "It's not so much about making a commercial impact as making a societal impact," he says.

Amputees are benefiting from the latest biomedical engineering technologies

Photo © Chas. A. Blatchford & Sons Ltd

The Michael Uren Biomedical Engineering Hub that Imperial College is building at its new White City campus

WHITE CITY ENGINEERING HUB

Biomedical engineering research is the focus for capital projects at several UK universities, reflecting the broad agenda that incorporates not just medical concerns but issues such as the ageing population and even sports science. But within the agenda different facilities specialise on different areas, sometimes based on core technologies such as imaging, sometimes on groups of disabilities or diseases.

The focus for the Michael Uren Biomedical Engineering Hub that Imperial College is building at its new White City campus in West London with the aid of a £40 million grant from the Uren Foundation is to be musculoskeletal treatments. "So that means bones and joints and muscles and tendons and the like as well as tissue engineering," says Professor Anthony Bull, the professor of bioengineering who is the engineering lead for the Hub.

"This has been what you might call a slightly 'orphan' area where more than half of us as adults have significant musculoskeletal conditions such as osteoarthritis or simple wear-and-tear, but because it doesn't usually kill you it's not at the top of everyone's list like cancer and cardiovascular. There are also not just in this country but across the world increasing issues of trauma injuries from things such as road traffic accidents.

"There's also a significant issue with the ageing population. Two-thirds of those over 65 have diagnosed osteoarthritis, and what they're doing effectively is waiting for a joint replacement, because currently that's pretty much all you can do. But joint replacements might be great at the hip, but they're not so great anywhere else and you also have many years of pain before you end up with what is not a perfect solution. It's a crying shame."

"We'd be able to take a medical device all the way through to clinical trials without having to go to industry and that is truly exciting: it means we can move things on more quickly and maintain the links into the original research. It would fundamentally change the research environment we work in." There are plans also for engagement with the local community and for close working with the Hammersmith Hospital, right next door and already part of the Imperial NHS trust.

If Imperial's plans are about strengthening the innovation process within biomedical engineering, then Professor Zahedi at Blatchford is aiming to take biomedical innovation out into broader territory. He is leading a European-funded Horizon 2020 project called MovAid that is about the mass customisation of prosthetic and orthotic devices with the aim of automating the personalisation of replacement and assistive body parts throughout the manufacturing process.

"Effectively we're looking at factories of the future and supply chain infrastructure that will achieve this customisation," Professor Zahedi says. "We need to make this customisation economic through additive manufacturing and 3D printing, for example, but we also need sensors that are able to capture dynamic data so that we know the requirements for different actions and activities and incorporate these requirements into the supply chain."

Blatchford's existing customers among amputees are just part of the potential market for this kind of work, he believes. "What we've discovered is that the needs of the disabled are pretty identical to those of the ageing population, and the needs of the ageing population are pretty much identical to those of workers who are doing tasks that involve stretching or reaching that are beyond the human body's normal capability.

"Some of the pain disabled people have is like the pain ageing people have and the same as a worker who is pushing the limits of their body. So there is a common thread here." MR

Read more about medical engineering on pages: 100 190

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THE IMPACT OF ROBOTICS ON NEUROSURGERY

Robots are rife in factories but they are also making an enormous contribution to safer surgical procedures, says Renishaw

The Renishaw neuromate® was the first commercially available robotice device for stereotactic neurosurgery

THIS ARTICLE EXPLAINS:

- **By 2018 1.3 million industrial robots will be in factories globally**
- **Robots have been used in surgery for 30 years**
- **Telesurgery involves a 3D and HD view and 'wristed' instruments**
- **Stereotactic neurosurgery used by neurosurgeons to locate surgical targets within the brain**
- **The first commercially-available neurorobotic device for stereotactic neurosurgical procedures was the Renishaw *neuromate***

Industrial environments are rife with automation and robotic systems. The upwards trend is only increasing, with the International Federation of Robotics predicting that by 2018, 1.3 million industrial robots will be entering service in factories across the globe. Automated or robotic systems can increase the speed, reliability and accuracy of industrial processes.

The first application of a robotic system in surgery happened in 1985, 24 years after the introduction of UNIMATE, the first industrial robot. In this first robotic surgery, surgeons performed a neurosurgical biopsy using a PUMA 560 robotic arm. The robotic system allowed for greater precision in minimally invasive surgery compared to more traditional methods. The need for precision during brain surgery has led to an increase in computer-assisted surgeries (CAS). This technique involves using imaging technologies such as magnetic resonance imaging (MRI), computerised tomography (CT) or positron emission tomography (PET) to generate an image of the patient's brain. The surgeon will use this information to plan the route of surgery.

SURGICAL ROBOTS

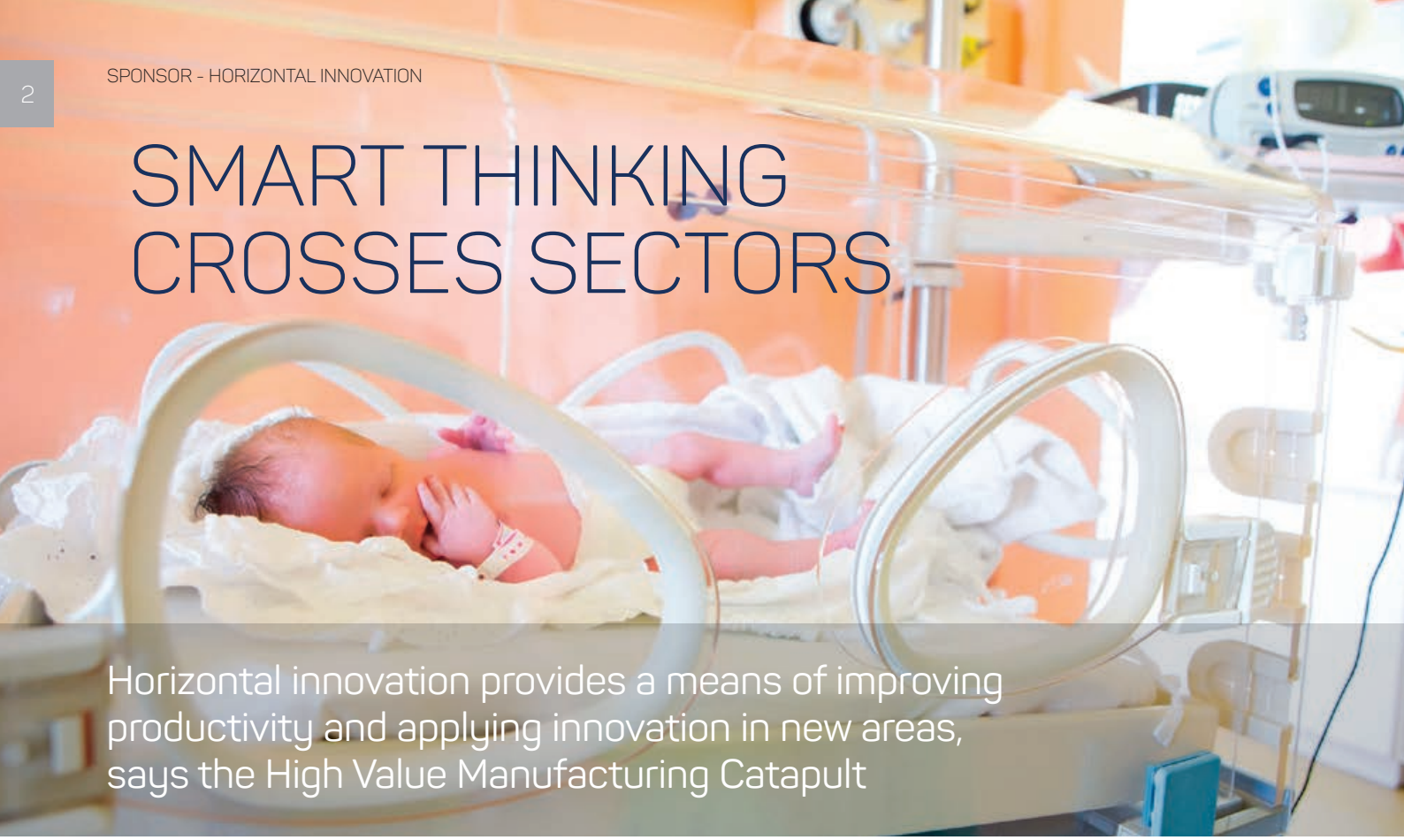
The most important factors to consider when classifying a surgical robot are in its surgical applications, its level of interaction with the surgeon, and the role of the robot in the surgery. Currently, the most common systems in robotic surgery are dependent systems, where the surgeon retains full control of the surgical instruments. This type of surgery is also known as telesurgery; it provides a 3D HD view, ergonomic design and wristed instruments that can bend and rotate more than the human hand.

Stereotactic neurosurgery is a technique used by neurosurgeons to locate surgical targets within the brain. It uses 3D imaging data and either an external frame or imaging markers attached to the scalp as reference points. This technique enables surgeons to reach targets that are deep in the brain in a minimally invasive way. Surgeons would most commonly use this technique in procedures including deep brain stimulation, stereoelectroencephalography, biopsy and endoscopy, or to deliver devices or instruments to a small target in the brain.

The first commercially-available neurorobotic device for stereotactic neurosurgical procedures was the Renishaw *neuromate* stereotactic robot. This device can decrease procedure time and increase safety in stereotactic neurosurgery in frame and frameless procedures. The robot has five degrees of freedom, can be mounted with surgical instruments and can be used in various procedures. MR

"The *neuromate* stereotactic robot can decrease procedure time and increase safety in stereotactic neurosurgery in frame and frameless procedures. The robot has five degrees of freedom, can be mounted with surgical instruments and can be used in various procedures."

SMART THINKING CROSSES SECTORS



Horizontal innovation provides a means of improving productivity and applying innovation in new areas, says the High Value Manufacturing Catapult

THIS ARTICLE EXPLAINS:

- UK productivity lags other industrialised nations
- Technology transfer represents 'tremendous opportunity'
- Innovations from one sector create applications in another
- IET and MIA started work on horizontal innovation this year
- Technologies moving from FI into neo-natal care and supermarket refrigeration

The latest ONS figures on productivity do not make good reading, but bridging the productivity gap is critical to our ability to compete in the high-tech, global markets of the future.

The manufacturing mantra of continuous improvement remains valid but, in a fiercely competitive global market, it is clear that it is not, on its own, enough to gradually improve our productivity. We need step change improvements. This requires the development and adoption of innovative technology solutions.

The centres in the High Value Manufacturing Catapult work with manufacturing companies of all sizes to accelerate the journey of new manufacturing technologies to commercial reality. Our recent economic impact figures show that the approach works – every £1 of government core investment in our Catapult has already embedded £15 of manufacturing value-add in the UK economy.

It is no coincidence that much of our work is done with innovation-hungry sectors that are already very productive, such as aerospace and defence – which increased productivity by 30% over the past five years – and the British automotive industry, which is the most productive in Europe. It is key that lessons learnt from innovation in these successful sectors are used for the benefit of UK manufacturing, and the wider economy.

THE OPPORTUNITIES OF TECHNOLOGY TRANSFER

There is a tremendous opportunity in terms of facilitating and encouraging innovations that are tried and tested in one sector, and translating them to applications in other sectors. Additive manufacturing technology, of which aerospace was an early adopter, now finds seemingly limitless opportunities in the medical technologies sector, including surgical instruments and orthopaedic implants.

The automotive industry has started to exploit the potential of advanced composite materials, which to date were mainly used in aerospace applications.

Above: The Greater Manchester Neonatal Transport Team at St Mary's Hospital, Manchester, conducted a project into the effects of transporting critically ill newborn babies between hospitals using an innovative piece of equipment with origins in F1

Advanced composite materials combine great strength and stiffness with low weight. The HVM Catapult is leading the charge to reduce cost and improve production rates of these materials to support the UK automotive market for high volume affordable composites, which is predicted to grow from a current value of £300 million to over £3 billion in 2030. The UK has an opportunity to build on existing capabilities and grab its share of the total global market, which could be worth £80bn. Lessons learnt to reduce costs in automotive can then be ploughed back into aerospace.

THINKING HORIZONTALLY

The Institution of Engineering and Technology (IET) and the Motorsport Industry Association (MIA) also joined forces earlier in the year to address the current lack of widespread exploitation of 'horizontal innovation' in the business technology community. The UK is internationally renowned for its creativity, research, and innovation, but often it seems that new technologies or processes can get

Engineers and technologists should strive to share information, transferring innovation between sectors to create new products and applications

locked into one sector, an industry – or even one specific company. As an industry and as a society, we don't tend to work together to fully exploit the potential of new technologies – which means that we are missing out on the rewards that they could bring. The IET's horizontal innovation initiative is about addressing the barriers to sharing ideas, and ensuring that more innovations are used where they are needed, and not just in the sector in which they are created.

There are already some outstanding best practice exemplars of horizontal innovation. For example, Formula 1 technology is benefiting neonatal care. The Greater Manchester Neonatal Transport Team at St Mary's Hospital Manchester conducted a project into the effects of transporting critically ill new-born babies between hospitals using an innovative, 'race-bred' piece of equipment, secured to a transport incubator. The data logger uses an accelerometer combined with GPS technology to provide an electronic movement profile of the whole transfer. The study compared how the speed of the ambulance, G-forces and vibration experienced by the baby related to the stability of the vital signs such as heart rate and blood pressure. Premature and critically ill babies needing intensive care transfer are at increased risk of brain injury. A better understanding of the physiological effects of movement and vibration, at a critical stage in their lives, will enable technological improvements in ambulance and incubator design and real time driver feedback, to improve long-term health outcomes when these journeys are unavoidable.

Williams Advanced Engineering has also collaborated with UK start-up Aerofoil Energy to develop a new aerodynamic device that can significantly reduce the energy consumed by refrigerators in supermarkets and convenience stores. Developing a new retrofit aerofoil system that keeps more of the cool air inside the refrigerator cabinet, this innovative technology will result in significant energy savings. Sainsbury's, the UK's second largest supermarket chain, has been testing the product at a number of its stores, with impressive benefits for the supermarket's carbon footprint and costs.

SHARING INFORMATION

Engineers and technologists should strive to share information and think about how to transfer knowledge and technology from one sector to another. The High Value Manufacturing Catapult and IET can help by creating connected communities fostering knowledge exchange, and generating new solutions – with existing technology and know-how. From an innovation and technology perspective, UK manufacturing is held in high regard across the world. But as with many other technology ideas or innovations, the real struggle is converting those ideas into GDP and growth. The High Value Manufacturing Catapult has been hugely successful in recent years, addressing shortcomings, and helping UK businesses to innovate and grow. By working collaboratively with the HVMC, the IET is looking to help UK businesses recognise the potential for their existing technologies within other industries.

Earlier this year, the IET invited SMEs to apply for its funded R&D programme to make innovation a reality. As the UK healthcare sector is an area that can greatly benefit from technology development in other sectors, the institution launched this programme to support a UK technology business in solving some of the current NHS challenges. The SUCCESSFUL APPLICANT IS [announced November], showcasing a technology that could potentially save the NHS up to £500m per annum.

The SME now has the opportunity to access one of the state-of-the-art HVMC centres in Coventry, the Manufacturing Technology Centre. It gains access to the MTC's flexible factory capabilities and use of some of the most advanced manufacturing equipment in the world, as well as receiving support in business planning, product design, IP protection and engineering expertise.

This programme is the first of what will be many collaborations between the High Value Manufacturing Catapult and the IET. If we are to effectively drive horizontal innovation forward, we need to reach out beyond engineering to the people that are experiencing the problems and challenges that we, as engineers, are trying to solve, and include them as an integral part of this new initiative. MR

The High Value Manufacturing Catapult and IET are collaborating to give small and medium sized enterprises the opportunity to use state-of-the-art MTC technology

PHARMACEUTICALS

BIG PHARMA COLLABORATES FURTHER TO THRIVE

Drug manufacturing in Britain is world-class and, in the spirit of partnership, is embracing technological trends such as big data and mass customisation. Zoe Cormier reports

Pharmaceutical companies and researchers used to closely guard secrets but there is now a high level of collaboration

With exports worth more than £20 billion annually, the British medicines industry is one of the country's leading manufacturing sectors. Because it is so heavily regulated, the sector as a whole changes and progresses relatively slowly compared to other industries: one drug could take 20 years to develop. However, the past few years have seen enormous changes in the industry, largely driven by the huge advances made at the core research level by projects such as the Human Genome Project.

One of the biggest drivers of change, says Craig Johnston, operations director for the Centre for Innovative Manufacturing In Continuous Manufacturing and Crystallisation (CMAC), was the establishment of the Medicines Manufacturing Industry Partnership (MMIP): an independent body set up by government and industry to ensure that the UK is recognised globally as a world-class, advanced centre for medicines manufacturing.

"This is a particularly good effort being made by pharmaceutical companies to speak with a common voice – historically, the aerospace and automotive industries have been much better at this," says Johnston.

"Research is a team sport," says Magda Papadaki, Head of Manufacturing Innovation at The Association of the British Pharmaceutical Industry (ABPI) and manager of the MMIP. "It needs to be collaborative, but it has traditionally been tricky to get people collaborating at the health system level. But now the willingness is there. We are seeing collaborations between players that are not used to working together, which is necessary to harness the latest developments in our scientific under-

THIS ARTICLE EXPLAINS:

- Pharmaceuticals industry is a leading light of British manufacturing
- Sector changes slowly but is embracing big data and personalised manufacturing
- Intelligent packaging that helps patients comply with medication regimes on horizon
- Industry moving to avoid wasting drugs
- Era of 'blockbuster' medications is changing to one of patient-tailored remedies

Technology in pharma manufacturing is embracing wider trends such as personalisation and big data

Advanced therapies will be produced in low volumes and targeted at small populations

standing of disease, as well as the new technologies that can be brought in from other industries."

CAPITALISING ON DATA

One of the biggest trends at the moment, says Papadaki, is the sector joining other industries in capitalising on 'big data': capturing the enormous amount of information that patients are generating, and finding ways to put it to good use. "This is a very new trend: manufacturers are perhaps the last to come into the big data era," explains Papadaki. "Until now the main purpose was to try and capture patient-level, real world outcomes, but now there is a movement in the industrial revolution called 'Industry 4.0'."

Also known as 'Intelligent Manufacture', this mode of operating would actually use the data gathered during the manufacturing process itself to make drug development and manufacture more efficient at every stage of production. "This would allow us to design end-to-end and continuous processes where we are able to see what's happening and to change our parameters and protocols in real time, essentially controlling not just the quality but also the end products," says Papadaki.

January 2016 saw the launch of a £20.4 million, four-year collaboration between commercial, government and academic partners to help the entire pharmaceutical manufacturing sector achieve this goal: ADDoPT (Advanced Digital Design of Pharmaceutical Therapeutics), which is part-funded under the Advanced Manufacturing Supply Chains Initiative (AMSCI) and supported by the MMIP. GlaxoSmithKline, AstraZeneca, Bristol-Myers Squibb and Pfizer are working with academics from the Universities of Cambridge, Leeds and other partners – keeping in line with the biggest trend of 2015: collaboration.

In the past, pharmaceutical companies tended to closely guard their intellectual property and trade secrets. But the past few years have seen a profusion of 'pre-competitive'

NEW CENTRES FOR PHARMA IN 2016

In keeping with 2015's trend for new, state-of-the-art facilities, the past year saw the approval, construction and opening of a number of new centres:

- The government is constructing a £55 million GMP (Good Manufacturing Practice) facility in Stevenage, just outside London: The Cell & Gene Therapy Catapult centre. Cell therapy – such as with T cells, a kind of white blood cell – promises to be one of the biggest areas of growth in the new arena of advanced therapeutics. It is due to open in 2017.
- The Centre for Process Innovation is making progress towards opening the National Formulation Centre and the National Centre for Healthcare Photonics, both of which are set to open in the NETPark in Sedgefield in 2018. Both of these – like other CPI centres – will be stocked with an array of cutting edge laboratory equipment which pharmaceutical companies will be able to use to develop, prove, prototype and scale up new products and processes, without having to invest in the hardware themselves, thus lowering costs and the barriers to getting products out to market.
- CMAC officially moved into The Strathclyde Technology and Innovation Building (TIC) in 2015, and this year the organisation stocked its new purpose-built facility with the latest scientific instruments with more than £30 million in funding.

Drugs are being targeted at the people who are genetically predisposed to respond positively

collaborations that allow for a more open and productive exchange of ideas. This ultimately should help the entire sector develop and refine manufacturing processes, analytics and designs more effectively.

"This will help partners not only better control the quality, precision and accuracy of their processes, but also start designing and rolling out the necessary infrastructure to capture the data, develop the methodologies to understand them, and create the frameworks to share solutions," says Papadaki.

REAL-TIME ANALYTICS AND INTELLIGENT PACKAGING

One of the most important ways that this wealth of data can be used to improve manufacturing protocols is by refining not the drugs themselves, but the materials that contain them: packaging and labels. "This might not sound like the most engaging topic in the world, but it's a very exciting area of innovation," says Clive Badman, industrial chairman of CMAC, and head of Pre-Competitive Collaboration at GlaxoSmithKline.

GSK is one of the two main pharmaceutical giants – along with AstraZeneca – partnering with academic researchers in a project launched in 2014: ReMediES (RE-configuring MEDIcines End-to-end Supply), initially funded to the tune of £23 million – a figure that has now grown closer to £26 million, says Badman. It is geared towards using emerging technologies – such as radio-frequency identification (RFID) or near field communication (NFC) chips – to reduce inefficiencies in the supply chain, and packaging and labelling in particular.

"Not only are there new materials we can use in packaging, there are also new ways of using electronic packaging being developed that can help us track where a product is, the environmental conditions in which it is being stored – such as humidity and pressure, which can affect shelf life – and also the things we can do to help with patient compliance," says Badman.

Getting medicine into the hands of somebody who needs it is just one step: making sure they take it at the right time, such as with patients with memory impairments, or ensuring that they take the entire prescription even if they feel better quickly, such as with antibiotics, is crucial to maximising the effectiveness of any drug.

Moreover, says Papadaki, electronic packaging could be used to send information back to the manufacturer, reporting and correcting any flaws in the production line. "If you have, for example, adverse effects from a batch of drugs, how soon could we recognize this in a patient population? And how quickly could we change the labels, or change the manufacturing protocol?"

Fergal O'Brien, director of the biologics division at The Centre for

Getting medicine into the hands of somebody who needs it is just one step: making sure they take it at the right time, such as with patients with memory impairments, or ensuring that they take the entire prescription even if they feel better quickly, such as with antibiotics, is crucial to maximising the effectiveness of any drug.

Process Innovation (CPI), agrees. "Real-time analytics are becoming an increasingly important feature of next-generation processes," he says. "The ability to determine the status and identify processing anomalies almost instantaneously can be the difference between a successful outcome and a failure. A lost batch or failed purification run can result in potential losses of millions of pounds."

The buzzphrase of the day is 'intelligent packaging'. Not only could packaging with printed electronics monitor the shelf life, quality, and use of manufactured drugs, it would ultimately feed into one of the biggest revolutions taking in pharmaceuticals: personalised medicine.

GETTING PERSONAL

Every area of medical science – from diagnostics to prevention and medication – is moving towards what are broadly known as 'personalised medicines', or 'advanced therapies': therapeutics that are manufactured in low volumes, aimed at small patient populations, avoiding wasting drugs on people for whom they will not work.

In the arena of pharmaceuticals, drug companies are moving away from the era of the 'blockbuster drug' – pills churned out in huge amounts, applicable to a large percentage of the population – and towards precision therapeutics, which are geared towards smaller numbers of people – but which are more likely to be effective. Using the latest findings from genomics, proteomics and physiology, physicians hope that they target drugs at the people who are genetically predisposed to respond positively, and thus avoid the waste that comes with prescribing drugs to people who do not respond – or who experience side effects.

"We just are at the dawn of the 'advanced therapy' era," says Papadaki. "Gene therapies, tissue-engineered products, and all other so-called 'precision medicines' are contributing to the growing trend towards patient-tailored medicines."

And all of these will require tailored diagnostics, tailored administration, detailed follow-up, and – crucially – new devices to ensure they are given and taken appropriately. "There is an entire pool of new technologies and platforms that we as an industry will need to understand and commercialise," says Papadaki.

"All these new technologies are bringing new complexities in their underpinning science, and that ultimately also calls for greater innovation in the ways that we do manufacturing," she adds. "Advanced therapies – in particular, biologics, which can contain genes, cells and tissues – are complex products, and they can become very costly if manufacturing capacity and manufacturing technologies do not keep up." To ensure that the UK remains at the forefront of innovation in this area of medicine, the Precision Medicine Catapult – funded by Innovate UK, the Government's innovation agency – was established in April 2015.

2017 AND BEYOND

As with 2016, the next year promises to see big innovations in 'advanced therapeutics', or 'precision medicines', especially in the arena of biologics: tissue-engineered products, cell therapies and gene therapies.

"Medicines will eventually become personalised in nature and therefore manufacturing paradigms will need to reflect this shift," says Fergal O'Brien, director of the biologics division at The Centre for Process Innovation (CPI). "The present manufacturing model has served the industry very well, but alternative models are presenting an attractive alternative due to a combination of research breakthroughs, regulatory advancements and patient demand."

There is an industry-wide move to adopt 'continuous manufacturing' processes, which keep reagents in continuous flow, rather than producing drugs one batch at a time. Considered the future in many areas of chemical and biological manufacturing, continuous processes keep costs down by reducing waste.

Advances in robotics, electronic packaging and big data will also be important drivers of change in 2017, says Papadaki of The Association of the British Pharmaceutical Industry. New to the scene, but potentially a big game changer, could be the introduction of 3D printing of drugs. "We are trying to encourage the use of 3D printing to produce more innovative compositions of products, such as medications that are tricky to produce, like drug-antibody combinations," she says.

But perhaps more dramatic in 2016 was not a shift in government funding for personalised medical treatments, but awareness in the general population. "For us, the biggest trend is the growing awareness and the publicity given to the importance and potential impact of peronalised medicine and targeted therapies – this has really only happened in the last 12 months," says Andrew Davidson, National Outreach Manager for the Engineering and Physical Sciences Research Council Centre for Innovative Manufacturing in Emergent Macromolecular Therapies. "But until recently, people in the industry really hadn't cottoned on to the reality that the economics of manufacturing was going to be an important issue."

Recently, however, that has changed. "Over the past 12 months, the supporting infrastructure and manufacturing infrastructure have both really progressed, and that is important to us because these innovations need to have the facilities in which they can be developed further, proven and demonstrated," says Davidson. "The government has made very significant investments in those areas – and those are now coming to fruition."

Johnston of CMAC agrees. "The biggest difference between last year and this year in the UK is the technology infrastructure – it has improved significantly," he says. "Investment has paid off." MR

Read more about pharmaceuticals manufacturing on pages:

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CAR PROVES THE PERFECT VEHICLE FOR ELECTRONICS SECTOR

ELECTRONICS

Electronics manufacturers need to innovate and embrace sustainability to be competitive. But it is the connected car that holds most promise for the future of the sector. Jonathan Newell reports

Sensors and miniaturisation are at the heart of Industry 4.0

THIS ARTICLE EXPLAINS:

- Industrial internet of things heralds miniaturisation drive
- Huge opportunities for UK electronics suppliers
- Brexit and currency volatility cause for concern
- Drastic transformation' of automotive electronics
- Autonomous cars close to reality

The ability to focus on sustainability, innovation and rapid development is the key to UK electronics industry players succeeding in 2017 and beyond.

2016 has been as good for innovators as it has been bad for those who doggedly persevere with stagnating technologies. There will certainly be no comfort in 2017 for manufacturers who do not move on to embrace such rapidly emerging applications as Industry 4.0, connected and autonomous vehicles (CAV), or miniaturisation at the next level.

There are also questions concerning the impact of Britain leaving the European Union, and of pushing the existing boundaries of sustainability – a position in which European electronics suppliers currently have the edge over their competitors further afield.

SUSTAINABILITY AND INNOVATION KEYS TO COMPETITIVENESS

Being sustainable, innovative and flexible are the keys to remaining competitive in a short-term future for the electronics sector that is technologically and politically more challenging than ever. The industry is watching the way trade connections with the EU change from their current position, and how the pound bears up in the currency markets – both of which can have a profound effect on business for UK manufacturers.

For exporters, there is the temptation to believe that a weaker pound will have a positive effect on export trade, which is certainly true for price-sensitive commodities. But for technology exports, which are more demand-driven, the effect will be on margin adjustments rather than increased sales. This should also be weighed against the price of materials, particularly if imported. The net effect could very easily be negative.

LEVELS OF AUTONOMY FOR THE CONNECTED VEHICLE

Level 0 - Non Automated	Driver only	Level 0 - Non automated
Level 1 - Function specific automation	Assisted	Level 1 - Assisted
Level 2 - Combined function automation	Semi-automated	Level 2 - Partial automation
Level 3 - Limited self-driving automation	Highly automated	Level 3 - Conditional automation
Level 4 - Full self-driving automation		Level 4 - High automation
		Level 5 - Full automation

LEAD-FREE SOLDER

According to Jeremy Pearce of the International Tin Research Institute (ITRI), two-thirds of the global electronics industry is currently lead-free, with this trend forecast to hit almost 90% by 2024. A lot of this growth is expected from the aerospace industry, which is slow to adopt lead-free technologies due to nervousness about reliability. Industrial products also expected to increase lead free solder content and consumer goods are already high in lead-free.

The UK and Europe currently hold a manufacturing advantage in terms of lead-free soldering as there is a lot of associated expertise in UK universities and defence companies, a position reflected in Europe, particularly Sweden and Switzerland.

By contrast, China still retains a high lead content in its manufacturing base, much of which serves the enormous domestic market. Wave soldering is the favoured process, with some companies transitioning to lead-free paste processes to meet the regulatory requirements of international market. Once China catches up in this respect, much of the technology advantage held by the UK will be eroded.

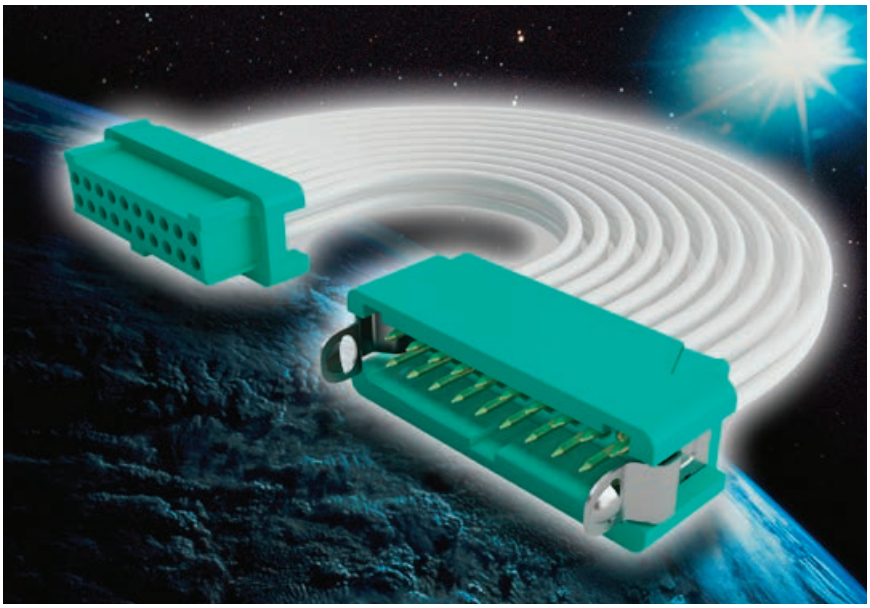
Another aspect of sustainability concerns the use of conflict minerals, particularly gold, tin and tantalum ores. Gold content has gone down in electronics and there is an active expansion in the recycling and recovery of raw materials from scrap, with an increasing desire to keep the value within the UK. The focus now is on the depopulation of circuit boards, which increases the ability to recover more materials like tantalum. In this process, the boards are first of all depopulated with components like capacitors put to one side to recover the tantalum. The remainder of the board is then crushed and processed to recover other metals like tin and gold.

To push this process along, ITRI is developing a voluntary, industry-led code of conduct based on OECD standards and which is planned to exceed EU and country standards.

CONSUMER GOODS DRIVE MINIATURISATION

Very high volume consumer goods remain the most significant driver of miniaturisation. Much of the manufacturing for such products has long been performed overseas, and will continue to be so. According to UK component suppliers such as Harwin and EDAC, the bulk of the UK customer base for their products comprises contract manufacturers and volume manufacturers for industrial and telecommunication products. Where industrial electronics systems had once not been subject to the same miniaturisation challenges as consumer goods, this tide is about to turn with the advent of the Industrial Internet of Things (IIoT).

With industry becoming more connected, and with the domestic IoT placing more industrial control technology inside the home, Harwin is predicting a large increase in demand for miniaturised equipment for control and communication systems, much of



Connecting vehicles with consumer electronics holds promise

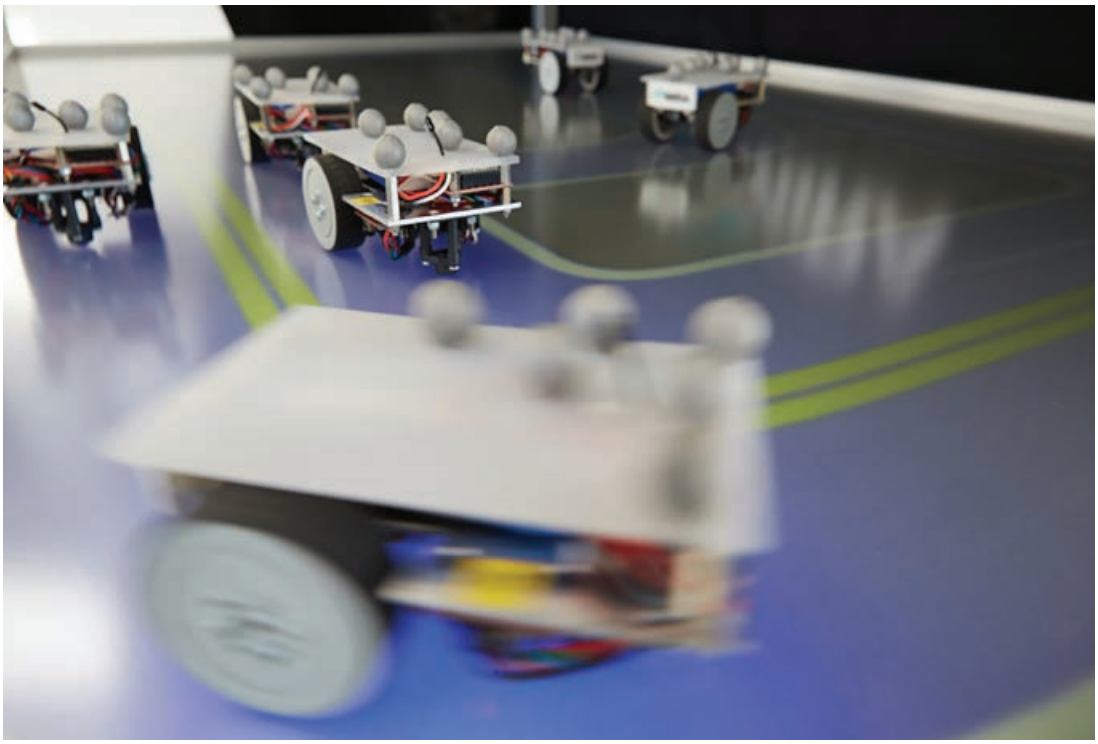
A MATTER OF COMPLIANCE

Emerging technologies are creating a new compliance landscape. Security for embedded electronics and the greater RFI vulnerability of miniaturised circuits are placing greater demands on skills needed within the electronics industry, says MIRA's David Ward.

2017 will see a move toward improved compliance in completely autonomous vehicle technologies and an emphasis on the need for diversified skill sets. Currently the only standard governing the realm of cybersecurity for automotive is SAE J3061. Launched in 2016, the standard defines a lifecycle framework to incorporate cybersecurity from concept phase through production, operation, service and decommissioning. In 2017, there will be a greater focus on conformity to ensure effective verification and validation techniques are in place in vehicle development.

There will also be a greater focus on electromagnetic compatibility as with any increase in electronic content in a vehicle, the potential for interference multiplies. Training and awareness of the latest standards will be a constant requirement, while access to the correct equipment and facilities used will be key to the development of the industry in the future.

"While the future for the automotive industry is not without its challenges, as it moves ever closer to full autonomy it is clear that the future is bright," Ward says.



The race to produce autonomous vehicles is hard fought and the UK is getting out in front

which is likely to be sourced from UK suppliers.

Predictions for the uptake of the IIoT vary but industrial equipment manufacturers have already begun to put explore connectivity options to take advantage of the phenomenon of Industry 4.0. Industry 4.0 evangelist at Robert Bosch GmbH, Dr Stefan Assman, describes it as, "An approach to manufacturing and distribution that employs Internet of Things (IoT) technology to build a connected and intelligent infrastructure using sensors and software." Assman goes on to say that the key to Industry 4.0's success is distributed intelligence, with sensor systems at its heart. For successful deployment, the enabling technology needs to be cheap and easily deployed, either in new machinery or a retrofit.

The opportunity is huge for UK electronics suppliers involved in programmable logic controllers, shop floor communications, or machine building. "Demand for wireless modules will grow enormously, and we're already seeing the impact," says Ben Green of Harwin.

THE LARGEST PIECE OF CONSUMER ELECTRONICS: THE CAR

After decades of small, incremental changes in automotive technology, the car is transforming into the largest consumer electronics device that anyone is likely to purchase. Advanced safety systems, electrification of the powertrain, and connectivity are at the heart of this transformation. The UK is one of the top nations for connected vehicles, along with Germany, Sweden and the US, which are driving the high level of innovation.

According to Guenther Kraft of automotive electronics giant Harman, we are undergoing a drastic transformation of automotive electronics. A significant element of this is the step change in connectivity, fuelled by device-hungry consumers demanding to be in touch wherever they go.

Emphasising the importance of the car on the consumer electronics market, Kraft says: "The automotive market provides a global, large-scale market that can amortise the development required of mass-market, powerful chipsets. In many cases, due to the scale and performance demands, the car is developing these technologies ahead of consumer devices.

"For example, scalable system on a chip (SoC) products are increasingly being driven by the car not by consumer devices. In the past, the tech drivers came from devices such as smartphones and the like, but that is now changing. The performance needed for infotainment, driver-assistance systems and connected cars means automotive SoCs will overtake the performance of SoCs in the most powerful smartphones."

The race amongst the car giants to produce driverless cars is intense, and the UK is in the leading pack, a place where it intends to stay with the help of government funding, and some of the world's best automotive engineering organisations, such as Horiba MIRA and TRL.

According to David Ward, senior technical manager for functional safety at Horiba Mira, in the move to connected and autonomous vehicles, there will be higher levels of automation and greater connectivity between vehicles. "As the automotive industry continues to move towards lower levels of emissions, there is also a renewed emphasis on electrification of powertrains. This means a much greater number of electronic devices in vehicles to enable these changes," he says.

Although the race is not over, it is certainly well on its way, with autonomous vehicles expected to be commercially available by the end of the decade. The SAE has defined six levels of vehicle automation from 0-5, with level 2 vehicles already commonplace on the roads. Moving to level 3 requires a leap in technology but some manufacturers, such as Tesla, have already begun to make that move. Autonomous cars are closer to reality than many believe and 2017 will see significant activity in technology development and testing. MR

A GOOD YEAR FOR INNOVATIVE PROCESSES

From the Internet of Things to bio-drug manufacture and energy from waste, it has been a busy 2016 for the CPI


The National Biologics Manufacturing Centre is helping deliver the government's strategy for life sciences

2016 has been another very busy year for The Centre for Process Innovation (CPI), from breaking ground on our fifth national centre, to leading some of the country's most exciting multi-million pound product and process development projects.

During 2016 we continued to build upon our position as a partner for companies seeking to capitalise on the internet of things, a world in which everyday physical objects are able to exchange data with one another wirelessly over the internet. Our leading expertise in the incorporation of printed sensors, ultra-thin flexible circuitry, and wireless communication devices, is enabling this next generation technology which opens up any object or process to potential digitalisation.

We are leading a Horizon 2020-funded project called SCOPE, which will create a UK manufacturing supply chain for the widespread adoption of smart packaging incorporating wireless near-field communication (NFC) technology. Another key project successfully completed in 2016 is HaRFest, which developed a novel printed energy harvesting device that draws energy from the user's mobile telephone to power NFC-enabled printed electronic components.

THE NATIONAL BIOLOGICS MANUFACTURING CENTRE: ONE YEAR ON

Our state of the art £38m National Biologics Manufacturing Centre opened in September 2015 to deliver the government's Strategy for UK Life Sciences, which aims to see the UK become a global leader in this field. In 2016 partners from every stage of the biopharmaceutical supply chain have benefitted from our expertise in all aspects of development and manufacture, including mammalian and microbial process development, scale up, tech transfer, advanced bioanalytical development, and multivariate data analysis.

In 2016 we brought together a consortium of industry partners comprising multinationals UCB and Lonza alongside SMEs to deliver a multi-million pound AMSCI-funded project which will demonstrate an improved pathway for developing and manufacturing novel biopharmaceuticals. This new route to market will facilitate early decisions as to the suitability of drug candidates, thereby reducing candidate failure at a much earlier stage to improve the chances of clinical and manufacturing success. This will enable funds to be targeted upon the most promising molecules only, making production and manufacturing cheaper, and incentivising biopharmaceutical research and development for the benefit of the UK health service and economy.

IN BRIEF

- CPI breaks ground on fifth national centre
- Centre building on position as IoT partner
- Biopharma supply chain benefiting from Biologics Manufacturing facility
- CPI plays key role in gold nanoparticle project
- Healthcare Futures Centre set for 2017

WASTE PRODUCTS

Throughout 2016 we continued to advance our objective of helping the UK strengthen its bio-economy. We are leading a multi-party project to develop an anaerobic digestion (AD) process utilising farmed seaweed. Currently an undeveloped resource which could be farmed from the UK's extensive shoreline, seaweed is highly efficient and sustainable as it does not require arable land, fertilisers, or fresh water for production. The project, entitled SeaGas, will investigate the use of seaweed to produce bioenergy and a digestate suitable for use as fertiliser. A unique UK implementation plan will be developed to facilitate uptake by AD end users, build a viable supply chain for farming and storage of seaweed, and enable further exploitation of seaweed across other applications. As a partner to several important collaborative research and development projects, we have helped to develop and commercialise useful bio-products derived from waste. Examples include a project with UK SME Fiberight to demonstrate a commercial process for turning landfill waste into a repeatable sugar which can be used as a raw material for production of bio-based fuels, chemicals and materials.

THE GRAPHENE APPLICATION CENTRE

Our Graphene Applications Centre is helping the UK to characterise and capitalise on graphene, the world's thinnest material, which is 200 times stronger than steel, incredibly flexible, and a highly effective conductor and barrier material. Two years into this five-year programme, CPI is enabling industry to prove, prototype and scale up graphene applications, and has made great progress in developing a unique capability for characterising and utilising graphene.

To date, CPI has run 34 projects and engagements with major UK graphene suppliers, and end users from a variety of market sectors including aerospace, coatings, electronics, nuclear, energy, and healthcare. Although many of these projects are commercially sensitive, examples of projects in the public domain include the development of graphene-based composites for aerospace applications, transparent non-metallic electrodes for wearable medical devices, and water filtration for the UK water and nuclear industries. MR

TEXTILES SET FOR TAKE-OFF

Backed by investment in new mills and the stamp of quality of the British brand, there is a renaissance taking place in UK textiles manufacturing, writes Kate Hills

The British textiles sector is benefiting from a wave of investment in new plant

UK textile manufacturing is in a very different place today compared to five years ago, when the Make it British campaign was launched.

Back in 2011, the textiles industry in the British Isles was still in decline; only a madman would have considered opening a new mill on these shores. Fast forward to 2016, and not only have several new textile mills and manufacturing plants opened their doors, but one of these new factories is a cotton spinning mill – the first of its kind in Britain for several decades. According to its owners, English Fine Cottons, it is the most technically-advanced cotton spinning mill in the world.

What has caused the U-turn? There have been several factors that have contributed to the rise in demand for UK-made textiles. These include the increasing costs of overseas production due to exchange rates and wage inflation; a concern about the sustainability of using overseas factories with poor safety and welfare rights following the Rana Plaza factory collapse in Bangladesh in 2012; a trend for heritage-look product, which suits the fine knitwear, tweeds, worsted woolens and Goodyear welted footwear that Britain traditionally makes so well; and a media focus on products that tell a story. There is no better story to be told than that of textiles being made in mills in the land where the Industrial Revolution began.

MADE IN BRITAIN

There has been a 25 per cent rise in the export of British-made apparel and clothing since 2011. This increase has been largely due to emerging markets, such as China, seeking products with a 'Made in Britain' label. A survey carried out by Barclays and the Centre for Economics and Business Research found that, in these emerging markets, a UK-made product could command up to eight per cent more by carrying a 'Made in Britain' label – something that the textile industry has been quick to capitalise on. This renewed interest in British-made clothing and textiles has seen staff employed within the garment manufacturing sector grow by nine per cent since 2011, according to research by the UK Fashion and Textile Association Up to 20,000 more jobs could be created within textiles by 2020 say estimates.

THIS ARTICLE EXPLAINS:

- British-designed and made textiles command premium overseas
- London remains the UK fashion capital
- Manufacturers reshoring textiles
- 'Made in Britain' is stamp of quality
- New mills and factories opening up

Yet the UK textile manufacturing sector remains a fragmented space. Decades of decline have left it bereft of many of the links which contributed to its supply chain, while years of underinvestment have seen most of the big players close down or move production overseas. This leaves an industry made up of thousands of micro businesses, who, on average, employ less than 10 people each, but who between them contribute to the manufacture of more than £9 billion worth of textile related products a year. Estimates suggest that technical textiles for the aeronautical and automotive industries contribute to up to £2bn of this figure, while the remainder is made up of cloth, garments, and footwear for the fashion and workwear sectors.

LONDON THE FOR HIGH-END GARMENTS

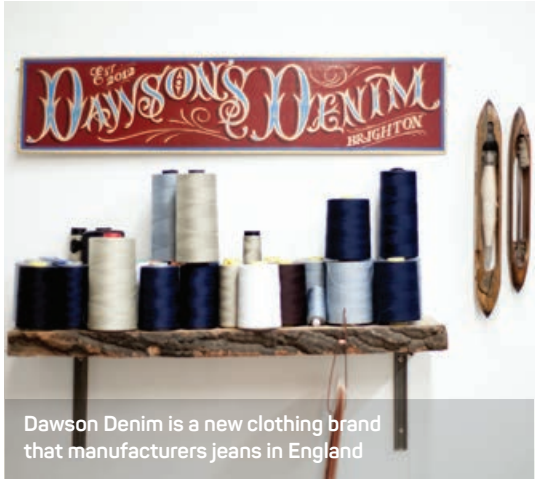
Geographically, the make-up of textile manufacturers across the UK is of specialists in each region. London has become the area for high-end garment production, catering to many of the designers at London Fashion Week. Leicestershire holds much bigger manufacturing units that predominantly make for the high street retailers. In terms of cloth, the vast majority of manufacturers are located in the traditional textile industrial heartland of Lancashire, Yorkshire and Greater Manchester. Northamptonshire, meanwhile, is still the centre of production for some of the best men's footwear in the world.

Over the last few years, the UK textile manufacturing sector has been awarded more than £12 million of Regional Growth Fund money, distributed by the Textiles Growth programme. This has enabled new mills to open, along with investment in state-of-the-art machinery by several established businesses. Investment by overseas firms looking to have British production facilities has seen Chinese investment in a Scottish knitwear factory, and a Thai-owned sock factory open in West Sussex. Many of the big fashion names who had all but abandoned Britain for cheaper production overseas are now looking at returning a considerable proportion of their production to the UK. Most notable of these is Burberry, which has announced it intends to open a fully vertical factory in Leeds to produce its world-renowned raincoats.

There is no doubt Brexit will have a considerable impact on textiles. In the short term, British-made brands are already reporting a rise in exports due to sterling's fall in value. However, the cost of raw materials, particularly in industries such as wool weaving, where the majority of the fibre comes from countries such as New Zealand, is likely to have an inflationary effect on the price of finished goods when they hit stores. However, with new factories and mills opening, the future looks bright for the UK textile industry. MR

Make it British

Meet the Manufacturer 2016 featured over 120 exhibitors from the UK textile and homeware sectors



Dawson Denim is a new clothing brand that manufacturers jeans in England

Roy Lowe & Sons are a sock manufacturer based in Nottingham. They recently reshored part of their production back to the UK

Kate Hills is the founder of Make it British and the Meet the Manufacturer trade show

John Spencer Textiles is one of the last remaining cotton weaving mills in Lancashire

Garment manufacturers, such as The Sampling Unit in London, are in much demand at the moment

UK TEXTILES FAST FACTS

The UK produces over **£9BN** worth of textiles every year

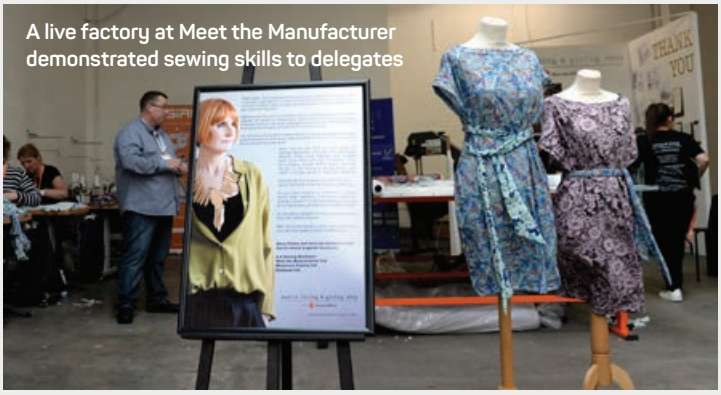
Over **105,000** people are employed in the UK textile industry and the figure is growing

In London there are over **5,000** garment machinists manufacturing high-end fashion

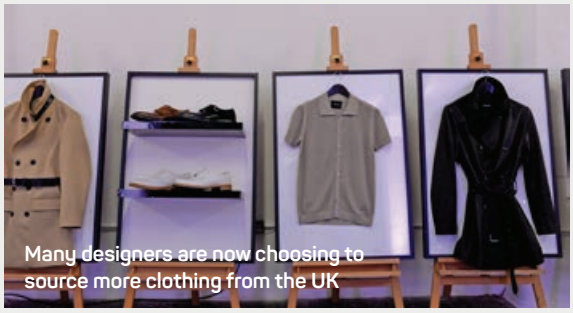
Over the last few years the UK textile manufacturing sector has been awarded over **£12M** worth of Regional Growth Fund money

The UK is the **15TH LARGEST** textile manufacturer in the world

Technical textiles contribute over **£1.5BN** to the UK economy



A live factory at Meet the Manufacturer demonstrated sewing skills to delegates



Many designers are now choosing to source more clothing from the UK

Next year's Meet the Manufacturer will have over 150 exhibitors, with plans to include more home textile suppliers

DON'T BE LEFT BEHIND

The world of wholesale distribution is changing. Make sure you can evolve with your customers' expectations.

THIS ARTICLE EXPLAINS

- How the historically conservative distribution world is changing.
- Why distributors are adjusting their business processes to adapt to the new normal.
- What key strategies distributors are turning to for success.

Over the last few years, much has happened in the historically conservative wholesale distribution industry. Distributors are realising that what drove their success in the past is not necessarily going to drive their success in the future. The industry has gone global and become more competitive than ever, with manufacturers moving into the wholesale distribution space, and online retailers looking for any opportunity to grab market share. The rise of social collaboration, the explosion of mobile devices, cloud and other digital trends are reshaping the industry as we know it. A new generation of employees, vendors and customers now expect to work the way they live, with access to information from any place at any time.

As customer behaviors and needs change, distributors must have the flexibility to adjust their business practices in order to meet expectations. The next generation of distributors is quickly embracing digital technologies to optimise daily operations and hone their competitive edge. It's not about offering the lowest prices. Instead, it's about finding ways to add layers of service that differentiate your business and build customer loyalty.

STAY COMPETITIVE

Staying competitive requires adopting new technologies that can transform your business. Three potential areas of investment that will support your efforts to win, serve, and retain customers include web/eCommerce, mobile devices, and cloud. According to Gartner, more than $1 trillion in IT spending will be directly or indirectly affected by the shift to the cloud in the next five years. That investment is also expected to lead to other opportunities[1].

This article goes on to say: "Cloud shift is not just about cloud. As organizations pursue a new IT architecture and operating philosophy, they become prepared for new opportunities in digital business, including next-generation IT solutions such as the Internet of Things," says Ed Anderson, research vice president at Gartner[1].

Distributors who can apply new technologies that allow them to evolve along with their customers will protect their businesses, gain market share, and more successfully engage with the buyer of the future. MR

The next generation of distributors is quickly embracing digital technologies.

"We have a national footprint and an evolving customer base who are increasingly relying on digital technology to do business. We therefore wanted to equip our colleagues with simple IT solutions in-branch."

– John Carter, Chief Executive Officer, Travis Perkins

MORE RESOURCES

DIGITAL STRATEGY IN DISTRIBUTION INFOGRAPHIC
http://bit.ly/infor-dist-graphic

SEVEN STEPS FOR BUILDING A DIGITAL STRATEGY FOR DISTRIBUTION
http://bit.ly/infor-dist-howto

CLOUD ERP IN WHOLESALE AND DISTRIBUTION: DRIVING SUCCESS ACROSS A WIDE NETWORK, ABERDEEN REPORT
http://bit.ly/infor-dist-cloud

INFOR CLOUDSUITE DISTRIBUTION ENTERPRISE VIDEO
http://bit.ly/infor-dist-video

[1] Gartner Newsroom, July 20, 2016, "Gartner Says by 2020 "Cloud Shift" Will Affect More Than $1 Trillion in IT Spending".

INVENTORY IMPROVEMENTS

IMPROVEMENT IN INVENTORY TURNS AS A RESULT OF ERP

41% CLOUD

25% ON-PREMISE

IMPROVEMENT IN PROFIT MARGINS OVER THE PAST TWO YEARS

15% CLOUD

8% ON-PREMISE

Source: Aberdeen Group "Cloud ERP in wholesale and distribution: driving success across a wide network", Nick Castellina, October 2015

Companies offering an exceptional customer experience can exceed the gross margins of their competitors by more than 26%.

Source: McKinsey, Customer experience: Creating value through transforming customer journeys, Number 1, Winter 2016

About Infor: Infor builds business software for specific industries in the cloud. With 15,000 employees and over 90,000 customers in more than 170 countries, Infor software is designed for progress. To learn more, please visit **www.infor.com**

SCOTLAND'S STAR OF THE SATELLITE FIRMAMENT

SPACE: Glasgow's Clyde Space is capitalising on a flourishing British space sector thanks to the big market for thousands of small satellites

Clyde Space is capitalising on high growth in the market for nanosatellites

THIS ARTICLE EXPLAINS:

- Exciting times for the UK space industry
- Glasgow's Clyde Space operates within the global nanosatellite market
- Company developing more than 70 satellites
- Tiny CubeSats are jewels in the small satellite crown
- Clyde designed and manufactured Scotland's first satellite, UKube-1

It is an exciting time for the British space industry, from the prospect of UK spaceports dotted around the country, to Major Tim Peake flying the flag for our space missions. This is a flourishing sector, and one which contributes £9.1 billion a year to the UK economy, growing at an average rate of 7.5 per cent per year.

This is showing no sign of slowing: the space industry in general is the hidden gem of the UK's economy, and the domestic market is anticipated to be worth £40 billion by 2030. Clyde Space operates within the niche global nanosatellite market, which shows tremendous growth year-on-year.

Factors driving growth within this market are reduced mission costs, increase in demand for earth observation-related applications of Smallsat, and the increase in number of application areas. Recognising the continued growth of the market, we have invested heavily in development over the past year, recruiting heavily, expanding facilities, and announcing our international expansion plans. We have more than 80 staff, and are growing at a rate of more than 50 per cent per year, a rate on par with our facilities. This increase is enabling Clyde Space to win more orders, and develop more than 70 satellites this year alone. With more than 80 per cent of our sales outside Europe, half of which are North American, our high volume manufacturing facility in Scotland contributes significantly to UK space exports, and is a hub for small satellite production.

THE POWER OF THE CUBESAT

Clyde Space is renowned for its extensive product heritage and products within the small satellite market, in particular in the area of tiny satellites. called 'CubeSats'. CubeSats are tiny satellites; a 1U is a single unit weighing 1kg, and measuring 10x10x10cm, and the 3U is 30x10x10cm. Our solutions have high credibility within the industry and have been busy for more than a decade racking up an impressive space mission heritage. We designed and manufactured Scotland's first satellite, UKube-1, the first of its kind to be commissioned by the UK Space Agency. Launched in July 2014 it has since successfully completed its mission.

In our 12th year of operation today, Clyde Space has continually expanded its capability and is now supporting missions at all levels, from conceptual design, development, integration, testing, through to launch and on-orbit operations.

We work with commercial, educational and government bodies and have supplied over 1800 subsystems for small spacecraft ranging from 1kg to 250kg in size to customers including: MIT, US Army, US Navy, LuxSpace, NASA and JAXA. This list is set to expand further with some game changing orders in the pipeline for projects over the next few years.

To meet rising demand, we increased our manufacturing capacity, creating an additional 2,500 square feet 'clean room' in early 2016 for building and testing satellites. This is being extended further still. With heavy investment in our processes, we are able to produce high volume spacecraft with shorter development times, without sacrificing on quality and reliability. Our increased capabilities and capacity allow us not only to offer our products at market disrupting prices, but also enable us to mass-produce full platforms and assemble constellations of CubeSats.

Our success is owed in part to the world-class engineering education opportunities and high-tech manufacturing heritage available right here on our front door. This combined with the growth of the market has provided Clyde Space with a platform to flourish and the business is moving from strength to strength. MR

THE SMALL SATELLITE MARKET:

- The global small satellite market is anticipated to be worth **$22 BILLION** for manufacture and launch
- More than **3,600 SMALLSATS** are expected to be launched over the next ten years, a significant increase compared to the previous decade

DISRUPTIVE INFLUENCES ON THE SPACE RACE

The new Satellite Applications Catapult is aiming to bring out of this world innovation to the traditionally conservative space sector

Satellite manufacturing can be conservative because of the hostility of the environment satellites operate in

THIS ARTICLE EXPLAINS:

- Space is an inspiring sector but the industry is conservative
- New Satellite Applications Catapult wants to help engineering companies
- New centre aims to break down barriers to innovation
- Disruptive Innovation for Space Centre will link with other facilities
- Companion centre in Bucks under development

The space sector has been responsible for many of the most inspiring and defining moments of the past 60 years, encompassing Moon landings, planetary fly-bys, discoveries of new worlds, and landing on comets. However, space is also increasingly part of everyday life. Businesses and consumers make daily use of spacecraft critical infrastructure that connects the planet, vastly improves weather forecasting and provides precise location information. Satellites orbiting hundreds or thousands of miles above our heads provide global reach and vision by virtue of their extreme altitude and velocity – more than 15,000 mph – travelling around the globe many times per day.

CONSERVATISM IN THE SPACE INDUSTRY

It is those extremes of altitude and velocity that can result in conservatism in the space industry. The space environment is hostile and satellites are exposed to large temperature variations, high doses of radiation, and a hard vacuum. In addition, delivering a satellite into space involves being mounted on a rocket which exerts high accelerations and energetic vibrations into the satellite on its journey from ground launch. As a consequence, there is a very strong tendency to stick with what we know works – as the saying goes, 'if it's not broke, don't fix it'. Finding the right balance between understandable conservatism and the need to progress the technology is often tricky.

Apart from a few notable examples such as the Hubble Space Telescope, it is technically extremely challenging and prohibitively expensive to service a satellite once in orbit. Therefore, a vehicle intended to last two decades in orbit must be designed with a high degree of reliability, encouraging a conservative approach. Indeed, some customers will refuse to buy a new technology unless it has already been demonstrated working for over three years in-orbit.

The flipside of this picture is that space is often viewed as exotic and an expensive solution to a problem. When developing terrestrial systems and services, design teams are unlikely to look to the space sector to provide part of their solution, when in fact the resilience and geographical coverage provided by a satellite system can present hugely lower lifetime cost and a more capable solution than a wholly terrestrial alternative.

ENTER THE SATELLITE APPLICATIONS CATAPULT

The Satellite Applications Catapult, with support from Innovate UK, is developing a number of initiatives to break down these barriers to innovation. In Oxfordshire, it is creating a Disruptive Innovation for Space Centre (DISC) that will facilitate solutions to several space-themed challenges facing industry. It will provide 'themed' equipment and expertise based around such areas as advanced manufacturing, next-generation networks, nanotechnology, embedded sensors, rapid satellite manufacture, sensing and robotics, position and timing, and launchers and spaceports. DISC will link up with other facilities to ensure that the developed capability is novel and does not duplicate existing national assets.

DISC addresses problems faced by all industry sectors in that, for small entities, the cost of an appropriate laboratory space with design, manufacturing and test equipment, and software, is almost always prohibitive. Additionally, access to expertise and an extended knowledge and capability network can be essential in enabling innovative technologies and ensuring that ideas flourish. Larger companies often struggle and frequently fail to truly innovate due to the company culture, environment and processes. The DISC can solve both problems for industry by providing a tailored facility and environment that is geared towards innovation and disruptive ideas and technologies.

A companion centre at Westcott, Buckinghamshire is under parallel development and will address a number of related challenges facing the space sector and industry, particularly around the need to verify and test new technologies and systems in areas such as spacecraft propulsion, prototyping of advanced (5G) communications networks that integrate space and ground-based networks, and the safe and economical operation of connected autonomous vehicles using space positioning and communications infrastructure.

The two facilities, working in concert, will provide the necessary support for industry to assemble project teams and take an innovation journey from equipment prototype to system demonstration, with end-users fully engaged. This will be a gateway for new suppliers and supply chains, and generate significant cross-sector fertilisation that will stimulate economic growth, not only in the space sector but in industry at large. MR

FIND OUT MORE

TO FIND OUT MORE ABOUT DISC
or other space-related activities, please contact info@sa.catapult.org.uk

PAPER PUSHERS TARGET LOW CARBON FUTURE

The Confederation of Paper Industries (CPI) says manufacturing paper already contributes a significant amount to the economy – and the sector is targeting a sustainable future

Rolling on: the paper industry is targeting a green future

THIS ARTICLE EXPLAINS:

- British paper industry significant employer
- Paper industry has turnover of £6.5 billion (2015)
- Climate change policy has affected production
- UK now world's largest paper importer
- Paper industry working on decarbonisation roadmap

The British paper-based Industries are significant manufacturing employers. They have a total direct workforce of 25,000 and support a further 100,000 jobs in their supply chains. The industry has a total turnover of some £6.5 billion and is a leader in the development of a sustainable, low carbon manufacturing sector here in the UK.

The Confederation of Paper Industries (CPI) represents the UK supply chain for paper, comprising paper and board manufacturers and converters, corrugated packaging producers, makers of soft tissue papers, and collectors of paper for recycling. Some 90 per cent of the UK paper industry is represented by the CPI.

IMPACT OF CLIMATE POLICIES

In the last 15 years, the impact of the UK's climate change policies has been to cut paper and board production in the country from 6.6 million tonnes in 2000 to just under four million tonnes in 2015. The UK is now the world's largest importer of paper. Demand for packaging and tissue products continues to grow, but without a UK papermaking base, such demand will only suck in further imports.

> "As a sector, we have identified a number of actions that would accelerate meaningful decarbonisation, but to bring them to fruition we need support from the Government to underpin energy efficiency investments"

The UK paper industry is working closely with the Government on its 2050 roadmap for decarbonisation. As a sector, we have identified a number of actions that would accelerate meaningful decarbonisation, but to bring them to fruition we need support from the Government to underpin energy efficiency investments.

In the context of the Brexit discussions, it is also clear that the UK's paper-based industries are firmly embedded in cross-European supply chains. We need to ensure tariff and non-tariff barrier-free market access for goods across Europe, and the ability of skilled personnel to work freely for their employers, wherever they may need them.

The paper-based industries are poised to play their part in the industrial renaissance of the UK. With the right policy mix, supporting new investment in decarbonisation, they can help underpin the economic growth and employment that the UK needs. MR

THE UK PAPER INDUSTRY, ENERGY AND CARBON

6.6 MILLION	3.3 MILLION	2.4 MILLION
TONNES OF CO2 EMITTED IN 1990	TONNES OF CO2 EMITTED IN 2012	TONNES OF CO2 EMITTED IN 2015

Source: Confederation of Paper Industries – Onwards and Upwards, Review 2015/2016

Phil Wild, chief executive, paper company James Cropper plc, says:

"We've always been committed to the constant improvement of existing products, development of new ones, and the applications of these – and 2016 was no exception.

"For the papermaking arm of the business, identifying and targeting niche markets, such as the premium packaging sector, has been an important part of our business strategy. Meanwhile, in our technical fibre products business, new products have been introduced to provide lightweight solutions for aerospace composite bodies.

"Continued investment into R&D in technology, whether that's in technical, equipment, product development or materials, is crucial for us to maintain and expand our foothold in the industry"

See www.ukmanufacturingreview.com/2016/paper for more of Phil Wild's article on the paper industry

WATCHMAKING

ALL THE TIME IN THE WORLD?

Once a jewel in the crown of British industry, a renaissance in watchmaking is on the cards in the UK. That is the view of a growing band of smaller, premium watch manufacturers. Ben Hargreaves reports

Above: Robert Loomes' designs are an example of the growing renaissance in British watchmaking

THIS ARTICLE EXPLAINS:

- British watchmaking experiencing a new lease of life
- Provenance a draw for international customers
- Smaller, premium watchmakers sourcing many parts in UK
- Skills a formidable challenge
- Domestic industry thriving

Some thirty years ago, watchmaker Robert Loomes might have been forgiven for being dissuaded from pursuing his chosen career. He recalls a conversation at the time with his father, a technical author and antiques dealer, that would have done little to encourage his eventual path. Loomes recalls: "In the 1980s my father said to me, 'Have nothing to do with watches – the whole watchmaking trade is dead and forgotten'. And it was at the time: there were lots of underemployed watchmakers who were shutting their businesses. They had run out of customers."

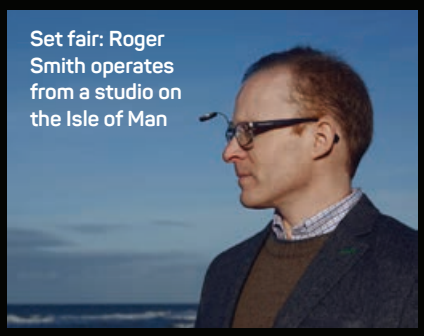
Fast forward to 2016, and Loomes runs a thriving watchmaking business based in Stamford, Lincolnshire that prides itself on producing high quality, English-designed and manufactured watches, and that is growing, not shrinking – manufacturing some 150 watches a year. Not bad for a business that began when Loomes – who had specialised in repairing and restoring watches and clocks – made his first watch "for fun" seven years ago.

MADE IN BRITAIN

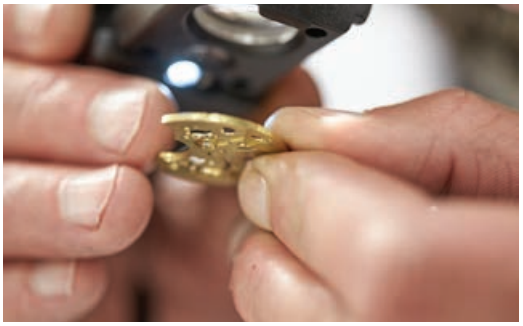
He is not the only UK watchmaker to be enjoying the current market for British-designed and made timepieces. The Schofield Watch Company produces bespoke watches in East Sussex, while Struthers London – a husband and wife team who trained, and are based, in Birmingham – handcrafts 10-15 watches a year with 80 per cent British content.

On the Isle of Man, Roger Smith and his small team – one engineer and three watchmakers – are producing ten to twelve bespoke, luxury pieces a year, completely from scratch. Smith, who trained under George Daniels, inherited the renowned horologist's equipment when he passed away, and like Daniels, he believes in creating watches entirely by hand. Brothers Nick and Giles English, meanwhile, have established the largest British watchmaker, Bremont, in a relatively short space of time, with 50% of the components in their watches sourced and made in the UK.

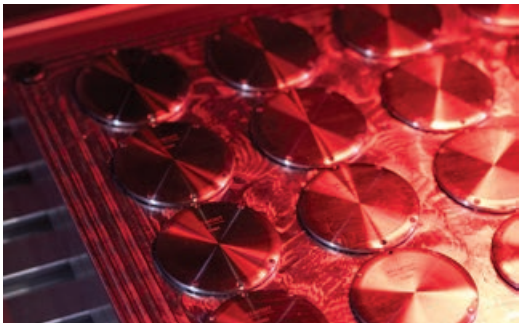
For Roger Smith on the Isle of Man, painstakingly crafting watches by hand is a labour of love – but also a lucrative industry, with designs selling for up to £250,000, to markets including the US, UK and China. Smith and his small team have extended their range of watches and the contents of Daniels' studio – he



Set fair: Roger Smith operates from a studio on the Isle of Man



Operating at minute tolerances poses challenges for even the most skilled machinists



British watch brand Bremont is beloved of aviators worldwide

passed away in 2011 – have been incorporated into the Roger Smith workshop on the island. This includes rare engine turning equipment now used to finish the dials of the watches, including hand-operated equipment made more than 200 years ago. "If used in the correct way, they produce a wonderful quality job," says Smith, who still adheres to the 'Daniels method' of watch production – or a methodology in which one watchmaker makes a timepiece from start to finish, which originated in the 1960s. "We basically have an entire watchmaking industry under one roof." Dials, hands, cases, wheels, pinions, plates and escapements are all made in-house. Smith says: "Of about 150 components that go into the watch, we make everything bar half a dozen. It is an obsessional approach, and very specialised." The waiting time for a new Roger Smith watch is several years.

By contrast, Giles English of Bremont began by making watches in Switzerland and the company sells seven or eight thousand watches a year. But English and his business partner, brother Nick, are gradually reshoring production, Giles English says. "Each year we bring a bit more of the manufacturing back to the UK." Styled as aviation and adventure watches, the Bremont brand has found favour with air forces across the world. But 'Britishness' of design and manufacture is desirable. "Britain is seen as a good market for manufacturing: people trust goods being manufactured in the UK. But it takes time to do it, and you need to invest properly." Bremont started by bringing assembly work back to Britain, then machining of cases, and then machining of some movement components of its watches. "You work at minute tolerances with everything you produce, and that's not easy," explains English. "We have found this, even in the UK; you'll get an extremely good machinist from F1 but you still have to retrain them, because no one is used to these tolerances."

TIME TO START TRAINING

Indeed, the skills shortages that bedevil manufacturing are particularly pronounced in watchmaking. Educational institutes such as the Nottinghamshire-based British Horological Institute and Birmingham Institute of Art and Design offer watchmaking – the husband-and-wife team behind Struthers London trained at the latter, for example – but, combined, they are only turning out 40 or so students a year, believes Robert Loomes. In fact, an independent British School of Watchmaking was established in Manchester in 2004 to help alleviate skills shortages.

It would be a shame if shortages in horology skills dampened prospects for the new generation of British watchmakers, Loomes says. "If the 20th century was about globalisation, then the 21st century is about localisation," he offers. "People want to know where it was made and how it was made. And they are prepared to pay significant premiums for that knowledge." As well as

BRITISH WATCHMAKING INNOVATION – A TIMELINE

1664
BALANCE SPRING
– Robert Hooke

1690
MINUTE HAND
– Daniel Quare

1715
OIL SINK
– Henry Sully

1753
TEMPERATURE COMPENSATION
– John Harrison

1755
LEVER ESCAPEMENT
– Thomas Mudge

1765
CENTRE SECONDS
– John Whitehurst

1807
CHRONOGRAPH
– Thomas Young

1820
KEYLESS WINDING
– thomas Prest

1924
AUTOMATIC WINDING
– John Harwood

Source: Great British Watch Company

tapping into the power of the 'made in Britain' stamp, watchmakers such as Loomes are benefiting from UK networks of academic and industrial manufacturing expertise. For instance, he has worked with the (now defunct) Manufacturing Advisory Service, and also tapped into the expertise of the Institute for Advanced Manufacturing at Nottingham University.

Loomes works with small suppliers all over the country to produce his watches, sometimes ordering tiny batches of very specialised components. His team has also rebuilt its own bespoke, in-house machine tools. So innovation is important, he says. The company is now manufacturing watch mechanisms from scratch, which means lower production volumes are forecast in 2017. "At Nottingham University we've been able to play about using different machines to see what the best way is of making a component. For example, looking at whether we can have a go at wire-eroding it, or making a diode to spark erode a section that we need." Loomes has also benefited from EU funding for an innovation for a production technique that saw three components of the balance wheel of a watch made in one piece. The Robert Loomes watch company is working on new projects with TWI in Cambridge and the National Physical Laboratory in Teddington, he says.

Germany has seen a revival of domestic watchmaking in the last decade and some believe a similar industry could be emerging in the UK as we enter 2017. Roger Smith says that there is "a lot of interest" in his company's processes and painstaking, home-grown approach to making watches. "We are contacted regularly by people wanting to know what we are doing, and how. But is it whether anyone is prepared to put the time and effort in. It is something that has consumed 20 years of my life."

Robert Loomes believes there is a chance that the small number of domestic watchmakers could become a growing band. "If you go back to the 1930s and 1940s, in Britain most people wore a British watch. I think there is a future for it. People would rather buy a British watch – if they have the choice available to them."

Oxfordshire's Bremont will continue to produce more and more components for its watches domestically. Giles English concludes: "At the turn of the century, we were making half of the world's watches. We have this wonderful history, and we're looking to build on it at Bremont.

"Ultimately, the world sets its time by GMT – not Geneva Mean Time. But getting that story out there is a slow burn – and hard work." MR

A VERY BRITISH TRADE

Roger Smith's entirely handmade designs retail for up to £250,000

Historically, watchmaking is a British trade with every major escapement design, and around three-quarters of the remaining innovations, coming from the UK.

Watchmaking can be said to have started with Thomas Tompion (1639-1713), often referred to as the father of English clockmaking. A student of Tompion, George Graham (1673-1751), made further innovations, before passing the baton to one of his own students, Thomas Mudge (1715-1794), who invented the lever escapement – still the most widely used escapement in today's watches.

John Harrison (1693-1776) solved the problem of finding one's longitude at sea. Enabling British ships to travel accurately and more safely around the globe was one of the major contributing factors to the growth of the British Empire. Following in their footsteps came other great watchmakers such as John Arnold and Thomas Earnshaw.

In 1800 Britain made around half of the world's watches. This equated to about 200,000 pieces a year. By 1900 the quantity produced in Britain had declined by half – despite the worldwide market for watches having risen to the millions.

The problem lay in the handmade nature of English watches and the heavy reliance on skilled workers who were reluctant to adapt to the changes in technology. The Swiss and the Americans were much quicker and more successful in adopting mass production techniques. Mass manufactured watches were soon able to compete directly with hand-made ones, and eventually surpass them in performance, despite only costing a fraction of the price. The industry in Britain collapsed.

There was a brief resurgence in postwar Britain, however the remaining businesses were not robust enough to survive the biggest crisis in watchmaking – the emergence of the quartz watch.

Credit: Source: Great British Watch Company

Read more about traditional British manufacturing on pages:

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PACKAGING

PACKAGED GOODS

Consumers don't buy packaging: they buy products. But the sector is big business for UK manufacturing industry, writes Dick Searle

The packaging sector has sales of more than £12 billion

THIS ARTICLE EXPLAINS:

- Packaging industry is one of the of the larger manufacturing sectors
- It represents more than 20 per cent of manufacturing employment
- Largest customer base is food and drink
- Packaging is 'service industry with product'
- Brexit will present sector with major challenges

The packaging manufacturing Industry is a major contributor to the UK economy. With sales of more than £12 billion and some 85,000 employees, it is one of the larger sectors within the manufacturing sector.

Together with the UK food and drink Industry – by far its largest customer base – it represents more than 20 per cent of UK manufacturing employment. Across the four main material sectors of the industry – glass, metals, plastics, and paper and board – there is a significant number of major players, many of which are foreign-owned, but there are also thousands of small local businesses providing valuable local employment. Our industry has been consistently profitable despite operating within some brutally competitive supply chains – with so much of its production directed to food and drink, it has survived good and bad times.

DEBUNKING PACKAGING MYTHS

Modern packaging is an indispensable part of society. Much of life as we know it could not function without it. Today's lifestyles demand the widest range of goods available 24/7, and this is made possible by the enormous range of highly innovative packaging produced by our industry. Indeed, modern retailing needs our products to make its methodologies work.

That said, packaging only exists where a product exists. It is, along with modern distribution systems, a delivery system for products. Consumers don't buy packaging: they buy products, although it is often the packaging itself which defines branded products, and promotes them at the point of sale. The demand for packaging is set by consumer demand for products and, in essence, our industry functions as 'a service industry with a product'.

Too much is still made of 'unnecessary packaging' and 'packaging waste'. The question is not, is packaging itself sustainable, but what role does packaging play in enabling sustainable supply chains?

ENVIRONMENTAL IMPACT

The truth is that the environmental impact of the damage that packaging prevents is far higher than that of packaging used. Packaging's net overall environmental impact is negative – products have, on average, more than ten times the environmental impact than the packaging that is used to contain and protect them. If global food waste was a country, it would be the third largest carbon emitter in the world.

WHAT A (FOOD) WASTE

- 10 million tonnes of food waste is created within UK households, hospitality and food service, food manufacture, and the retail and wholesale sectors
- 60 per cent of this could have been avoided, with a value of more than £17 billion a year
- This waste is associated with around 20 million tonnes of greenhouse gas emissions. By weight, around 85 per cent of avoidable food waste arises in households and food manufacture

Source: WRAP, 2016

In the developed world, our packaging enables very low wastage in the supply chain but, despite this, food waste in the home is a major challenge – one which our products are designed to address if used correctly, with storage instructions properly followed.

The supply chains that use packaging have been, for many years, on a journey to minimise the impact of packaging – driven less by environmental concerns than by the hard commercial reality of reducing costs – and this commercial reality alone will continue to drive the 'optimisation' of packaging.

PACKAGING THE FUTURE

What of the future? As for much of industry, Brexit will represent a major challenge. Significant issues for us are labour and skills availability (some 15 per cent of our workforce are non-UK nationals), rising input costs (raw materials are >50% of our total costs and most are imported, in the absence of UK sources) and uncertainty about regulation – the most important for us are the EU Food Contact Legislation and the EU Packaging & Packaging Waste Directive.

However, as a quasi-service industry, our greatest concern is the impact on our customer base as our volumes depend entirely on the sales performance of our customers. Given that the wealth of the economy is generated solely by business at large, the last thing we need is more cost, restrictions and barriers to trade dumped onto us – not just by Brexit outcomes but, in particular for our industry, by attempts to offload public sector tasks to industry.

We look forward to the uncertain future with some trepidation, but plenty of confidence. MR

Dick Searle is chief executive of The Packaging Federation

Themes

IN OUR IMAGE Fabrication Process Engineering Snapshot, from a project entitled CHANGES, taken by Elaine Vizor at Aycliffe Fabrications in Newton Aycliffe. Shortlisted in the amateur category of the EEF Photography Competition 2016.

BREXIT: BOOM OR BUST?

Fears of an immediate post-Brexit depression in manufacturing have been allayed, but engineering firms are uncertain what the future holds in terms of trade with the EU. By James Hurley

In the wake of Britain's vote to leave the European Union, businesses could hardly be blamed if they put investment decisions on hold.

THIS ARTICLE EXPLAINS:

- Opinion divided over whether Brexit will benefit manufacturing
- Many manufacturers are already increasing export sales
- Concerns remain over import costs and access to EU market
- Manufacturers should 'make hay while the sun shines'
- Will genuine industrial strategy materialise?

But despite the referendum vote, Tony Hague gave the green light for his mid-sized company, PP Control & Automation, to spend £1 million on a factory expansion so it can capitalise on an anticipated increase in demand.

The business, an outsourcer for automotive, aerospace and electronics manufacturers, among others, is in the process of hiring 30 staff.

And although there has been anxiety since the Brexit vote, Hague's sense of 'business as usual' has been reflected across manufacturing industry.

Figures from October 2016 showed that the volume of new orders and employment in the industry had been on the rise for three consecutive months, with export sales boosted by the

Top left: PP Control & Automation spent £1 million on a factory expansion after the Brexit vote

Top: The addition of the words 'industrial strategy' to the May Government's business department is welcome, but scepticism persists over the details among the manufacturing community

Above: Figures from October 2016 showed that the volume of new orders and employment in manufacturing industry had been on the rise for three consecutive months, with export sales boosted by the weakness of the pound

weakness of the pound. Hague, managing director of PP Control & Automation, says: "I think we're in a better position than many of us manufacturers dreamed possible. That's not to say everything is rosy, but I thought we would be in deeper trouble, far quicker."

OVERSEAS INVESTMENT

In a post-referendum period where uncertainty and often downright confusion have reigned, the first major overseas investment decision has also gone the right way for Britain's manufacturers.

To the great relief of thousands of workers and a large chunk of the nation's automotive supply chain, Nissan confirmed it would build the next model in its popular Qashqai series in Sunderland, after receiving "support and assurances" from the Government.

However, once that relief had subsided, the questions began. Had Nissan been given a special deal by a Theresa May government desperate to avoid the disastrous symbolism, let alone the direct economic consequences, of the Japanese car manufacturer leaving? Would other manufacturers, including those in sectors such as steel, aerospace and pharmaceuticals, be given similar assurances? With the government still fending off demands for the exact terms of its arrangement with Nissan to be made public, it is clear that the majority of the anxieties which the episode highlighted have yet to subside.

Indeed, Kenichi Ohmae, the Japanese business adviser who recommended Nissan set up a plant in Britain in the 1980s, did not see the Sunderland decision as a ringing endorsement of the UK's post-Brexit foreign investment prospects. He told the BBC that he did not think "other companies will follow suit". He said other international businesses should hold fire on investing in Britain until "the course is clear and until the conditions of Brexit are worked out – not only by what the UK government says, but what the European Union says".

Even John Longworth, the former boss of the British Chambers of Commerce who left the employers' group to campaign for Brexit, admits there are difficult challenges ahead. These include the risk that the "EU will act in an economically irrational way, leading to EU tariffs for a period before a free trade agreement is secured", he says.

SCEPTICISM OVER INDUSTRIAL STRATEGY

The addition of the words 'industrial strategy' to the May Government's post-Brexit business department is welcomed by many manufacturers, but there is scepticism as to whether it will be matched by real action.

"Industrial policy is about skills, capital, ideas, technology and export [promotion]. We are nowhere near conceiving such a national level plan, never mind executing it," says Malcolm Evans of The UK Manufacturing Accelerator.

Like those in science and education, the EEF has also expressed concerns that hard Brexit could cut off European investment money in areas like support for advanced manufacturing, undermining state backing for industry. The scrapping of the Manufacturing Advisory Service last year was bemoaned by industry and manufacturers will now be looking for what targeted support they receive during the Autumn Statement.

Rowan Crozier, chief executive of Brandauer, a Birmingham pressworks and stamping business, says: "The UK has got the capability to be the best in the world, but we need a government that is going to be with us for the long-run and not just when they feel the sector is flavour of the month."

A more pressing concern is the quality, or for some, the lack thereof, on show in the ministers charged with delivering Britain's departure. "I look at the Brexit team and think, 'there's not much credibility there'," adds Crozier. Others are more satisfied with the political response. Jonathan Lane, of Arrow Solutions, says, "The talk is tough and information is limited. That feels to me like an organisation serious about negotiation.

"I was in Saudi Arabia recently and had a couple of people describe Mrs May as the new 'Iron Lady'. They said it with respect."

Nissan's concerns about continuing to use the UK as its European production base were said to centre on the prospect of trade tariffs restricting its access to key markets on the continent.

Hague says it is a concern shared by exporting manufacturers of all sizes. "Access to the single market is absolutely key and any future deals should be based around this. We do not want and must resist a tit-for-tat taxation game starting."

Longworth urges industry to look on the bright side. "If [EU tariffs are introduced] UK goods will still be cheaper on the continent than before, as the value of sterling has reduced by more than the tariffs. "Reciprocal tariffs would lead to a shift to UK domestic production, for example, the purchase of more UK manufactured cars and fewer German ones, as the combination of sterling and tariffs make UK manufacturers more competitive at home. Exports to the rest of the world, in the meantime, will be boosted.

"We're in a better position than many manufacturers dreamed of"

Tony Hague, PP Control & Automation

Japanese business adviser, Kenichi Ohmae, has said "other international businesses should hold fire on investing in Britain until the course is clear and until the conditions of Brexit are worked out – not only by what the UK government says, but what the European Union says"

Richard Bunce of Mec Com, a Stafford sheet metal fabricator, worries that Brexit will make a "difficult situation a lot worse"

"In short, the risk is a period of creative disruption and uncertainty during which there will be winners and losers. But overall, the UK manufacturing sector will emerge better off."

Jonathan Lane, sales director of Arrow Solutions, a Leicestershire manufacturer of cleaning products, agrees: "There will be economic pain for a while, but, over time, exiting the EU will deliver genuine economic benefit," he says. He also supports Longworth's assertion that there is an opportunity for a renaissance in UK manufacturing.

"Many of the requirements to do so are already in place. I recently visited the Manufacturing Technology Centre in Coventry and was hugely impressed by the technology demonstrated. The know-how is here in the UK and it can [deliver] the competitive advantage we need."

WILL BREXIT EXACERBATE SKILLS CRISIS?

The other major Brexit anxiety that abounds is that it will exacerbate an existing skills crisis for British industry. With many manufacturers already deeply concerned about their ability to find the right staff even before June's vote, Richard Bunce of Mec Com, a Stafford sheet metal fabricator, says he worries Brexit will make a "difficult situation a lot worse". "From talking to employees at our sister company, European Fabrications, in Romania, Romanians are already very reluctant to come to the UK because of Brexit."

Malcolm Evans, is a co-founder and chief executive of The UK Manufacturing Accelerator, a specialist investor in early stage manufacturing companies. He has seen little immediate disruption following the referendum. "We are all getting on with it while the media still peers here, there and everywhere for the arrival of industrial Armageddon." However, he calls for some balance in the debate. "Those who proclaimed Brexit as an unqualified passport to new global success are living in cloud cuckoo land. We are in febrile times – global capitalism is always weaker than those who work within in it care to [admit]. Brexit is a destabilising tremor."

Despite the boost to export sales it has delivered, Evans adds that the belief that the weak pound is a zero sum game in favour of British exporters is a "dangerous delusion". "There is some benefit to UK manufac-

"There will be economic pain for a time"
Jonathan Lane, Arrow Solutions

"I look at the Brexit team and think, 'there's not much credibility there'"
Rowan Crozier, Brandauer

Brexit: Are companies like this pressings firm just "getting on with it" while the media talks us into Armageddon?

THE COST OF BREXIT

5 PER CENT: Proportion of UK adults who think that loss or damage to the manufacturing sector is a price worth paying for leaving the EU *(Source: EEF)*

52 PER CENT: Share of total manufactured exports, by value, going to the EU in the 12 months to April 2016 *(Source: EEF)*

71 PER CENT: Proportion of companies who believe the EU lowers the cost of doing business through this single regulatory and legal environment *(Source: EEF)*

£12.9 BILLION: Predicted bill for EU firms exporting goods into the UK under WTO terms if there is no new trade bill in place post-Brexit *(Source: Civitas)*

£5.2BN: Equivalent bill for British exporters to the EU under WTO terms *(Source: Civitas)*

turing in a low pound scenario but in this country we are largely higher value-added rather than commodities; in the latter case there is a simpler drive to swap supply on a price basis.

"I am more connected to high value-add activities, where quality and reliability play a significant role alongside price alone, and where relationships are long-term and volumes more stable. Those trumpeting major and lasting advantage to UK manufacturing from a low pound are overstating their case."

He also predicts there will be manufacturing "casualties", even among exporters, from the low pound as raw material prices increase. PP Control & Automation works with machine builders who export the majority of their produce priced in euros and dollars, so the weakening pound has aided its international sales prospects. However, the decline in sterling is also pushing up the price of the production process for many, since a large proportion of raw materials are imported. Industry data shows the average selling price of manufactured goods rose in October at the fastest pace for more than five years.

Hague says: "There does seem to be a trend towards rising material costs and you don't attend many business meetings where 'uncertainty' is not mentioned.

"Rising material costs... will be passed on without fail. There might even be some profiteering going on. However, the effect for manufacturers will still be positive."

That said, he does fear that the weak pound and short term gains could be masking bigger issues. These include weak productivity, skills shortages and lack of investment in robotics and automation across the supply chain, he adds. "We need to address this through a UK manufacturing strategy that is indiscriminate of political party," he says.

Lane of Arrow Solutions agrees: "The challenges I foresee are those of attitude and commitment. Manufacturing requires longer-term investment and I guess that is markedly different from internet businesses that can flourish or fail almost overnight." Evans voices a cautious optimism that, despite their numerous concerns, many manufacturers have faith in the longer term trading impact of Brexit. "Britain will not cut its own throat over trade [nor] will the EU strangle such an important trading partner."

While Hague fears a period of uncertainty and possible stagnation is on the cards in the medium-term, he adds: "That does not mean there aren't opportunities out there to be pursued...as long as you have something different to offer, or best in class capabilities, you will always win new work." MR

Read more about the impact of Brexit on manufacturingon pages:

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MANUFACTURING PROSPECTS

THE POST-BREXIT LANDSCAPE

The United Kingdom's decision to leave the European Union ("Brexit") will have a profound effect on manufacturing. There are early signs that all is not doom and gloom and sector data since Brexit has been mostly positive (UK manufacturing PMI in October was at 54.3 with upturns in output, employment and new orders and GDP grew by 0.5% in the third quarter).

BDO partnered with the Institution of Mechanical Engineers (IMechE) to survey UK manufacturing companies to ask their opinions on the likely effects of Brexit on their business.

Below are some of the findings from our survey and you can download the full report at: https://www.bdo.co.uk/en-gb/insights/industries/manufacturing/manufacturing-prospects-report

51% think Brexit will have a **negative impact** on their business

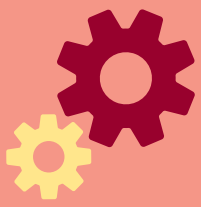
18% of respondents said Brexit would be '**positive**' for manufacturing

37% want to stay in the European Economic Area, with **free movement of people**

67% and **42%** think **exchange rate volatility** and the **political landscape** are the biggest risk factors for manufacturing from Brexit

45% are **not at all confident** that the government will negotiate a good deal to leave the EU; **26%** are somewhat confident it will

79% selected a **long-term strategy over 15-20 years** as the most important element for an **industrial strategy**



65% of manufacturers said they are making **no changes to their investment plans** post Brexit

44% of businesses are focusing on **internationalisation** as their business strategy in light of the decision to leave the EU

82% believe it is very important for the government to **continue funding engineering R&D** that may have been funded by the EU

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UNCERTAIN TIMES FOR EMPLOYERS

THIS ARTICLE EXPLAINS:

- Brexit means huge uncertainty for employers
- No reason to discard workable elements of EU law
- Employees expect to be protected by fair practices
- Legislation may be changed or trimmed
- Stability means growth

A wholesale dismantling of European employment law during Brexit is unlikely, and the elements of the law that work for everyone should be maintained, says FBC Manby Bowdler

It's all very well our politicians repeating their new mantra, 'Brexit means Brexit' – but it does not make anything to do with the issue in the slightest bit clearer for manufacturing employers.

Even now, months on from the vote, we have no idea what shape a split from Europe will actually take. This is not helpful for employers, but what we can do is make some sensible assumptions that we will not be looking at a wholesale dismantling of the employment laws we are all currently familiar with, and adhering to.

For a start, EU laws are very often a reframing of existing UK laws, in principle and intent, if not in the exact wording. There is no reason to believe we would suddenly wish to discard these principles (around issues such as equal pay, and race and disability discrimination) or that the Government would be able to get away with trying to do so.

Staff and employers are familiar with the generally fair practices which govern industrial relations and which are appreciated by workers at many levels.

> "There is no reason to believe we would suddenly wish to discard these principles (around issues such as equal pay, and race and disability discrimination) or that the Government would be able to get away with trying to do so"

LEGISLATION TO BE TRIMMED

There is also no getting away from the fact that if we wish to trade with the EU, as we know we must, we will be required to adhere to a certain amount of EU employment and social protection. What is most likely is that we will experience a trimming of the most unpopular legislation or parts of that legislation. For example, some EU demands around holiday pay and working time are already tailored to the UK and could be further so, while the Agency Workers Regulations 2010 are complex, unpopular with business, and not yet widely in common use – so are ripe for early removal.

Freedom of movement is a key issue, but it is likely that quid pro quo will be reached allowing citizens from the EU and UK to remain in the countries where they currently work and reside, at least for the time being. In the much wider picture, the EU and UK law are so entangled that it is likely to be a piecemeal approach will have to be adopted, keeping the majority of laws but making minor alterations, following existing precedents (to preserve legal certainty) and viewing European Court of Justice decisions as persuasive if not binding.

We may not be any clearer on detail, but it is becoming more obvious that seismic shift is less likely than tailoring of what exists, in order to maintain social and economic stability. And stability above almost everything else is what allows the manufacturing sector to grow – and order books to increase. MR

TECHNOLOGY TRANSFER

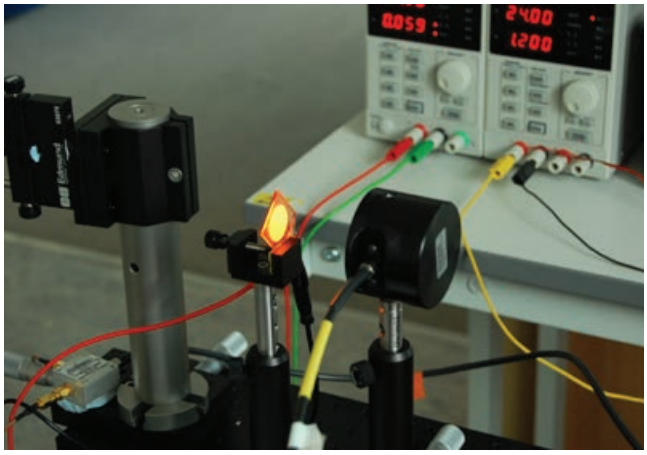
SHARING GREAT IDEAS WITH THE WORLD

Britain's got talent – and leading universities are finding ways to convert it into hard cash via technology transfer. Charles Orton-Jones reports

Haydn Ward (front) went to work at parking and train ticket firm BemroseBooth Paragon and refined 10 types of magnetic ink now used across the country

THIS ARTICLE EXPLAINS:

- University of Edinburgh taking a lead in technology transfer
- Novel ideas from the research base are being commercialised
- Spin-out companies in Edinburgh, Hull and Surrey exemplify technology transfer
- University of Leicester up-and-coming
- Balance between blue-sky thinking and commerce must be struck



The LiFi R&D centre transmits internet data using beams of light at speeds many multiples faster than current WiFi bandwidth

The great mathematician Thomas Bayes lived and died in obscurity. He spent his earthly years preaching in a quiet corner of Tunbridge Wells. During his lifetime his entire published works amounted to just two tracts, one on the benevolence of God, the other a defence of calculus. It wasn't until Bayes died in 1761 that a friend trawled his papers to discover his *Essay towards solving a Problem in the Doctrine of Chances*, which was passed on to the Royal Society. It was an electric idea, explaining how to calculate the odds of something happening by factoring in prior knowledge.

Bayes' posthumously published ideas now form the foundation of an entire branch of maths. To pick just one example: the entrepreneur Mike Lynch built Autonomy into a £9 billion company on Bayesian logic.

The obscure life of Thomas Bayes is what the technology transfer sector is designed to avoid. Its mission is to take great ideas and share with them wider world as quickly possible.

Universities look at a wide range of options. These include licensing ideas to the private sector, forming spin-outs, funding co-research with commercial partners, open sourcing intellectual property – and the old fashioned method of explaining concepts to whomever wants to listen.

The University of Hull offers a brilliant example. Haydn Ward graduated with a first class degree in chemistry in 2014. A day later he went to work at BemroseBooth Paragon (BBP), a Hull-based provider of parking and train tickets, as part of a knowledge transfer partnership with the University of Hull. His mission was to develop magnetic inks at BBP. Supported by the university's partners Ward refined 10 types of magnetic ink, which are now used in rail tickets across the nation. The arrival of this young star through a knowledge transfer partnership is turning BBP into an international success story. It's a simple yet classic example of how the university expertise can benefit the private sector.

UNIVERSITY OF EDINBURGH A LEADER

The University of Edinburgh is a world leader in technology transfer. It began commercialisation in earnest more than 40 years ago. From 2010-2015 Edinburgh negotiated 836 licence agreements, bringing in £14 million a year in royalty income. The university boasts 184 spin-outs and start-ups companies in the same time period – taking the total since 1967 to a remarkable 417. An independent impact report estimated that

THE FORMULA FOR SUCCESS AT SURREY RESEARCH PARK

Surrey Research Park is the science campus owned by the University of Surrey. It was set up 30 years ago by Dr Malcolm Parry, who still runs it. The aim is to commercialise university technologies. The park now works with universities across southern England, owing to its scale, expertise and reputation.

"We have around 140 companies in the Park," says Dr Parry. "It's hard to keep count and they come, grow, and merge."

He adds that the companies come because, "We have entrepreneurs-in-residence. We offer access to talent, image and reputation, easy in-and-out contracts, a business angel club in the Park, and we coach people to work with angels." There's a co-working centre for entrepreneurs in the computer games sector called Rocketdesk. It hosts games designers, music composers, video editors and website builders, who can collaborate side-by-side, and make use of facilities such as the university's motion capture equipment. The location is a stone's throw from EA Games office, the developer of the popular FIFA console game, and Criterion Games, maker of games such as Need for Speed. Plus there's a 5G incubator on the campus. Vodafone, Huawei and Telefonica are involved.

What more does a start-up need? Tenants vary in size from one-man bands to full scale multinationals. SSTL is a spin-out from the University of Surrey that builds and operates small satellites. Today it employs 450, and is majority-owned by Airbus. "Out of SSTL come other spin-outs," observes Dr Parry. "A company like that burgeons into a cluster."

The manufacturing side of the Park is improving. Dr Parry points to GnoSys, which helps manufacturers develop prototypes, and Unique Secure, which creates payment terminals, as two stand-out manufacturing prospects in the Park.

The appeal of the Park means other universities are drawn to it. MedPharm is producing a topical drug delivery technology, derived from work done at the University of Hertfordshire. Angle is a pharma company with a method of separating cells, based on research at the University of Manchester. Angle isn't tied to Surrey, says Dr Parry, it merely finds the Park the best place to be, and has been here since 1994.

The value of Surrey Research Park is clear. Dr Parry sums it up: "The Park is worth more than £100 million. And we've produced over £100m in cash from the Park, which has been used to strengthen its research base. It's met a target of creating independent income for the university, it is shared technology. And it has raised the profile of the university."

"We have around 140 companies in the Park. It's hard to keep count and they come, grow, and merge"

Dr Malcolm Parry, University of Surrey

Ian Sharp of Edinburgh Research and Innovation says the organisation will never stand still

The University of Edinburgh has an outstanding record of commercialising research, with more than 180 spin-outs over the last five years

Edinburgh Research & Innovation (ERI), a wholly-owned subsidiary of the university which is responsible for technology transfer has supported 3,500 jobs worldwide and generated £200m annually.

"We'll never stand still," says Ian Sharp, head of marketing at ERI. "We continually look for ways to connect industry to our researchers."

One recent innovation has been the Academic Industry Meetings, or AIMdays. "AIMday is a one-day event at which challenges posed by companies around a central theme are tackled by a panel of academics in an hour-long workshop. The outcomes are to identify possible pathways to solutions. One pathway may be the potential for a licensing agreement or it can also lead to collaborative research projects with the company," says Sharp. "We've been holding AIMdays for three years and on average have one every three to four months around industry-led themes."

When it comes to high profile achievements in the technology transfer arena the winner in 2016 must be the LiFi R&D centre, based at the Kings Buildings campus. LiFi means transmitting internet data using beams of light at speeds many multiples faster than current WiFi bandwidth. Advances at the LiFi centre are available through a "flexible collaboration" model. The LiFi research alone has been covered globally in journals from Wired magazine to El Pais in Spain.

Spin-outs from Edinburgh are also always worth watching. Sharp singles out two favourites. "Particle Analytics have developed a software tool for

Two Big Ears – a creator of sound software for virtual reality – was acquired by Facebook in May 2016

SCOTLAND'S NEW SENSOR PROGRAMME

In 2013 the Scottish government invested £10 million in a scheme to promote technology transfer between universities and their respective industries in the sensor and imaging sector. The result, Censis, is now up and running and forming links between academics and the private sector, with a target of 150 collaborative R&D projects.

The tie-up between the Centre for Anatomy and Human Identification (CAHId) at the University of Dundee, and Amethyst Research, is a typical project. The partnership focusses on the use of infra-red light to identify evidence at crime scenes. Niamh Nic Daeid, professor of forensic science at the University of Dundee, says: "We are still in the early stages of this research, but will be exploring ways in which infra-red light could be used to identify traces of material such as body fluids on surfaces like dark fabrics where they may be difficult to visualise, and as a consequence allow forensic teams to focus on potential evidence which may be relevant to an investigation."

Manish Jain, programme manager at Amethyst Research says: "In theory we'll be able to take a 360 degree camera into a crime scene, scan a room, and identify old and freshly deposited material in real time.

"We think it might also be possible to adapt the technology to detect explosives and drugs, meaning the research might highlight wide-ranging practical uses should it be successful. We are also exploring the potential for using the technology to identify trace material obscured by deposits such as soot."

The idea came from a meeting of experts organised by CENSIS. Another project is based on work by academics at Glasgow Caledonian University to monitor oxygen levels in buildings, and take action to remedy it. The commercial partner is Cumbernauld-based Gas Sensing Solutions, which sees wide potential uses. Alan Henderson, Managing Director and co-founder of GSS, comments: "While this system could be used to improve air quality in an office, it could equally be employed in hospitals to monitor patients' conditions. With the right configuration, it has the ability to take action in response to any problems which could relieve some of the time pressure placed on medical staff by reacting to issues as they arise."

Overall, CENSIS is targeting the £7bn global sensor and imaging sector. It will give companies and universities the ability to work together on R&D and commercialisation.

manipulating particulate solids. The company is working with partners in pharmaceuticals, manufacturing and the chemical industries, allowing them to make significant savings when handling solids." His second pick is student start-up, Two Big Ears, a creator of sound software for augmented reality and virtual reality. In May the start-up was acquired by Facebook as it prepares to launch the Oculus Rift VR headset.

BALANCE BETWEEN BLUE SKY AND APPLIED RESEARCH

Naturally, there is a balance to be struck between blue sky research and applying research outcomes. Sharp says: "At Edinburgh have a rich history in terms of fundamental research. A Nobel laureate was awarded this year for Edinburgh alumnus Professor Sir Fraser Stoddart in Chemistry, and in 2013 with Professor Peter Higgs, who discovered the Higgs boson particle."

Sharp says, "This pioneering science will always be at the forefront of the ethos of the University of Edinburgh and fits well with industry requirements for cutting-edge innovation."

Naturally, the lure of riches is sometimes cited as a distraction for academics. Sharp admits it's a challenge, but says there's no trade-off: "At Edinburgh have a rich history in terms of fundamental research. We had a Nobel laureate this year with Fraser Stoddart in Chemistry, and last year with Peter Higgs, who discovered the Higgs boson particle. We want to do more of that, as well as more industry-oriented research. It's a big question, yes, but we don't see one at the expense of the other."

In the Midlands lies a university keen to emulate Edinburgh's success. The University of Leicester is an 'up and comer'. "Some other universities like Oxford, Cambridge, and some of the London universities, are further down the road," admits Dr Sandy Reid, the new head of spin-outs at Leicester. Although, she adds, no one really has the cracked the formula. Dr Reid comes to Leicester after eight years as the CEO of a venture capital-backed chemical company. She says she'll be helping potential spin-outs with the nitty-gritty of forming a company, such as writing business plans and attracting investors. She's got rich material to work with. "We have a technology partnership with Alstom," says Dr Reid. "And there's the Impact doctoral centre for metal processing. We've pooled resources with Birmingham and Nottingham, and work with industrial partners such as Rolls-Royce, Tata Steel, and ESI. There's the ASDEC centre for advanced vibrometry. The technology developed there has been made available to industry." The use of lasers to measure vibration is ideal for the automotive industry. ASDEC's location is Nuneaton, putting it in the heart of Motorsport Valley, home to prospective customers.

Dr Reid stresses that it is hard to measure a university's ability to transfer technology to the wider world. "Some measure patents, or the number of spin-outs or licensing. But my personal view is that none of these capture the interactions a university has with industry, which can run from consultations to a conversation. Just publishing research gets the information in the public domain, which companies can pick up without the university ever noticing. So I don't think you can measure it accurately."

There's no doubt British universities are now adept at sharing knowledge. The dark days of Thomas Bayes, toiling on papers with no hope of an audience, are long over. MR

Read more about technology transfer on pages:

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PROTECTING IP SHOULD BE PRIORITY

THIS ARTICLE EXPLAINS:

- **Companies don't know how valuable intellectual property is**
- **Many firms experiencing infringement of intellectual property**
- **Chinese manufacturers will often breach IP rules**
- **Business should protect designs in UK and Europe**
- **British manufacturers spend billions on R&D**

When a tech giant like Apple can fail to win a battle to stop a Chinese company using the name 'iPhone', it shows why intellectual property should be at the top of the priority list for manufacturing businesses.

"Innovation is vital for growth. Research and development can cost big money – yet still despite this investment, many companies don't see the IP as potentially one of their most valuable assets"

Innovation is vital for growth. Research and development can cost big money – yet still despite this investment, many companies don't see the IP as potentially one of their most valuable assets.

Corporate lawyer David Preece is an expert on intellectual property and works with manufacturers across the Midlands and beyond to help them safeguard their IP, and challenge those who seek to steal it.

"IP probably covers almost every part of a business, from the branding and copyright right through to the trademarks and patents. British manufacturers spent nearly £20 billion on R&D last year, yet they risk effectively losing the value of that spend if they fail to protect the innovation which happens as a result."

Many manufacturing companies experience IP infringement

fbc manby bowdler.
SOLICITORS

"It's important that manufacturers consider their options for both new or existing design registrations, as to whether they need to protect their design in either the UK and Europe, or in both"

QUARTER OF FIRMS EXPERIENCE INFRINGEMENT

Research last year revealed that 30 per cent of small firms with IP, employing fewer than 250 people, are reliant on those rights for at least 75 per cent of their turnover. And a quarter of those have experienced some level of infringement.

Preece says: "This research shows that businesses of all sizes need to be concerned about IP. Apple is one of the largest, most well-known and most valuable brands on the planet but the need to protect your own creative ideas and products is the same for many businesses, big or small.

"China is a notoriously difficult market for Western businesses. Chinese manufacturers will often ignore IP and simply manufacture what they want, and in reality the authorities do little to prevent this."

One way in which businesses can help protect themselves is by taking advantage of cheaper registration fees to secure greater protection for their intellectual property. Registering designs with the Intellectual Property Office could also be a route to protection for manufacturers in the UK post-Brexit. A registered design is one of the options available from the Intellectual Property Office, alongside trade marking, patenting and copyright.

It protects the visual appearance of a product including the shape, texture, materials, colour and pattern and gives the right to prevent others from using the design for up to 25 years through a renewal process every five years.

Since the Intellectual Property Act was introduced two years ago, it has been a criminal offence to copy a registered design intentionally. The reduction in fees for registered designs sees the cost of a single online application cut by £10 to £50, with bigger savings for multiple applications.

Preece says: "This reduction opens the door to much more affordable protection for smaller manufacturers seeking to safeguard their business ideas and designs."

UK DESIGNS AND EUROPE


David Preece

The UK process protects designs solely in the UK, so for businesses looking to protect designs in Europe the EU Trade Marks (EUTM) and Registered Community Designs (RCD) will continue to be valid in both the UK and the rest of the EU until Brexit is completed.

Post-Brexit, UK businesses will still be able to register a Community Design, which will cover all remaining EU Member States, but it will not be valid in the UK.

The Government has also said it intends to ratify The Hague System for the International Registration of Industrial Design in a national capacity, to enable continued access for UK designers post Brexit. This allows registration of up to 100 designs in over 65 territories through one single international application.

Preece adds: "In the run-up to Brexit, it's important that manufacturers consider their options for both new or existing design registrations, as to whether they need to protect their design in either the UK and Europe, or in both." MR

"China is a notoriously difficult market for Western businesses. Chinese manufacturers will often ignore IP and simply manufacture what they want, and in reality the authorities do little to prevent this"

THE MANUFACTURING 2020 ROUNDTABLE

Additive manufacturing, the Internet of Things, big data – and how manufacturing will change

In association with igus.co.uk

BACK ROW, L-R: Jen Harley; Daniel Green, Charlotte Horobin; Dr Sara Ridley, Crawford Warnock; Stuart Cooper; Daniel Barrow.
FRONT ROW, L-R: Andrew Kinder, James McTaggart, Peter Hannon, Justin Leonard, Keith Willett, Will Stirling, Chris Hill

Andrew Kinder, vp industry and solution strategy, Infor

Stuart Cooper, head of sales, manufacturing, Ilmor Engineering

Dr Sara Ridley, head of production engineering and quality, Mahle Powertrain

Justin Leonard, director, igus

David Barrow, managing director, Haddonstone

Peter Hannon, managing director, Harting

Keith Willett, regional manager, manufacturing, Lloyds Bank

Daniel Green, founder, G23 Engineering

James McTaggart, UK operations manager, Scott Bader UK

Charlotte Horobin, interim region director, Midlands and East, EEF

Andrew Kinder (AK), vp industry and solution strategy, Infor: We have a productivity gap in the UK: we never really recovered from that in 2008. I have a number of technologies I want to put on the table today and ask the question, 'are we taking full advantage of these to tackle productivity?' Top of the list is automation. Technology number two is 3D printing. The next technology, Big Data, means 'big insights'. With the right science, you can pull in data from across the supply chain and find new ways of improving quality or reducing waste. And you can't talk about big data without talking about the Internet of Things (IoT). With more than 50 billion connected devices expected by 2020 we have never had a better opportunity to seek out new operational efficiencies, deploy predictive maintenance for lower downtime, improve health and safety and discover more about how customers are actually using products – which drives innovation. But the most exciting area for me is, how do I make money out of this new information? How do I make money out of the data that is coming in my direction? The connected car is the best example. What are the services I will buy when the car becomes a vehicle not just for transport, but for new value added services?

The last technology I want to consider is digital business. We live in strange times, where the biggest retailer – Amazon – owns no stores, where the biggest taxi cab business owns no taxis; that's Über. And the market capitalization of comparison services businesses like Priceline is higher than the value of the top 5 global hotel chains added together. These companies have found a way of owning the customer experience.

Stuart Cooper (SC), head of sales, manufacturing, Ilmor Engineering: We're similar to Mahle. We're automating a lot of our CNC machines for classic, lights-out running. You can offer a better service in the evening, and cheaper rates, potentially, to draw customers in. You


Andrew Kinder, Infor


Stuart Cooper, Ilmor Engineering


Dr Sara Ridley, MAHLE


Justin Leonard, Igus UK

have to have someone running the machine, normally. We can pick up that work and run it at night. It's a free money scenario, running lights out. We've spent a lot of time on that at Ilmor.

Dr Sara Ridley (SR), head of production engineering and quality, Mahle Powertrain: We've tended to go down the route of using robotics for what we would consider some of the more dangerous operations; some of our heritage parts, particularly. We use liquid nitrogen to freeze valve seats before they go in. We don't really want a person operating that, so we've tended to go down the robotics route. In terms of 3D printing, one of the things we are using it more and more for is replacement parts to keep our machines going, particularly for some of the older equipment, where parts are not available, or we've had a bespoke piece of kit. Robots are great – but it's the integration that is the hard thing. Finding someone who really understands your specific needs is crucial.

The other thing we are doing is digitising and Bluetoothing our gauging. When we collect variable data, which we collect a lot of, we have that Bluetoothed to our systems, which analyse the data. We don't introduce the variability of transcribing the information, or recording it manually on a system. It all directly feeds into the system. That has been a huge change, and we're only just seeing the benefits of that.

Andrew Kinder (AK): It used to be the case that you would put the factory robot in a cage so it didn't kill anybody. Today, you find the more modern robots are working side-by-side with employees, because they sense their surroundings.

Justin Leonard (JL), director, igus: We've developed a series of component parts using our dry bearing technology that can be built into a robot for around four or five thousand pounds. One of the key things is that the robot is not powerful enough to do any damage to humans working around them. But it is powerful enough, in the manufacturing sense, to carry out a lot of functions and yet be programmed incredibly easily. A large investment is needed currently for a robot, but many businesses won't need something of that scale, or of that power. A customer might want one or two axes, and not six axes. You can program this low cost robot very easily to get exactly what you want, in fact the customer can easily do that. This is becoming a very important technology for us.

David Barrow (DB), managing director, Haddonstone: I can see 3D printing being a technology we will need: the trouble is, all of our products are quite large, and as far as I am aware, 3D printing is mostly quite small. I know there are printing houses in China and other places, but it's quite rough. I don't know whether the technology is moving fast enough yet, and whether the price points are coming down fast enough.

Andrew Kinder, Infor: What about for the moulds you use?

DB: We could think of jumping the actual technology, and going straight from the drawing to the product. Jump that mould-making technology. For example, when making a sculpted head, 3D printing would be very interesting.

Peter Hannon (PH), managing director, Harting: We are trying to use more robots, and more humanistic robots as well, to increase safety of processes. We are working with ABB, for example, who are very strong in the market, and have some much smaller robots as well. We are looking to incorporate more sensors in our connectors to collect data to transmit that data to local nodes too. That's a big drive for us, to make the connector more intelligent so it can communicate, as opposed to being 'dumb'. Ours is a German company, so it's very much into Industry 4.0.

We've done a lot of research with local institutes in the area. We are making our manufacturing modular and flexible: mass-customisation, as they call it. At the Hanover Fair last April, it was very much the case that it was modularisation in terms of manufacturing. There was a big push.

Will Stirling (WS), Stirling Media: Working for a German company, do you think technology is led by countries like Germany, Japan and Korea? And that France and the UK follow?


Peter Hannon, Harting


Keith Willett, Lloyds Bank


David Barrow, Haddonstone

PH: I think Germany has the culture and environment to support that. It's not that we couldn't do it – it's that we are not encouraged to work collaboratively together to do it. I find in Germany, there's a lot more of that going on. We saw the debate get bigger. It became Industry 4.0, and then the Internet of things.

Keith Willett (KW), manufacturing at Lloyds Bank: That's the key word in any research, and pushing your business forward: funding. You can have the greatest business idea, but if you don't have that funding...

Justin Leonard (JL): I do see hope. I was recently at the MTC in Coventry, which is a manufacturing Catapult centre developing advanced manufacturing, so there are definitely signs of progress.

Stuart Cooper (SC): They will come out and look at your business and see how you can apply these things – free of charge.

Andrew Kinder (AK): Often when I start a conference I say, 'how many people here think they are a digital business?'; very few hands go up: 10% maybe. Then I explain what a digital business is, that it's just a journey. At the end of the session, they all put their hands up and say, 'yeah, I am'. Everyone has a website: then your website becomes a place that evolves to a site where you can buy. The next stage is. 'how do I optimise that buying experience?', and then 'how do I make people buy more?' – which is what Amazon do, and Netflix.

You can always find a way to sell. The next stage after that is put the devices in. Then you are starting that journey of autonomous or semi-autonomous business, right up to the point some companies are at, where the machines talk to one another – machine-to-machine conversations, which is where Industry 4.0 is heading.

WS: As an SME, Daniel, do some of these terms mean much to you?

Daniel Green (DG), founder, G23 Engineering: We started a Facebook page first. My brother started it, making the modified car scene, showing them purely on Facebook and Instagram. And now we've got six machines. It started on Facebook and Instagram, so it's definitely a digital world.

WS: And how old is the company?

DG: Four or five years. The last 18 months, we've had massive investment. Everything we have earnt, we put straight into the company and the machines. If there is a piece of an equipment that suits a particular job, we will buy it as soon as we possibly can. People come in and they are shocked by what equipment we've got in a short space of time.

WS: With vape cigarettes, companies are now capturing data about how often they are used, and the flavours. You would never be able to get that data through a market survey. I am not sure whether that would apply to the products you are making; having embedded sensors in the machine?

DG: We've got thousands of email addresses related to the car seats, so you know the person's interested in that sort of thing. You could target them that way.

Andrew Kinder (AK): One of our customers is Ferrari, and that is a classic example of extreme customisation: 7,000 cars a year and every single one is different - uniquely configured by its owner – right down to the colour and style of stitching on the leather interior. There are a million permutations. That's why I could never buy a Ferrari. It's not that I wouldn't want one. I just wouldn't be able to decide.

WS: Do you think, James, that the customisation of products applies to the chemicals industry?

James McTaggart (JM): We're not a big chemical company: we are quite niche. In terms of developing customer requirements on the resin side, that's very much where we see growth, on our speciality resins. So a lot of our resins are for yachts, but we are doing more on the automotive speciality range. Our challenge is about the future of the products we make. Our focus is now on sustainability, because you need to take a long-term view. All our raw materials are oil-based, and all of our products are non-recyclable. That is the challenge facing us.

WS: On the technology side, I assume that when you use a resin in a thermoplastic environment with carbon fibre, once it has set and it's been used, you can't reclaim the resin again?

JM: This is where recycling comes into it.

WS: You can recycle by destroying it.

JM: You can destroy it. There's various things. But green chemistry is really where we need to focus. The challenge for a site like mine today is investment. You talk about automation. Our processes are automated, because we are dealing with highly flammable and, more importantly, highly toxic, chemicals. We want the operators away from the reactors, as much as possible. Those aren't cheap investments: we are regulated by the HSE and the. So there are costs there – it's not like a normal E&I spend. You can multiply it by five, ten times, because of health and safety. That's the challenge for the UK, and why so many people in our industry are closing UK sites.

But we are employee-owned. Ernest Bader, who started this company, gifted the company to us. So we can't be bought, and we can't sell the company. We're very secure. That's why we are able to invest in the UK. But it is a challenge, because the engineering costs are very high.

WS: Employee ownership seems like a model that lends itself to manufacturing. Otherwise, why invest? We don't have vertically-integrated industries in the way that Germany does.

JM: There are no external shareholders putting pressure on us. It really is very positive.

AK: I think you've introduced a good topic there, which is not technology, but is a 2020 topic – sustainability.

WS: Yes. Do you think in the machining industry waste – water, energy, swarf – do you think that has come down in recent years?

Stuart Cooper (SC): The classic in manufacturing is to be like Airfix. With Airfix, you see two operations, three at the most. If you're making something out of billet and you run four or five operations, I think you are making it wrong. So, you are trying to reduce the amount of operations. If you are using five-axis, which nowadays is from all sides, you come off, tag it, take it out, and the product is made.

Dr Sara Ridley (SR): We have a managed tool supply. So while we do buy in specialist tools for specific applications, our tools are managed for us by our tool supplier. We make maybe 76,000 components a year that are identical, so for us, it's a much better way of doing it. It actually increases our speed, apart from anything else. Then we are not speculating on tool life. That's all managed. Some of the more specialist ones, the technicians will set. We will have regular meetings with them. We ask, 'how do we run dryer?', because we don't want to use so much coolant. How do we manage our systems better? What is the new technology that will enable us to get the finish we want, without the waste? But I think it also comes back to the design. One of the things we don't do in terms of sustainability is design for reuse. We don't design to extend the life of the product. Ironically, as engines have become smaller, and lighter and more fuel-efficient, they are actually much harder to remanufacture and to sustain.

Sensor technology might give you a really accurate picture of what the lifecycle of your components is, and what they are used for. Actually, you can build in that sort of technology to help you understand your market better. Because one of the problems of dealing with the whole lifecycle is what happens to the product when it leaves you.

WS: In terms of business metrics, does anyone here have sustainability as a target?

Justin Leonard (JL): If you're involved in the automotive industry it is a very strong driver. With our bearings, we get designed into a lot of automotive applications and as such have to comply with the vehicle end of life directive which relates to sustainability and recyclability. In aerospace and defence to it is starting to become a topic of interest – but in automotive it is already very advanced.

SR: I think the End of Vehicle Life Regulations that came in at the beginning of the 2000s have been getting increasingly tight; the targets are getting tighter every year – I think that's been a real driver for that. We don't see that in other industries in the same way.

WS: Do you think sustainabillity will become more ingrained, more compulsory?

SR: I don't see how it can't be. I think legislation is going that way. If you're looking at where we are going in terms of minerals, I don't think there is any choice.

WS: So sustainability is going to become more important for business. What about people? My theory on the big problem


Daniel Green, G23 Engineering


James McTaggart, Scott Bader


Chris Hill, EEF


Crawford Warnock, centre


Charlotte Horobin, EEF

with the image of manufacturing is not attracting enough young people. But does more digital technology making its way into the factory make it easier to engage with young people?

Stuart Cooper (SC): For us it is different because our core business is motorsport. I guess you're at the exciting end of engineering, and we find it very easy. We have a staff of 84 and six apprentices, in different areas of the business, from inspection to engine build, machine shop to assembly. We find it easy because there is an element of excitement – you can watch Indy Car Racing, Moto GP, NASCAR – and you are involved. You are not making washing machine parts. We find it easier to draw people in from outside. We do have links to Northampton College.

SR: We do try and build those as well. One of the problems we have is we have a reasonable apprentice programme, but with the Levy coming in, which is going to be huge for us, we are actually trying to expand that into other areas of the business, as an engineering apprenticeship. I did an engineering apprenticeship when I left school. It was what people did – and there were plenty available.

Image is a huge problem for us. That everybody who's an engineer also has overalls and a spanner, and big boots, and that's all they do. I've worked as a STEM ambassador to dispel the myths. But even so, they are very firmly embedded. In terms of manufacturing engineering education, if I want somebody who isn't an apprentice, who has done a degree – actually a manufacturing engineer is really hard to find. Everybody wants to be a design engineer.

WS: Has that always been the case?

SR: It used to be less so. We don't value manufacturing in the way we used to. And I think that's a real problem. We've got really good links with the college, and going into Northampton University, but even there, going into manufacturing engineering is really hard – it's an afterthought. Actually, a good manufacturing engineer is hard to find. Most of my manufacturing engineers are within five years of retirement. That's an enormous business risk for me.

WS: Perhaps we could just go around the table quickly, with any of your own thoughts about the sector? Will it be better or worse in 2020?

SC: Our racers will always be racing, and that's our core business. Ilmor Engineering is like a garage project, dare I say it – he gets to go racing. I think if we're out of Europe, we should be doing as much as we can to bring work back in. Factories that have been barren, disused places, should be brought back – but then we go back to the problem of filling them with staff.

We've got a young apprentice at Northampton College that is learning on equipment that is 80 years old. He's learning technology, he's learning the same things I learnt 20 years ago, with the same machines, no CNC – it's all manual. He's bored, but he's getting paid for it. We've said to him, 'do what you need to do at college, and come to us'. He's coming on leaps and bounds – but college is giving him nothing.

WS: David, as a lower-tech manufacturing company with a good market, how do you see the skills issue?

David Barrow (DB): We have a very good apprentice who has been with us for three years. But it is quite hard, being out in a village, in the middle of nowhere, to get a 17- or 18-year old lad to travel to work under his own steam. To obtain apprentices we speak to the local teachers, and ask 'who are your best lads coming through in terms of business?' We short-circuit the official system.

WS: And what is EEF's perspective on manufacturing in 2020?

Charlotte Horobin (CH): We're pushing for a clear industrial strategy – with skills right at the top. The conversation that I have with manufacturers is that graduates and apprentices can be difficult to attract. And there's the issue of women in manufacturing, not just to tick a box, but to fish from a wider talent pool. There is also a silent, but deadly, problem in terms of there being a skills gap in middle management. There are lots of managers who've been promoted that are technically very good, but can't manage people.

Innovation is an area where we are continuously pushing for investment within the UK. We're a huge supporter of the Catapult centres and are engaging with the UTCs, universities and colleges. Infrastructure is another area where we are pushing for investment. And we need to introduce low carbon technologies, while remaining competitive.

And for the UK, we need to secure our trading relationship with the EU while also grasping whatever other opportunities fall out from Brexit. I would encourage all manufacturers to become involved in that debate. MR

CORPORATE GOVERNANCE

GOING FOR GOLD – NOT JUST PROFIT

The British model of corporate governance ensures shareholders and directors thrive on short term success, but not necessarily the country as a whole. Robert Bischof asks whether companies should also be run for the benefit of employees and society

2016 were the most successful Olympic Games ever for the United Kingdom. With 27 gold medals – and 67 medals overall – Team UK came in second place, ranking only behind the United States. In spectacular fashion, the UK beat both China (3rd) and Russia (4th), as well as Germany (5th) in the overall standings.

What makes this very special Olympic glory so noteworthy is the contrast to the Olympic Games two decades earlier. In Atlanta in 1996, the British team received just one gold medal – its lowest score ever.

THIS ARTICLE EXPLAINS:

- **Britain's record-breaking Olympics the fruit of long term planning**
- **Too much short term thinking in British boardrooms**
- **Shareholder value puts corporations under pressure to massage balance sheets**
- **Theresa May rethinking corporate governance**
- **Germany provides an example of doing things differently**

WHAT A DIFFERENCE SMART PLANNING MAKES

What has made the difference over these 20 years? The short answer seems money from The National Lottery, with each ticket sale generating proceeds that were dedicated to funding Team UK at the Olympic games. But that is not the whole story.

Once Britain was awarded the 2012 Olympic games, the country's then-government under Blair and Brown decided to change things around a bit. A long-term strategy was developed and priorities were set to focus on certain sports where the chance of medals were greatest. To that end, specialised facilities like the Manchester Velodrome were created. In addition, the best coaches were hired, and they and the athletes were highly motivated through incentive schemes based on performance.

Britain has got plenty of sports talent but, as the Olympics strategy has proven, that talent must be properly nurtured. England's national football team failed at the European Championships in summer 2016 because of systemic problems.

A key part of the explanation is short-term pressure on results, paired with too many foreign owners and managers with no interest in the national game. They look for spectacular foreign signings

rather than developing home-grown talent over the long term.

SHORT TERM DECISION-MAKING

The Anglo-Saxon 'shareholder value' governance system, with its inherent pressure on quarterly results, drives short-term decision-making by boards. M&A activity yields quicker results to make a corporation larger than organic growth would. For the latter approach, you need patient product improvement and development, investment in the latest technologies, focus on opening up new markets and, above all, on skills development in- house – at all levels, from shopfloor to top floor.

All that costs money and reduces profits in the short term. The approach chosen instead is to massage the balance sheet – often through share buy-back schemes – to make the company's results 'look' better, even if this is just a financial engineering exercise achieving no real enhancement in value. It is part of the shareholder value model where the incentives for directors are in line with those of the shareholders; unfortunately, both thrive on short-term results.

Even more importantly, they mostly just pay mere lip service to the stakeholders – employees and their families, the towns and cities where operations are based, as well as society as a whole. To give a concrete example of how far society can be affected by irresponsible corporate governance, just consider Sir Philip Green's purchase and subsequent sale of British Home Stores.

The sale of BHS and its subsequent collapse has left 20,000 employees potentially facing hardship in retirement thanks to a £570 million black hole in its pensions scheme, which is now being probed by the Pensions Regulator.

This ugly chain of events has rightly been described as the unacceptable face of capitalism. It clearly highlights big shortcomings in the UK's corporate governance.

To cut a long story short, under the British business-as-usual rules, the deck is amply stacked against long-term thinking and value creation.

SELLING ASSETS TO SHORE UP ECONOMY

Britain has lived for decades on the proceeds of selling assets to shore up the country's current account deficit and the exchange rate. Ports, airports, the energy sector, and huge numbers of industrial businesses have been sold to foreign investors. The London Stock Exchange and high-tech ARM Holdings plc are the latest in a long line. For a long time, all this selling off the family silver was falsely heralded as underlining the attractiveness of Britain as an investment location and considered a virtue.

> "As a top manager of German companies, I was always paid bonuses on market share and profit – never on profit only. The search is on for a workable construction that combines the best of both worlds and allows British managers to act in a long-term oriented fashion to the benefit of their shareholders, employees and national performance"

Why was all this misleading thinking pushed on the British public? Because plenty of people in the City got rich in the process of acting as advisors to, if not instigators of, these transactions.

Just ask all the lawyers, investment bankers, accountants and management consultants.

Now, at long last, doubts are being voiced over the long term effect of all this so-called inward investment. Mark Carney, the governor of the Bank of England, warned before the Brexit vote that the reliance on "the kindness of strangers" might backfire.

There undoubtedly is a short-term gain for the national accounts when the proceeds of a sale support the British balance of payment. However, the dividend flow leaves the country forever.

Unsurprisingly, the UK's once considerable earnings flow from overseas investment has reversed. While the country's trade balance has for decades been negative, it is a new and worrying development of the last few years that the service sector is in deficit, too.

In some areas, the open door policy has of course worked with remarkable results. The car industry, once the perpetual laggard, is now thriving as it is almost completely under foreign ownership and management.

That is a great success story — and so are hundreds of foreign owned businesses in the UK. The profits from these operations, however, are only partly re-invested in the UK.

The largest part flows abroad. It is thus like English league club football – a great success story, but sadly not so much for the national team.

Prime Minister Theresa May appears to understand that there is a problem. Rather atypically for a former Home Secretary, she has been referring to rethinking the role of workers on boards of publicly-listed companies; and refocusing on industrial strategy and board room remuneration in terms of the ease with which British companies and assets can fall into foreign hands. It will be interesting to see what she can actually do about it.

WORLDWIDE GLOBAL COMPETITION

Britain's businesses are up against worldwide competition from the Germans, Japanese, Chinese and others who are determined to play the long game. These nations engage in the long game for very different reasons. For example, most German companies, even in the export sector, are not listed on the stock market. They are family-owned enterprises, whose main aim is to grow, survive and look after their stakeholders – their employees, customers, suppliers and the community.

But even those companies that are listed on the stock market have supervisory boards with worker and management representation.

This structure, reflecting in actual voting rights for workers at the supervisory board level, prevent a company's top managers from purely self-interested behaviour that underlies most prettifying balance sheet manoeuvres.

I know because I was there: as a top manager of German companies, I was always paid bonuses on market share and profit – never on profit only. It is impossible, and even counter-productive, to try to copy the German governance system and corporate culture for many reasons. It would be ironic, to say the least, if Britain would turn in the direction of the continental economic model after leaving the EU.

But the search is on for a workable construction that combines the best of both worlds and allows British managers to act in a long-term oriented fashion to the benefit of their shareholders, employees and the national performance.

Bob Bischof is chairman of the German British Forum. MR

UNITING TOWARD COMMON GOAL REQUIRES INDUSTRIAL STRATEGY

Unite and Prospect are two leading unions representing manufacturing workers and engineers. Tony Burke, Unite assistant general secretary, and Mike Clancy, Prospect general secretary, discuss industrial relations in Britain today

Tony Burke

Unite is Britain's largest manufacturing union, representing more than half a million manufacturing workers. From foundation industries such as steel, through to automotive, aerospace, science, chemicals, printing, and engineering, our members are the beating heart of the UK manufacturing sector.

On a daily basis we work with some of biggest manufacturing companies and forge relationships with trade bodies and employer organisations such as EEF, the Society of Motor Manufacturers and Traders, and others.

While we don't always agree on everything, we are at one and united in a desire for a strong UK manufacturing sector underpinned by an active industrial strategy led by the government.

As the sector grapples with the swirling uncertainty of Brexit and all the challenges that it throws up, it is vital that this common approach between Unite, employers and their workforces is developed.

On the key issues of securing tariff-free access to the single market in Brexit negotiations and a grandfathering of workers' rights, Unite is in step with many major manufacturers and employer associations.

Dialogue and transparency have been key to this unity of purpose as it is with successful and productive industrial relations. While it may be robust a times, without that dialogue a car maker like Jaguar Land Rover (JLR) would not be the success story it is today.

It was Unite members who a number of years ago made sacrifices to ensure the car maker had a future and who worked hard to make it the world beater it is today. Those sacrifices were made on the basis that the company had a plan for success, which workers played a key role in shaping through their representatives.

The understanding was that once the company got through the tough times, the workforce would share in the success. So it is only right that JLR workers this year will enjoy a 3.5 per cent pay rise plus bonus and an inflation proofed RPI plus 0.5 per cent in the next.

> "The temptation for a minority of employers will be to use Brexit as an excuse to cut workers on the cheap"

Trust has been the watchword in JLR's success and so it will be for the wider manufacturing sector as we turn to face the immense challenges of Brexit. In the words of prime minster Theresa May it will be a bumpy ride, but it will be a smoother one if employers and unions work together to secure the future of the sector.

The temptation for a minority of employers will be to use Brexit as an excuse to try and trim workers' terms and conditions or cut workers on the cheap to further boost shareholder profits. Such opportunism will be challenged by Unite.

A race to the bottom will only serve to weaken British manufacturing leading to a breakdown of trust between workers and employers. In a part of the economy which has a widening skills gap it will make the sector less attractive to the manufacturing workers of tomorrow and lead to a brain drain.

Manufacturing will not be able to thrive or meet the challenges posed by digitisation and the rise of robots if the pressure is always downwards. Unite recognises this and in a world where skills are a premium is at the forefront of negotiating good quality skills and training opportunities for the manufacturing workforce.

Unite has worked with Jaguar Land Rover, BMW and BAE Systems and in the science industries to develop gold standard apprenticeship programmes. We've worked with the Sector Skills Councils, Semta and Cogent, to develop high quality sector standards for training and skills too.

This collaboration has been about ensuring UK manufacturing has the skills to compete and deliver a sustainable future in which the sector invests in its most important asset – its people.

People, trust and dialogue between unions and employers will be central to the success of UK manufacturing in the years ahead and forging an industrial strategy which cements the UK as a world-leading manufacturing nation. MR

UNIONS BY NUMBERS

6,445,000 – union membership in Britain, 2014

6,500,000 – union membership in Britain, 2013

2.7 MILLION – private sector union membership, 2014

3.8 MILLION – public sector union membership, 2014

13,000,000 – union membership in Britain, 1982

Source: TUC

Prospect members demonstrate over changes to their pension scheme at the Atomic Weapons Establishment

Mike Clancy

Prospect represents specialists across the public and private sector, with the uniting factor that its members are often in mission critical activities. They are scientific, technical, engineering, managerial and, above all, expert.

Perhaps the most distinctive feature of our members is that they want their voice heard, in respect of employment conditions, personal advancement and employment security – but that they also know the best way to achieve this is for their employer to succeed and prosper. This means we need to reflect on how we bargain, that we understand the situation of their employer, and can suggest solutions as well as challenges.

This creates a distinctive rapport with members when we get it right, as their union is seen as credible and authoritative, operating in spaces that are not just in the conventional domain of terms and conditions. In fact, it helps grows the agenda, as issues such as performance and work-life balance are just as important to our members.

It may seem an odd claim but we are of the greatest value to employers where our membership is highest; where representatives are well-trained, and have the time to give evidence-based voice to their constituents.

Prospect has often argued to employers that the worst basis for sound employee relations is low density union membership, and an atmosphere where unions are tolerated but tightly controlled – there only for 'sufferance'. For good industrial relations to flourish, there needs to be trust and time invested. Employers get the unions they deserve.

> "Conflict will not be eradicated by muzzling and diminishing unions, it will just take on unpredictable forms"

That is not to say there are not tensions, but Prospect representatives have deep expertise, know their companies – and know what works. Employers know they need to hear the independent voice and act on it for a better outcome. These are also sectors where their future in terms of government policy, investment profiles and skills are all areas ripe for union/employer collaboration and joint lobbying.

I often ask conference audiences of HR practitioners and managers, what do they want from public policy when it comes to unions? Would they regard zero union presence in the economy as success?

Few would want or support such an objective for public policy but posing the question focuses the mind as to what the role of government is in fostering conditions where unions can thrive and work well with employers.

Prospect is convinced that the answers to our productivity puzzle lie in reconsidering three decades of declining collective voice in the workplace. Atomised employment relationships, 'Uber' models and growing dependent work styles do not form the basis for enduring and stable consumer demand.

Our best working relationships reflect clear understanding of the long term, are reciprocal and evidence-based. It is time for employers and unions to solve some of the workplace challenges together and try to change a policy direction from government that reflects nothing about best practice.

Fail to do this and conflict will not be eradicated by muzzled and diminishing unions, it will just take on new unpredictable forms. It will be technology-enabled and will show itself if anyone looks. Ostensibly people may seem to on message, but privately reluctant to give of their absolute best – because they know they are expendable. MR

Manufacturing is crucial to the economy and could boost UK productivity

Photo: WMG and High Value Manufacturing Catapult

SKILLS

MIND THE GAP: MANUFACTURING SKILLS FOR THE NEXT GENERATION

Manufacturing is vital to the economy and could provide the productivity boost the UK needs. But considerable concerns remain over skills – despite outreach activities improving the sector's image, writes Paul Jackson

The 2016 Engineering UK State of Engineering report tells us is that the contribution made by manufacturing industry and by engineers is invaluable. Engineering drives the economy, drives productivity and drives employment – both directly and indirectly. Turnover stands at £1.2 trillion, productivity is 68 per cent higher than for the retail and wholesale sector, and the UK's 609,000 engineering companies employ more than 5.5 million people. Engineering generated £445.6 billion GDP for the UK. That's 27.1 per cent of the total UK GDP (£1,683bn). Engineering sectors produce the majority of the nation's exports, with manufacturing accounting for 44 per cent of UK exports.

For every £1 generated in engineering, £1.45 is generated elsewhere in the economy. Manufacturing makes up 10 per cent of UK gross value added (GVA) and 54 per cent of UK exports, and directly employs more than 2.5 million people. This strong economic performance suggests the industry is in rude health and prospects are good, so why is there concern within the industry about its long term future?

It's because we know we continue to struggle to attract bright new talent to diversify our workforce – and we continue to fall short in terms of showcasing career prospects in manufacturing and engineering.

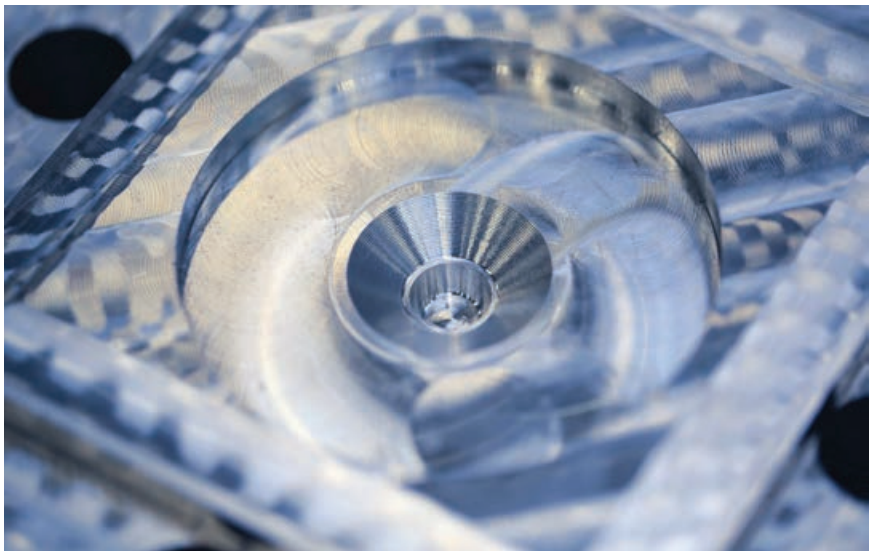
THIS ARTICLE EXPLAINS:

- Manufacturing and engineering are closely linked to productivity
- Skills remain an issue for most manufacturing employers
- Big Bang Fair is attracting tens of thousands of school children
- Tacking STEM skills shortages could add billions to economy
- Outreach activities gradually improving perceptions

MANUFACTURING CAN BOOST PRODUCTIVITY

At a time when the political discourse is dominated by talk of how Britain will extract itself from the EU and what this means for the country's economy, productivity is at the forefront of people's minds. When it comes to boosting UK productivity, the engineering sector and manufacturing in particular, is in a very strong position. The trend for reshoring manufacturing has strengthened. Over the past two years, reshoring has added £600 million to the UK economy and created approximately 10,000 new jobs.

Engineering is an area recognised by the Migration Advisory Service as a priority area. The newly added job titles on its shortage list relate to the aerospace, railway, electronics, mining, automotive manufacturing and design, and the civil nuclear industries. It is the MAC's view that this reflects increasing demand for specialist engineering skills continuing to outstrip potential supply.



Engineering accounts for most British exports, with manufacturing making up 44 per cent

"When it comes to boosting UK productivity, the engineering sector and manufacturing in particular, is in a very strong position. The trend for reshoring manufacturing has strengthened. Over the past two years, reshoring has added £600 million to the UK economy and created approximately 10,000 new jobs"

Businesses across the engineering industries report widespread difficulties in recruiting people with science, technology, engineering and maths (STEM) skills. The shortfalls have been consistently high and rising. Close to a third of firms (32 per cent) this year reported difficulties in meeting their need for such staff (up from 22 per cent in 2013). Crucial manufacturing supply chains are particularly hard hit by these growing shortages. There is an urgent need for action to address intensifying STEM skill shortfalls. The CBI calculates that by increasing public and private R&D spending and tackling the STEM skills shortage to improve UK business supply chains, we could boost the manufacturing sector by 500,000 jobs – and add £30 billion to the UK economy by 2025.

GOVERNMENT COMMITS TO APPRENTICESHIPS

Government has committed to a challenging target of 3 million apprenticeships by 2020. There is evidence that manufacturers, who have historically outperformed other sectors in this area, are taking on the challenge. Two-thirds of manufacturers plan to recruit an engineering apprentice in the next 12 months. We know, however, that in manufacturing a third or more of firms report difficulties in recruiting at every level, including people to train through STEM-related apprenticeships (33 per cent). There is a hidden challenge of progression: From a cohort of 1,000 11-year olds, 111 boys and 101 girls will get GCSE physics A*-C grades. Of those, only 44 boys and 13 girls will go on to study for and attain A-level physics A*-C grades. Only 33 people of all ages will then go on to undertake an engineering-related Advanced Apprenticeship. In 2015 27,195 level 3 apprenticeships in Engineering were achieved, a shortfall of 28,000. That means that, as an industry, we need to double the number of apprenticeships.

It is set against this background that EngineeringUK, working in partnership with organisations across the engineering community, is working to inform and inspire young people about careers in engineering. And we are starting to see some progress: the trend over the last five years is that the perceived desirability of a career in engineering is up to 43% from 27% in 2011 amongst 11 to 14-year olds. Our activities are driven by a robust evidence base, as well as carrying out detailed statistical analysis of essential information about the engineering industry and its place in the UK economy. Through research into public perceptions of engineers and engineering, we monitor and evaluate all our activity to see what works.

THE BIG BANG EXPLODES

The Big Bang UK Young Scientists & Engineers Fair, led by EngineeringUK and delivered in partnership with more than 200 organisations, has grown from 6,500 visitors in 2009 to 73,000 in 2016. It is the largest celebration of

Paul Jackson, chief executive of EngineeringUK

THE ATTRITION IN TAKING ENGINEERING APPRENTICES

	Of 1,000 11-year olds	
	Boys	Girls
GCSE physics A*-C grades	111	101
A-level physics, A*-C grades	44	13
	COMBINED	
Combined boys & girls with physics A-levels	57/1,000	
Taking an engineering-related Advanced Apprenticeship	33/1,000	


The Big Bang Fair had 73,000 visitors in 2016


Engineering outreach activities are having an impact but perceptions of industry need to change much further

science, technology, engineering and maths (STEM) for young people in the UK, an award-winning combination of exciting theatre shows, interactive workshops and exhibits and careers information from STEM professionals. Statistics from the Engineers and Engineering Brand Monitor, 2015 (EEBM) show that only 23 per cent girls (11-14) know what to do next to become an engineer. For girls who attend The Big Bang Fair this figures doubles to 49 per cent. Where young people have participated in Tomorrow's Engineers and/or Tomorrow's Engineers Week, results are above the UK benchmark. Key Stage 3 students who attended Tomorrow's Engineers are much more likely to be knowledgeable about what engineers do (50 per cent versus 25 per cent), this includes a large increase among Key Stage 3 female students (43 per cent vs 16 per cent). More than half (51 per cent) of 15 and 16-year-olds said that The Big Bang Fair had motivated them to choose physics as an option when they had the choice, including 38 per cent of female students.

Teachers and good careers advice are critical to ensuring the future supply of suitably skilled individuals for the manufacturing industry. Three in five STEM teachers of 14-19-year-olds have been asked for careers advice about engineering in past year. Only two in five STEM teachers feel confident giving careers advice about engineering. Thirty-four per cent said they are not confident giving this advice. EngineeringUK programmes are starting to reach more schools with better, regional, relevant careers information, and messaging.

The EEBM showed that a new emerging trend impacting career choice is pay. Young people are more concerned about the potential earnings form a career choice than other factors, such as enjoyment. The average graduate starting salary for engineering and technology graduates is £27,079, and for manufacturing and production engineering the mean starting salary is £28,883.

The average graduate starting salary for engineering and technology graduates is £27,079 and for manufacturing and production engineering the mean starting salary is £28,883

The vision of the Tomorrow's Engineers programme is to create a national network of employers, already 160-strong, working locally to reach one million young people every year with effective careers interventions from STEM employers. It brings a strategic approach to schools engagement, building links with industry and schools. This greater coordination means employer outreach extends to where the need and potential impact are greatest.

Tomorrow's Engineers works centrally with national employers and locally with Employer Support Managers based regionally, working with employers to help make their outreach more inclusive, more impactful and more tailored to local requirements. Tomorrow's Engineers shares good practice, encourages peer-to-peer advice and guidance and respects the distinct needs and approaches of individual companies, institutions and schools.

CAREERS INSPIRATION FOR THE FUTURE SUPPLY OF ENGINEERS

In addition to the need to double the number of Advanced Apprenticeship achievements in engineering and manufacturing technology, construction planning and the built environment, and information and communications technologies, EngineeringUK believes there are crucial steps needed to secure the future supply of engineers needed to meet the demands of employers.

We need to provide careers inspiration for all 11-14 year olds. This should include opportunities for every child aged 11-14 to have at least one engineering intervention with an employer. We must highlight high value of STEM skills and promote diversity of careers in engineering. We know interventions are most impactful if they provide a real life engineering context.

We need to ensure that there is support for teachers and careers advisors delivering careers information so they understand the range of modern scientific, technological and engineering career paths, including vocational and technician roles.

Since 2010, we have seen a significant rise from the 38 per cent of the general public who could cite the engineering development of the last 50 years that has had the greatest impact on them, to more than three in five (61 per cent) in 2015. This improvement in public awareness and understanding of engineering provides us with a useful backdrop against which to work together to ensure that our education system recognises the employer value placed on STEM subjects, and that young people have the opportunity to learn more about the opportunities that a career in 21st century engineering represents. MR

Paul Jackson is chief executive of EngineeringUK

THE MODERN APPRENTICE

Hannah Clarke, 18, product design apprentice, Ishida, explains why doing an apprenticeship instead of going to uni was an easy decision to make

From a young age, I always wanted to be a design engineer. I have always loved and excelled in engineering-based subjects such as: maths, physics and product design. It was due to my enjoyment of the subjects that I took them at A-level, and completed them with high grades.

After A-levels I went on to choose an apprenticeship, even though I was steered towards university. For me, an apprenticeship was a no-brainer. I was able to get qualifications as well as four years' experience within the industry, something that I would struggle to get at university. It was the experience that won me over. I felt that the experience would help me to become the best design engineer I could be. This could be because I could apply my knowledge, learn extra information from the company, or even gain more respect within the company as I have experience.

The added help that an apprentice gets from the company is something that I have considered very valuable. Ishida, the company I work for, is a prime example for this. When I return to Ishida, not only do I get experience within the industry, but help with any problems that I may have faced during the week.

But it is not all positives. I am still getting used to the early morning rises and the added bonus of the morning commute! MR

ENGINEERING A SKILLED WORKFORCE

Initiatives such as Formula Student are engaging youngsters with engineering

Skills shortages are bedevilling industry but initiatives to attract youngsters should bear fruit, says Sue Parr, business development director, WMG

WMG
THE UNIVERSITY OF WARWICK

THIS ARTICLE EXPLAINS:

- Reports highlight skills shortages across industry
- Shortage of engineers means delays to products and services
- UTCs and a new push for youngsters to study STEM subjects provide impetus
- Degree apprenticeships are an exciting new route
- Retaining existing skills and knowledge also a challenge

Two reports, out this year, have both highlighted the need for more skilled engineers in the manufacturing sector. The EngineeringUK 2016 report found 41 per cent of engineering enterprises saying it is hard to fill vacancies, meaning delays in introducing new products and services. Those manufacturers surveyed for the Annual Manufacturing report 2016 also identified their greatest challenge as attracting and retaining a sufficient number of skilled people, particularly youngsters, to fill a high number of vacancies.

Is enough being done to make the manufacturing sector an attractive career choice? To enable young people to make an informed decision they need more information about what engineering is today and what type of career they can expect. They need to be able to gain early experience of engineering and to develop the skills, and mindset, that will help them to become successful engineers.

With the opening of more University Technical Colleges, and the push behind STEM from many of the engineering institutes, hopefully we will start to see a pipeline of young people selecting engineering as their career of choice.

DEGREE APPRENTICESHIPS PROVIDES A NEW ROUTE

Over the last couple of years, we have seen many more options opening up when it comes to gaining knowledge and skills. Higher apprenticeships and, from 2017, the degree apprenticeship, provide an interesting new route for young people. Degree apprenticeships combine working for a business and developing appropriate technical and practical, work-based skills with academic study at a university, such as the programme at WMG, University of Warwick, or other degree providers, for

Left: Is enough being done to attract youngsters into the manufacturing sector?

Above: Degree apprenticeships provide a new route into industry for youngsters

a Bachelors degree. Those studying this way have the best of both worlds: they learn on the job while receiving a salary and gain a degree – but without the student debt. This provides an exciting pathway, which can also be taken by those who might not have traditionally chosen to go to university. For businesses, it will mean engaging highly talented youngsters early, and enabling them to grow in the business.

The challenges don't stop at attracting staff. Retaining the staff and ensuring they have the skills they need now and for the future is equally important. Ongoing skills development is beneficial for both the individuals and the business. It is clear from industry studies that employees want ongoing investment in their development and it is a significant factor in whether they stay or leave a business. Changes in markets and technology also mean that companies need to ensure that their staff continue to have the skills they need to gain maximum benefit from these developments.

PARTNERS IN LIFELONG LEARNING

Universities and businesses are natural partners in lifelong learning – universities have both the fresh perspectives needed for new ideas, and the rigorous standards required for business relevance. Being able to study but also apply this back to business is one way in which WMG enables businesses to ensure that they have the skilled staff they need in the right areas.

In 2017, there is the potential for greater integration of new technology which will be challenging – and potentially game-changing – for many businesses. We've seen that greater servitisation is also altering the nature of the relationship between suppliers and clients. These and other changes in markets are having a massive impact, often requiring a shift in the practices, style and culture of a businesses. Staff need new skills to help them and their business take advantage of these current developments – and the ones that will undoubtedly follow.

But let's not forget that once a business has invested in their staff, they need to be able to retain that information if that member of staff leaves or retires.

This in itself is another challenge, which needs its own approach and one that will be different for each business. MR

> "Those studying degree apprenticeships have the best of both worlds: they learn on the job while receiving a salary and gain a degree – but without the student debt. This provides an exciting pathway, which can also be taken by those who might not have traditionally chosen to go to university"
>
> **Sue Parr, WMG**

Read more about engineering education on pages:

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WHEN THE LEVY BREAKS

eef The manufacturers' organisation

The apprenticeship levy promises to provide a new means of funding apprenticeships in England but concerns persist over the speed of its implementation

KEY FACTS:

New Apprenticeship Levy introduced from April 2017

New system replaces all current funding for apprenticeships in England

Single companies, or groups of companies, with a pay bill of more than £3m in scope of levy

Levy-payers must pay 0.5% of their pay bill to HMRC monthly

Levy-payers have a £15,000 allowance to deduct from their levy annually

From 2018, employers can transfer 10% of funds to other employers

Non-levy payers must co-invest 10% of the cost

Photo taken at Ishida, Birmingham

Above: Apprenticeships are in the spotlight as the Government looks to raise funds for more of them across all sectors

WINS FOR THE MANUFACTURING INDUSTRY

- Increase in the lifetime of levy vouchers to 24 months
- Uplift of funding for STEM apprenticeships
- Increase in funding for key engineering standards and frameworks
- Commitment to work with business of transferring unspent vouchers
- Ability to use funds for up-skilling and re-skilling

WHAT CAN EMPLOYERS EXPECT IN 2017?

- A new Digital Apprenticeship Service (DAS) will be launched
- Levy-paying employers will see levy funds in new accounts
- Employers only get back the "English fraction" of their paybill
- Funds can be spent on approved apprenticeships with approved providers

BEYOND 2017?

- Levy payers can transfer up to 10 per cent of unspent vouchers from 2018
- By 2020 all employers will be registered on the Digital Apprenticeship Service

While the manufacturing industry has seen some major wins on the apprenticeship levy, the challenge for employers now is timing. Verity O'Keefe, Senior Policy Adviser at EEF says: "Apprenticeships are critical for our industry, but manufacturers have long been wary of the levy and wanted it to be delayed until they could be satisfied it was fit-for-purpose. Recent government announcements have reflected our sector's concerns and are a positive step forward." She adds: "Timing is now all important. With a shrinking window of opportunity to prepare for the levy, Government must carefully prepare a final implementation plan while remaining mindful that employers as well as Government need time to prepare for the sea change in apprenticeship funding next year." MR

WANT TO KNOW MORE ABOUT THE LEVY?

CONTACT apprenticeshiplevy@eef.org.uk

EDUCATION

Engineering is expected to have 2.56 million job openings in the run up to 2022 including 257,000 new vacancies

ENGINEERING TWICE AS MANY ENGINEERS

Boys and scientific toys: engineering's image is getting an overhaul - slowly

Engineering continues to suffer from an image problem, but there are signs that increasing numbers of students are taking the subject. Meanwhile, an array of schemes is encouraging youngsters to take an interest.
By Dr Will Whittow and Kate Clift

Engineering is an exciting, vibrant sector employing more than five million people and making a vital contribution to the British economy. It is expected to have 2.56 million job openings in the run up to 2022 including 257,000 new vacancies. These interesting, well-paid opportunities will make a real and positive difference to people's lives across the world. Yet recruiting talented people remains challenging.

THIS ARTICLE EXPLAINS:

- High demand for young engineers
- Myriad schemes encouraging youngsters to pursue STEM careers
- Only nine per cent of British engineers are female
- Physics: 80 per cent male at A-level
- Widespread confusion over what an engineer is

In European languages 'engineer' is derived from words related to ingenuity. Several countries often have a specific word for engineers with a degree. One issue may be how broadly defined 'engineer' has become in English. The majority of engineers we meet in everyday life do not have degrees. It is impossible to think of engineering and not think of engines. If you Google 'engineer' the images are white men in yellow hard hats. The battle is partly to overcome the many misconceptions and prejudices which often deter young people from pursuing engineering – engineering is 'dirty', 'difficult', 'nerdy', 'for boys' and 'is all about hard hats and boiler suits'. If society is not sure what engineering is, then how can we expect young kids to see it as their future?

SHIFTING PUBLIC PERCEPTIONS OF ENGINEERING

It could be argued that the sheer breadth of engineering to some extent diminishes the public's ability to truly appreciate and be inspired by its impact. It makes it difficult for potential engineers to identify with particular roles and to imagine where their own skills and interests might fit in. Finding new ways to show potential engineers the various aspects of engineering and how different roles can impact on the world's challenges in healthcare, energy, communications, transport and manufacturing are important. Weaving these stories across all media channels and consistently making explicit the connections with engineering will go a long way towards creating a shift in the public's perception of engineering.

Meeting this challenge head on is a multitude of events and organisations, supported by an army of enthusiastic volunteers, designed to inspire future

Left: Building solar-powered cars at Loughborough University

Above: There are hundreds of engineering outreach initiatives. Should there be more coordination?

engineers and to shine a light on the numerous pathways to engineering people can follow. These volunteers do incredible work but the hands-on activities can only reach small numbers of people. The Royal Academy of Engineering recently identified more than 300 activities targeted at inspiring people to pursue careers in engineering ranging from annual events like the Big Bang Fair through to ongoing activities, supported by organisations such as the Smallpiece Trust and Engineering Experience. First Lego League is a brilliant activity for younger children – the final held at Loughborough University in 2016 exuded talent and enthusiasm. These events highlight how hard so many people are working to address one of the biggest threats to the UK's industry and economy: the lack of engineers.

This huge effort is slowly building momentum and creating a pipeline of potential engineers. In 2012, nearly 23,000 students were accepted to study engineering at University, by 2016 the number had crept up to 28,710 (UCAS data) – not a massive leap, but a step in the right direction. The Tomorrow's Engineers scheme run by Engineering UK and the Royal Academy of Engineering is working hard to engage young engineers. It aims for everyone between 11 and 14 to have at least one engineering experience with an employer, and for equal number of girls and boys to aspire to become engineers. Participants in the scheme demonstrate a marked increase in their levels of understanding about engineering and come away with a more positive view of engineering as a career option. In 2015, the scheme reached more than 200,000 people and since April 2015, 850,000 young people and 20,000 teachers have benefited from Tomorrow's Engineers careers resources. Admissions tutors look for and are impressed by these types of activities on UCAS personal statements.

Our university, Loughborough, is playing its part. It has invested in its own activities to inspire future engineers. The Solar Car Project, showcases Electrical Engineering and already has reached nearly 6,000 people from seven year olds in primary school through to library users and girl guides. Participants work in teams to build fully functional mini solar powered vehicles and then race their inventions against one another. So far, over 1,200 cars have been made giving thousands of potential electrical engineers a taste of what being an electrical engineer in the automotive manufacturing industry might mean.

NINE PER CENT IS NOT ENOUGH

Despite the fantastic work of organisations such as WISE and WES1919, women currently represent only nine per cent of the engineering workforce in the UK, the lowest percentage in Europe. At the time of writing, the hashtag #9percentisnotenough – coined by The IET – was trending on Twitter. Clearly more work is needed to address the gender imbalance and promote role models. A highlight of 2016 was the announcement by the Royal Academy of Engineering that, with support from the Motorola Solutions Foundation, a new programme of Visiting Teaching Engineers would place 15 professional women engineers into teaching roles in further education colleges across the UK. This programme helps to address the shortfall in strong positive female role models in the engineering sector. Manufacturers' organisation the EEF also acknowledges the lack of role models for female engineers in its current campaign Women in Manufacturing, which explores the perceived barriers to women considering careers in manufacturing and celebrates the success of female engineers in the sector. Maths and physics are vital to engineering. However, physics is 80 per cent male at A-Level and only three out of 500 girls will study engineering at university.

With investment in large-scale, potentially transformational engineering research projects both in universities and companies it is important to continually consider how engineering on the grand scale and at the edge of what is possible can be communicated effectively to the general public. It is the blurred edge of science and science fiction which is often the most inspiring for budding engineers.

Every child has an innate curiosity and a creative approach to problem solving – they are engineers by nature. Experienced and trained (but not necessarily better) engineers in the workplace and academia, share a responsibility to nurture this raw talent and to support the next generations of engineers who will help to solve the big societal challenges we all face. MR

ENGINEERING OUTREACH ACTIVITIES

THE BIG BANG

The Big Bang Fair is the largest STEM event for young students and takes place throughout the whole year across the UK. The fair is inspiring 7-19 year old students about STEM. It is largely based on hands-on demonstrations, interactive workshops and career information from national employers. Its website www.thebigbangfair.co.uk is continually updated with new activities and events. To date, the fair has been visited by more than 130,000 students and 900 employers.

The national Big Bang Fair 2017 will take place at The NEC Birmingham on March 18th. Last year more than 70,000 people attended, and the fair was supported by more than 200 organisations.

BLOODHOUND SSC

Bloodhound SSC is a project to design a 1000 mph rocket car and set a new ground speed world record. Since 2008, the mission of the project has been to inspire young students to take up careers in STEM. Last year the programme reached 100,000 young students through a network of ambassadors and various exhibits. Schools can register teams to participate in a model rocket car competition for students aged 11-16. Registrations can be made via www.raceforthe line.com

Credit: Stefan Marjoram

STEMNET

STEMNET helps schools to inspire pupils about STEM subjects and careers through utilising the experience of more than 30,000 STEM ambassadors. The ambassadors provide support for STEM projects in the classroom; give career talks; help students with mock job interviews, and help with STEM-related practical demonstrations. More than 93% of secondary schools and a large number of primary schools in the UK accessed STEM ambassadors in 2015-16. The ambassadors also help secondary schools with 'out of hours' STEM clubs, to increase students' knowledge and interest in STEM subjects.

WOMEN IN ENGINEERING SOCIETY

The Women in Engineering Society (WES) encourages young girls to adopt engineering as their career, and to sheds light on the enormous opportunities available for women in the engineering sector. To achieve this WES started National Women in Engineering Day (NWED) in 2014. The purpose was to stimulate government, professional and educational institutions to hold events to support the cause. Since then NWED has grown significantly, and UNESCO will join them as a patron from 2017. From 2017, NWED will be known as the International Women in Engineering Day. In 2016, NWED reached over 350 schools across the UK.

ENGINEERING EXPERIENCE

Engineering Experience is a fully subsidised five-day course for 16-17 year olds. Applications are encouraged between Jan and April. Headstart is also a residential course for Year 12 students with an emphasis on gender equality. Loughborough University hosted 300 students at these two events in 2016.

ROYAL AIR FORCE SCIENCE AND ENGINEERING ROADSHOW

The Royal Air Force, Science and Engineering Roadshow is in its eleventh year. The event is based around practical demonstrations, and is aimed at primary and secondary school students. In 2016, the Royal Navy joined the programme, which will reach more than 90,000 students. The event takes place in more than 420 schools all around the UK.

BAE TASTER WEEKS

BAE Taster Weeks have been held every summer for more than a decade. The weeks are targeted at students interested in choosing engineering as a career, especially in the aviation industry. The weeks are held at Warton, Lancashire where the students work on a week-long project, culminating in a presentation. BAE Systems supports the event by providing course content, accommodation and food. Applications for the taster week open in January for year 12 students aged 16-18.

SCARBOROUGH ENGINEERING WEEK

Scarborough Engineering Week is a three-day event to inspire 7-19 years old to consider careers in STEM subjects. In 2016, more than 4,000 youngsters attended. Pre-registered schools and colleges participate, and the event is also open to general public in the evenings. More than 20 exhibitors took part in 2016 providing some inspirational demonstrations like a coach/bus driving simulator, a proposed mining site model, and robotic arms.

TIMES ARE CHANGING FOR SCOTTISH MANUFACTURING

By Professor Keith Ridgway CBE, Executive Chairman of the University of Strathclyde's Advanced Forming Research Centre

Scottish manufacturing is on the cusp of change.

Gone are the days when the sector relied primarily on heavy industry and a handful of big companies such as the ship-yards that adorned the banks of the River Clyde in Glasgow. Instead, Scottish manufacturing is now about more diverse businesses operating in a more dynamic environment.

The Advanced Forming Research Centre's (AFRC) customer base is typical of this new environment. It includes everything from aerospace to opto-electronics companies manufacturing precision optical surfaces for medical devices, from companies who are inventing new heating technologies to those who are looking for applications for new products they've designed.

Scotland is still home to factories belonging to several high value manufacturing organisations such as Rolls-Royce and Spirit AeroSystems but there are notably fewer than in the 20th century, and they rely on agile, flexible supply chains to support them.

Both the UK and Scottish Governments have identified this shift in the landscape and have highlighted that smaller businesses need to be supported and can play a huge part in introducing innovation into the sector.

THE NEED FOR INNOVATION

Innovation is key to the growth of any manufacturing business but it's an area that many struggle with, and manufacturers in Scotland are no different.

In Scotland, the AFRC, the country's only High Value Manufacturing Catapult centre, is providing manufacturers with the tools and help they need to allow them to innovate and consequently increase their competitiveness in the market place. Much of this is around developing and connecting the various organisations in the supply chains of growth sectors such as automotive and aerospace.

> Originally the AFRC had success at a Scottish, UK and global level providing skills and capabilities within the technology themes like forming and forging. More recently there has been growing investment in aerospace, pharmaceuticals, and major contract success in marine and defence.

A lot of what we do at the AFRC is about equipping manufacturers for competition in the modern manufacturing and consumer world. Even traditional industries, such as textiles in the Borders, are reviving - with companies introducing digital technologies that allow them to be much more flexible in their response to customers.

One of the biggest barriers to innovation is often budget constraint but there is a lot of help available to manufacturers in Scotland and part of our remit is to help them access the financial support needed for research. This is paying dividends as innovation is growing and in Scotland today more than 50% of research and development (R&D) spend is from the manufacturing sector, although manufacturing only accounts for 9% of GDP.

A HELPING HAND FROM GOVERNMENT

In England, centres such as the Advanced Manufacturing Research Centre (AMRC) in Sheffield, a partner organisation of the AFRC in the High Value Manufacturing Catapult, have become a focal point for companies in the

Facilities at the Advanced Forming Research Centre are helping companies in Scotland to modernise and implement digital technologies

innovation community. Scotland, as yet, lacks anything similar to the AMRC in terms of size and investment.

The Scottish Government's policy on manufacturing is very forward-thinking and a key element in the economy; last February the national manufacturing action plan, 'A Manufacturing Future for Scotland', was launched. Owned by Scottish Enterprise it identifies the key themes where investment is needed to develop a solid manufacturing future for Scotland.

These themes range from infrastructure to leadership, skills development to smart manufacturing - and all of that has been followed up by the Scottish Government. The Government has made it clear that it would like to deliver on the national manufacturing plan's promise of a joint manufacturing centre of excellence and skills academy with the founding of a National Manufacturing Institute for Scotland (NMIS).

First Minister Nicola Sturgeon has announced that, along with other organisations such as Scottish Enterprise, Skills Development Scotland and the Scottish Research Partnership in Engineering, the University of Strathclyde is helping to develop NMIS, and we're pleased to respond to the Scottish Government's request for support in advising on how that can be established for Scotland.

The First Minister has visited the AMRC and she referred on Twitter to it being a potential model for what is required and we see that as being very positive.

THE NEED TO UPSKILL

In future, the Scottish Government is looking to double the contribution of manufacturing to GDP, and it's absolutely vital that we have a research base that can support inward and continuing investment in the sector.

Currently, there are in the region of 200,000 manufacturing jobs in Scotland, mostly paying above the average wage; half of the country's R&D activity is underpinned by well-paid, high contribution jobs.

Scotland's engineering drive: Scottish Enterprise, Skills Development Scotland, the Scottish Research Partnership in Engineering and the University of Strathclyde are working to develop NMIS – a National Manufacturing Institute for Scotland.

These jobs need to be increased and protected and significant up-skilling of the workforce is required to embrace new and emerging technologies. That is why there is talk of a skills centre as part of NMIS – it's about apprentices and graduates, but also about reskilling the existing workforce. This is important when talking about new technologies. We need to be able to convert the skills of people working in the traditional industries into what's needed to operate and maintain modern pieces of equipment and work in flexible factories of the future.

THE FUTURE IS BRIGHT

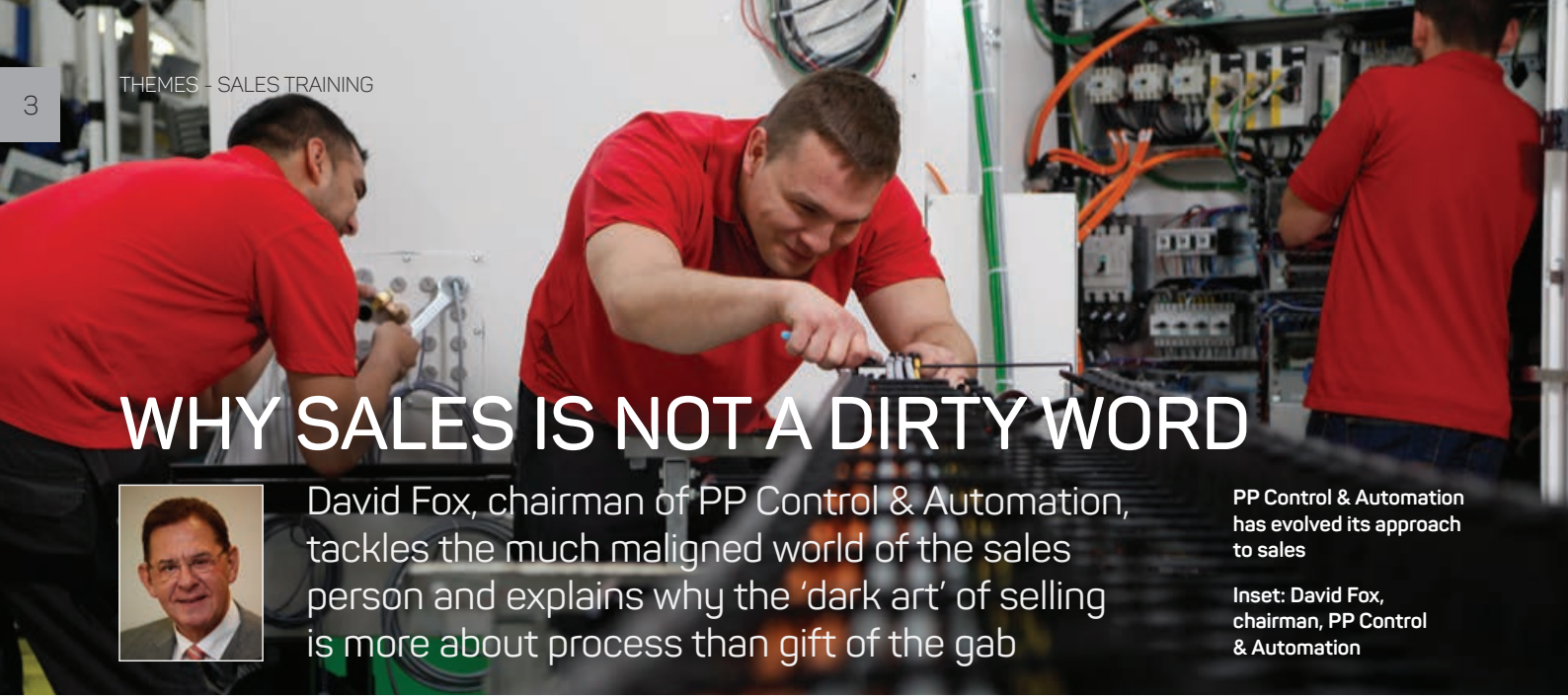
NMIS, whatever form it takes, won't only be about the blue sky research that universities throughout Scotland already do well. It is about having a centre that makes the case technically and commercially for these ideas to be invested in and to go into production. This requires a particular combination of specialised skills and capabilities that universities don't deal with and that companies struggle to do themselves without support.

Originally the AFRC had success at a Scottish, UK and global level providing support, skills and capabilities within the technology themes in which it specialised, i.e. forming and forging.

More recently there has been growing investment in aerospace, pharmaceuticals, and major contract success in marine and defence - and across a range of sectors we're seeing growth in manufacturing in Scotland. It is our hope that a centre such as NMIS will build upon this strong foundation of success.

The feedback we receive when speaking to companies is that to sustain manufacturing growth we need innovation, and to deliver that we need the people and the skillset to bring high quality research to a production environment.

Thankfully both the UK and Scottish Governments are listening to these companies and are embracing the changing landscape of Scottish manufacturing by providing the necessary support for future growth. MR



WHY SALES IS NOT A DIRTY WORD

David Fox, chairman of PP Control & Automation, tackles the much maligned world of the sales person and explains why the 'dark art' of selling is more about process than gift of the gab

PP Control & Automation has evolved its approach to sales

Inset: David Fox, chairman, PP Control & Automation

THIS ARTICLE EXPLAINS:

- There is a dearth of good salespeople in manufacturing
- Sales is not a black art but benefits from training and teamwork
- PP Control & Automation has evolved its approach to sales
- Salespeople deserve to be treated with respect

When we list some of the big issues facing UK manufacturing, you could be forgiven for being blinded by the ramifications of Brexit and the widely acknowledged skills gap.

There will be little discussion about the lack of expert sales people coming through the ranks, a widespread problem that I believe is the biggest hurdle facing industry now and in the future.

It is not a statement I make lightly, but it is one that I feel very passionate about. With more than 50 years' experience in internal and external sales, I am well versed in all the different nuances of what many people in the sector call a 'black art' – not difficult to understand when 80 per cent of orders are supposedly won by 20 per cent of sales people.

NOT JUST FOR THE FEW

I'm not buying into this magic formula that only a few have got it when it comes to sales. Sales is about getting the process right, and making sure people get access to the right training and support. And I do sometimes wonder what sales people did in a previous life to deserve such a lack of respect and appreciation.

It seems that the US is the only country in the world where sales professionals are put on a pedestal. The rest of the world prefers to tuck them away in the smallest possible office and, in recent years, bestow a whole new job title on them – business development manager, for instance.

Securing orders is the lifeblood of any business. Without it a company can't grow, invest in technology and employ and develop people. This is why we should make a concerted attempt to change perceptions and perhaps even look at developing some form of qualification for this profession.

> Is the fact that 80 per cent of orders are won by 20 per cent of sales people good enough, or sustainable, for British industry?

There has to be a joint approach, which industry can drive by lobbying government and academia to develop some form of formal training or, taking it one stage further, the launch of our own sales degree.

I took over PP in 1979, when it was predominantly offering panel building services to a small customer base. I recognised in 1993 that in order to succeed, the firm needed to behave differently to its competitors, and this started a 23-year journey of continuous improvement, embracing automation and giving every member of staff a personal development roadmap. The latter now stands at 200 hours training for each employee, and the company now employs 200 people, providing electrical control systems, cable harnesses and sub contract manufacturing solutions to customers all over the globe.

CHANGE OF APPROACH

We had a significant change in our sales approach in the mid to late nineties, starting, really, with our successful pursuit of a world number one machinery builder. This transformed our thinking as it proved we had an offer that would sell; we just needed to make sure we targeted the right people and embraced the very latest processes. I'm a firm believer of learning from the very best and that involved readings lots of sales books, the majority of which – unsurprisingly – were written by Americans. We get everyone in our sales team involved, almost like a book club, you could say. Each person takes a section and then presents what they have learned to the rest of the group. Sales have gone up from £12 million to £20m in three years so something must be working.

Researching your customer before making the initial call is one of the most important bedrocks in the PP sales approach, and then not assuming you know the answer to your customer's requirements. Over the last year, this approach has seen us identify outsourcing solutions that has reduced three-week build times to just four days, and boosted production for another client so they can now make 12 machines every month, instead of just eight.

Sales doesn't have to be a dirty word and it's up to industry to ensure it isn't. We can start by putting sales people on a pedestal for the first time. MR

The Crimson casting facility means light metal and aluminium foundries need only heat enough material needed to fill a single mould

CAST MASTERS GET IT JUST RIGHT

Cranfield University is working on ways to make casting technology more efficient with an eye on long-term sustainability

> "We are aiming to develop a methodology and a modelling toolkit to enable true energy resilient manufacture"

THIS ARTICLE EXPLAINS:

- **Manufacturing needs new best practice models**
- **Cranfield is focusing on manufacturing processes, modelling and simulation, and systems**
- **Crimson technique makes light metals casting more efficient**
- **Enables aluminium foundries to heat just enough material for a single mould**
- **Cranfield working with automotive suppliers on sustainability**

There is little doubt that manufacturing needs to be transformed to ensure its long-term viability and Cranfield University is creating new models of best practice to help businesses think small, smart and social.

Our work focuses on three strategic areas – manufacturing processes; systems; and modelling and simulation – to help ensure commercial success and sustainability.

Novel low energy casting processes such as Crimson, a new technique which makes light metals casting more energy and material efficient, as well as centrifugal casting and grinding equipment, are utilised on campus.

Crimson, or Constrained Rapid Induction Melting Single Shot Up-Casting, enables light metal / aluminium foundries to heat only enough material needed to fill a single mould rather than large batches of metal melted as in their current approach, could reduce energy costs by at least 50 per cent.

The Crimson capability advocates 'small is beautiful', only using precise amounts of raw material for casting and aiming for this to give higher yields than found in traditional techniques. The castings produced are also of a higher quality than under previous techniques, leading to a reduced scrap rate and lower remelting costs.

Software such as Flow-3D, Magmasoft, iSankey, GFM (Glass Furnace Model), Simapro and CES EduPack is also used to support our research and teaching.

OPTIMISED CASTING METHODS

Some of our other research work includes developing an optimised casting method for the production of lead sheet, used in both the construction and healthcare industries, through computer modelling and simulation. This is in collaboration with Midland Lead. We are also working with a journal bearing manufacturer, JH Richards, investigating ways of improving their production and reducing energy usage, while we have worked with some of the UK's paper mills to see if the cellulose-based by-products derived from paper manufacturing waste can be used as possible raw materials for products in other industries to reduce their environmental footprint.

We recently worked with suppliers to the automotive sector looking at the sustainability and environmental impacts of substituting traditional iron-based alloy components with aluminium alloys. This has now led to phase two of a major UK Government-funded project, Small is Beautiful. We are aiming to develop a methodology and a modelling toolkit to enable true energy resilient manufacture with the production of castings at maximum yield rates with minimal energy and material usage through process routes that maximise profit, while meeting customer needs accurately and timely.

In the FMCG (fast-moving consumer goods) sector we have worked with Coca-Cola Enterprises (CCE) in recent years on the sustainable 'factory of the future', and also reviewed established manufacturing processes to find energy-saving opportunities for the sector. Further related research is looking at evaluation of open innovation models for food manufacturing with real case studies from industrial collaborators, focused on enabling conversation and collaboration between consumers and brands for developing new food products.

Last, but certainly not least, we are using artificial intelligence and working on the control of the assembly of molecules that are the building blocks of many functional materials, consumer and industrial products. This work will have outstanding impact in areas such as personalised healthcare and food production, transport systems and fuel production, housing construction and consumer electronics. MR

SPOTLIGHT FALLS ON ILL HEALTH

New employees need a health and safety induction and the right protective clothing for the job

Photo courtesy of Unipart

Serious accidents are rarer today in manufacturing but ill health and safety breaches still cost firms dearly. Ben Hargreaves looks at how improvements to health and safety culture can boost productivity

THIS ARTICLE EXPLAINS:

- **There are fewer accidents and fatalities occurring in manufacturing but room for improvement**
- **HSE focusing on days lost to ill health as well as accidents**
- **Musculoskeletal disorders, long latency illnesses and stress in the spotlight**
- **Brexit will impact on health and safety regulations**
- **EEF advocates small changes rather than upheaval when it comes to legislation**

Autumn 2016 saw the Health and Safety Executive writing the kind of headlines it hopes will one day be a thing of the past.

In October, a chemicals company was sentenced and fined £3 million for an incident in which a worker was killed and another left with "life-changing" injuries at a plant in Grimsby following the release of a toxic vapour cloud. And in November, Oldham manufacturer R Tindall Fabricators was prosecuted after a worker was crushed under metal pipework while stacking a forklift and died.

A Health and Safety Executive (HSE) investigation found there was no risk assessment, or documented system for moving and stacking pipework or items around the site, and that the method of packing bundles had changed without being documented. If these safeguards had been in place the worker would not have been exposed to such dangers, the HSE investigation found.

Happily, the recent trend in manufacturing is that these types of fatal incident are becoming rarer. "Injury and ill health rates are improving, says Giles Hyder, head of general manufacturing and musculoskeletal disorder policy at the HSE. Hyder says that over the past decade, injury rates in manufacturing have come down by about 40 per cent. Ill health rates in the sector have come down by 25 per cent. And ill health due to musculoskeletal disorders has come down by about 30 per cent. "In terms of fatalities," he adds, "there has been a drop in the last five years of about 25 per cent."

MILLIONS OF WORKING DAYS LOST

For the HSE, one fatality is a fatality too many, however. Millions of working days are lost to injury and ill health in the engineering and manufacturing sectors, so addressing problems effectively could provide a much-needed productivity boost. Musculoskeletal issues are prevalent, closely followed by stress-related absences. Also of particular concern are "long latency" illnesses caused by exposure to substances. "There are incubation periods of up to 30 years for some illnesses, so they hit when people have left their employers," explains Hyder. The HSE sees this as an area where a "push" in terms of health and safety regulation is required, because the problem isn't staring engineering employers in the face. Respirable crystalline silica is an issue because it causes silicosis; chronic obstructive pulmonary disease and other lung diseases are also prevalent, as is occupational asthma – the HSE is targeting the woodworking industry in an effort to prevent this. It is also looking at flour dust in grain mills and its impact on health. Welding fumes and metalworking fluids can also cause health problems.

There is a still a significant number of injuries and fatalities caused by – as in the case of R Tindall – movement of heavy loads and workplace transport. "Manufac-

turers must ensure they have a proper health and safety policy in place – you would be surprised by those who don't," says Julia Fitzsimmons, partner at Midlands law firm FBC Manby Bowdler. She adds that manufacturers must also ensure staff are properly trained in health and safety and that new employees receive a health and safety induction. "Health and safety has to be part of the culture. And if there are breaches of policy, they need to be taken seriously."

Automotive manufacturing and logistics firm Unipart won the latest in a string of awards from the British Safety Council for its health and safety culture in October 2016. Unipart aspires to be one of the safest companies in the world and sets challenging safety objectives, using problem-solving tools and techniques to manage safety. It also has risk assessed and safe systems of work that are fully documented within standard operating procedures, as part of a process of continuous improvement, known as the Unipart Way.

"Our accredited Team Leaders will have met stringent assessment criteria, that ensures they are able to manage health and safety in their area, holding competent skills in risk assessment, accident investigation and emergency management, as well as how to communicate and engage individuals to use The Unipart Way to identify and make safety improvements," says Unipart spokesperson Emma Gascoigne. Crucial to the company's approach is that areas where accidents might happen – 'near miss situations' – are thoroughly documented by employees. "It is essential for organisations to promote a culture where near misses are reported," adds Gascoigne.

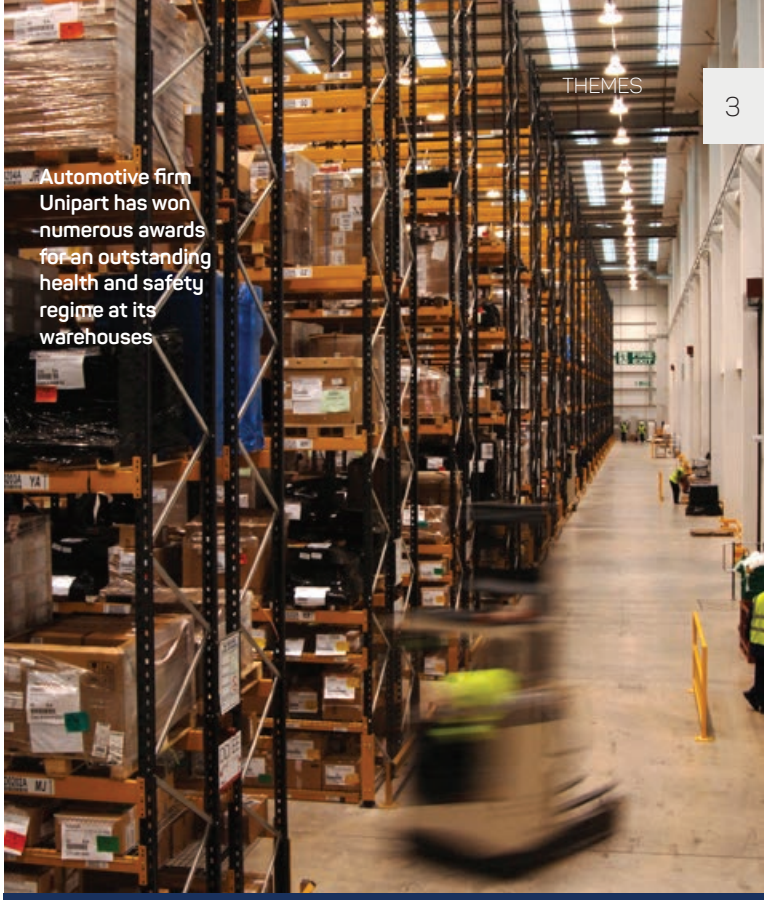
While it is good that Unipart's efforts in terms of accident prevention are recognised, Gascoigne also says that offering an employee assistance programme reduces workplace absences and that increasing employees' psychological well-being is associated with an eight per cent increase in productivity. "We are investing in staff capability to promote wellbeing, for example by starting to roll out mental health awareness training, and providing additional training to line managers in identifying and addressing pressure within their team members. We monitor ill health and provide health promotion and interventions to support ill health," she says.

Technology is also constantly reviewed to reduce risks within Unipart operations. This includes monitoring the daily safety of automation and machinery through comprehensive planned preventative maintenance programmes. "The Unipart Way ensures we regularly inspect and undertake safety checks, and have very visible information available to all on these checks and on everyone's competency levels."

Terry Woolmer, head of health and safety policy at manufacturers' organisation the EEF, says new European legislation on exposure to electromagnetic fields came into force in April 2016 and will affect manufacturers' future health and safety policies. He adds that all European health and safety legislation is currently being reviewed in Brussels. Modifications may be made as a result of Brexit, but the less disruption for engineering employers, the better, he says. "We would prefer to see legislation 'grandfathered' across when we leave Europe. Because companies are using existing procedures, it would be very disruptive to have to adopt something completely new on the day of Brexit."

But he stresses, nonetheless, that there are aspects of European legislation that could do with an overhaul.

Woolmer concludes: "We are still advocating a review process. We recognise that there are modifications that could be made – and certain things we could get rid of." MR



Automotive firm Unipart has won numerous awards for an outstanding health and safety regime at its warehouses

2017 AND HEALTH AND SAFETY RULES

2017 will mean questions on Brexit, and what it means for occupational health and safety.

Derived from EU Directives, most UK health and safety law has been in place for many years, and is embedded in company investment decisions, policies, management systems, safe systems of work, and working practices.

There will be in due course be opportunities to repeal certain areas of regulation, without reducing levels of employee protection. Some candidates for repeal include the Artificial Optical Radiation and Electro Magnetic Fields Directives, and eyesight testing for employees using display screen equipment.

In the area of product safety, such as the Machinery Directive, the story is a little different. Export of goods from the UK are subject to rules around product directives and product standards, many of which will have been established jointly by the EU and by CEN & CENELEC, though national standards-making bodies, such as BSI. Post-Brexit, companies that wish to continue trading in the EU (using CE marking) will want to continue meeting EU product safety directives and the product standards which are mutually recognised across Europe.

Turning to the future, new and emerging technologies that could impact on health and safety policy include nanomaterials and collaborative robots. For nanomaterials the EU and the UK need to decide which legal frameworks are appropriate for protecting workers. It would make sense for the EU to use the existing Chemical Agents Directive (COSHH in the UK), but there is a danger that adoption of the precautionary principle for nanomaterials in the EU might lead to rather more prescriptive requirements.

In terms of automation such as co-bots, man-machine interaction is nothing new. However, it is now becoming commonplace and complex, as robots are operating in segregated areas less and less, but rather working in tandem with humans.

What will this mean in terms of safeguarding standards? This question still needs to be fully addressed.

Source: EEF

Surf Air will offer all-you-can-fly travel for a fixed fee in Europe in 2017

SERVITISATION

SERVICES SKIP ACROSS SECTORS

Manufacturers are embracing servitisation as a means of generating revenue based on the reliability and durability of their equipment, writes Charles Orton-Jones

The European Commission has a bit of a problem. When regulating imports and exports it needs to decide whether the transaction involves goods or services. Yet today it is hard to discern whether certain trades are one or the other. Manufactured goods are supplied as a service, complete with care packages, upgrades and other necessities. Lucian Cernat, the chief trade economist at the Commission, notes in a paper on the subject, "A growing share of manufacturing goods can no longer be simply referred to as 'goods' but should be regarded as a complex bundle of products and services interactions". It's a business model known as 'servitisation'.

THIS ARTICLE EXPLAINS:

- Servitisation is booming across Europe
- Rolls-Royce's pioneering model has been widely adopted by other firms
- Companies pay for availability of the asset, not repairs when it breaks
- Sensors and data collection vital to servitisation
- Some manufacturers resistant to providing services

Rolls-Royce pioneered the concept. It used to sell aircraft engines as individual products, paid for in a one-off transaction. Then in 1997 Rolls-Royce switched to a long-term care package concept. The service agreement covers all and any work. If there are any repairs to be done Rolls-Royce engineers conduct the work at no extra cost. The engine can be completely replaced, if needed, with no surcharge. Users pay for what they use, and no more.

Rolls-Royce expanded TotalCare as the strengths became apparent. Under the 'servitised' contract incentives are converted from low-reliability to high-reliability. Rolls-Royce used to get paid when engines broke down and they could fix them. Now they are rewarded for durability. The cash-flow for both parties is smoothed. There's no huge capex outlay for buyers. And Rolls-Royce enjoys recurring revenues year after year, in a predictable pattern.

By 2014 a total of 90 per cent of the Rolls-Royce Trent engine fleet was under TotalCare. In a customer satisfaction survey three-quarters cited increased availability of engines, 83 per cent highlighted predictable costs, and

The servitisation model pioneered in aero engines by Rolls-Royce has taken off in other sectors

72 per cent called the deal "value for money". The ongoing communication engendered by a service package changes the nature of the vendor-buyer dynamic. Rolls-Royce found 87 per cent of TotalCare customers felt the service model had improved their relationship.

The model has coincided with a period of extraordinary performance at the engine maker. During Sir John Rose's tenure as CEO from 1996 to 2011 total shareholder returns totalled 373 per cent – and that included the bleak post-9/11 airline market, and 83 per cent under his successor. The share price suffered in 2016 but rallied at the end of the year.

COUNTLESS COPYCAT SERVICE MODELS

The success of Rolls-Royce triggered countless copycat service models. Caterpillar has charged for tonnes of earth moved. GE charges for pounds of thrust by its jet engines. Reg Kenney, president of engineering and manufacturing at DHL, works with many Fortune 100 companies on their supply chain, and he believes the trend is justified by the outcomes for both parties. "At DHL, we've noticed a clear trend emerging in the industry towards more service-oriented business models." says Kenney. "This is being driven by three things. First, the fact that manufacturers must meet new and changing customer demands. Their customers want more value-added services and now expect continuous care beyond the point of sale. Let's take the example of a jet engine purchase. The purchaser is increasingly likely to insist that the manufacturer includes maintenance, repair and even upgrades in the deal.

"Second, there is the ever-present need for manufacturers to control costs. But they're operating these days in a challenging and uncertain economic landscape with fluctuating commodity prices and increasingly saturated markets. Given this environment, many manufacturers find that developing a new service offering is less risky and less asset-intensive than developing a new product.

"Third, manufacturers are now able to access more data in the supply chain. With this information, they can move from a 'to-stock' business model to a 'to-order' business model. Manufacturers can reduce their inventory because they can predict when a product or part will be needed and they can manufacture any required items on demand. This capability is enhanced by using intelligent parts – in effect these are items that anticipate and communicate their own status and maintenance needs."

This analysis is supported by manufacturers. JCB enthusiastically offers service, repair and maintenance deals on plant kit. It calls the model the "the ultimate risk-free method" of acquiring, running and maintaining vehicles. Costs are capped. It's tax efficient. Working capital is preserved.

Martin Leeming is the chief executive of TrakRap, a packaging machine maker based in Lancashire. He reports the

SERVITISATION: THE UK STRATEGY

Rolls-Royce and the High Value Manufacturing Catapult launched the National Strategy in Through-life Engineering Services in July 2016 in London. The Through-Life Engineering Strategy's goal, says partner Cranfield University, is to achieve a 20 per cent reduction in cost, with a 20 per cent improvement in asset availability, across more than £20 billion of UK economic output: a 20:20 vision, heralding "a significant transformation of national productivity and global competitiveness". Around 16.8% or £275.2bn of the UK economy is attributable to sectors that could be influenced by engineering services. Of this at least 1.9% or £31.6bn is potentially associated with the creation or application of through-life engineering services. (Source: *A National Strategy for Engineering Services, 2016, Cranfield University*). "Within ten years many more companies will sell service capability across multiple platforms creating applications for economic growth at firm and national level," says Prof Raj Roy, director of manufacturing, Cranfield University.

"We are aligned to our customer's objectives: if it breaks down, it costs us money to fix it, so we are incentivised to make the product super-reliable. When a customer increases the speed of their production lines, we upgrade our equipment to suit"

Martin Leeming, TrakRap

service model has changed the way customers use his products, and how they regard his company. “In the traditional model, a customer buys a piece of packaging equipment and they’re stuck with it,” says Leeming. “Even worse, they will usually use it for a long time after it’s fully depreciated, because the equipment is not high on the list for capital expenditure or because the perception is that it’s cheaper to maintain it. Either way, the pace of technological change means that, in the bigger picture, they miss out on vital advances in productivity, energy saving, reliability and cost improvements.”

By shifting customers to a rental model, backed by aftercare, the entire approach changes. Customers want to upgrade as soon as possible. “We are aligned to our customer’s objectives: if it breaks down, it costs us money to fix it, so we are incentivised to make the product super-reliable. When a customer increases the speed of their production lines, we upgrade our equipment to suit. Over the last four years, one of our partners has increased production from 16 to 28 packs per minute. We have worked with them to constantly upgrade our equipment without the need for any capital expenditure. By offering our customers this pay per wrap structure, our relationship moves more to one of partners rather than client and supplier.”

MAKING THE SERVICE MODEL WORK

Naturally, the contract is the key to making the model work. Leeming is happy to explain how he’s shaped his contract offering. At the start comes a cost for packaging film consumption a year. This is then divided into fixed monthly payments over a fixed term, usually five years, but with a ‘walk away’ clause after two and a half years. Siemens Financial Services takes care of the leasing arrangements. Lemming says, “The customer gets improved margins and reduced energy costs with no capex, and no requirement to

Right: Companies are now rewarded for durability and reliability of equipment

Below: Lancashire packaging machinery firm TrakRap has transformed its business through servitisation

SEVEN CRITICAL SUCCESS FACTORS IN THE SHIFT TO SERVICES

1. **ASSESS YOUR MARKET AND INTERNAL READINESS:** making the shift to services means that all parties involved must be ready to change and understand the value of doing so
2. **CREATE THE RIGHT STRATEGIC AND CULTURAL CONTEXT:** a service business is different to a product business and needs a completely new mindset to be instilled throughout the whole service ecosystem
3. **BUILD THE STRUCTURES AND GOVERNANCE FOR SERVICES:** firms need to make a clear commitment to services by creating properly empowered teams and the appropriate organisational structures
4. **GET THE RESOURCES READY FOR SERVICE INNOVATION AND DELIVERY:** short- and long-term budgets need to acknowledge that services are very resource-intensive, and change over time
5. **PROACTIVELY MANAGE ENGAGEMENT AND TRUST:** services are co- created with customers who are active participants in the service journey
6. **DEVELOP AND EMBED SERVICE PROCESSES:** firms delivering services must experiment and adapt and they need processes that enable them to do that
7. **OPTIMISE SERVICES AND COMMUNICATE BEST PRACTICES:** services rely on continuous innovation and so require a 'best-practice' mindset

Source: University of Cambridge, Cambridge Service Alliance

maintain the asset, so a better return on net assets."

The technical challenges of the servitised model are considerable. For a contract to work smoothly it is essential that the vendor know how their equipment is being used. Typically, sensors report usage data back to the vendor over the internet. Data analytics is used to identify behavioural patterns. This has led to companies like GE re-imagining themselves as digital-first enterprises. As CEO Jeff Immelt said in 2014, "All companies need to become Internet and software companies. The industrial world is changing dramatically, and those companies that make the best use of data will be the most successful."

Each year Cranfield University hosts a course on implementing servitisation technologies. Professor Ian Jennions, who runs the course called Asset Management: coupling business and technology, says the model comes alive when all aspects of the chain of action are mastered. "The chain is sense, acquire, analyse, and react. You start with sense, using sensors to gather data. Don't use too many, as you get an awful lot of data. Then you acquire it, usually locally. Often you find you are in the wrong place. You could be on a wind turbine in the middle of the North Sea, or in an aircraft at 35,000 feet. You need this data on the ground, because by and large you want to look at it on a fleet basis. So you transfer the data. You then analyse it. And then, by exception, the stuff that isn't conforming to what you expect, you then flag to operational control centre. We concentrate on the whole chain. There is no point putting a sensor on something if you don't know what you are going to do with the data, or what action to take if something is going wrong." Companies come to Cranfield to improve their use of machine sensors, and usually, says Prof Jennions, their failings are due to a neglect of one aspect of the chain.

When the process is done smoothly the potential to optimise a servitised offering is immense. Manufacturers can monitor the use of their equipment, and liaise with the user to repair, upgrade, and modify hardware before the client even realises there is a problem.

"Those that aren't offering a servitised model will probably go bust," says Prof Jennions. "The MD of Man Trucks was convinced by the service model, and took Man from six per cent to 12 per cent of the UK truck market by offering a service rather than a product."

Yet, he notes, not all companies are on board. "It reminds me of Kodak and the digital camera. They just don't want to change. The blockers we've seen are incredible. It can be something like an accounts department that can't cope with a different billing system, to someone who says, 'Oh, it'll never catch on'."

For those that do grasp the potential, there are umpteen ways to capitalise. Jennions points out, "One of the clever things is that you can change your model very quickly. You can change the service, despite offering the same product." The plurality of service packages offered by companies like JCB and GE testifies to this.

In the future we'll see a growth of new and disruptive service models. NetJets changed the private jet market by offering travel by fractional ownership. It made the idea of owning a jet outright seem obsolete. Now Surf Air is bringing a similar model to the consumer market. It offers all-you-can-fly travel for a fixed fee. Launched in California in 2013 as the first private members' airline, Surf Air has 3,000 members with 90 flights daily to 13 destinations. In 2017 it launches in Europe, offering London, Zurich, Geneva, Dublin, Paris and Cannes for £1,950 a month. The planes are Learjets and Embraer Phenom 300 turbo-props. The engines are usually supplied on a servitised lease.

Innovations like this further blur the lines between services and manufacturing. It poses a problem for regulators. Lucian Cernat at the European Commission proposed an entirely new category of trade goods for servitisation. Since the World Trade Organisation GATS calls cross-border services Mode 1, tourism Mode 2, overseas branches Mode 3, and temporary expat workers Mode 4, Cernat suggests Mode 5: which he defines as services exports of "domestic intermediate services inputs that are incorporated in one country's merchandise exports traditional sense but as complex bundles or hybrids of goods and services interaction".

The Brexit negotiations will cover arrangements for Goods and Services separately. The treatment of servitised trade, booming across Europe, will give negotiators another issue to worry about. MR

Read more about servitisation on pages:

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TARGETING THE PRODUCT LIFECYCLE

There is a new national strategy for through-life engineering services as manufacturers look to drastically decrease cost and increase availability of assets such as aero engines, trains and power stations

Through-life engineering focuses on generating revenue via maintaining and servicing products across their whole life

THIS ARTICLE EXPLAINS:

- New national strategy on through-life engineering services launched
- UK must realise economic potential of TES
- Increased availability of complex assets targeted
- Bombardier, Siemens and BAE among companies involved
- Cranfield delivering Through-life Engineering Services Institute

Leading figures from across the manufacturing industry came together in July to launch a new national strategy in Through-life Engineering Services (TES), calling for the UK to realise the economic potential of TES.

The strategy's goal is to achieve a 20 per cent reduction in cost of ownership, with a 20 per cent improvement in availability of complex engineering assets – such as aero engines, trains or power stations – which account for at least £31.6 billion of annual UK economic output.

Cranfield University, Rolls-Royce, and the High Value Manufacturing Catapult have been leading the strategy with the support of many of the biggest names in UK manufacturing, including Babcock International, Bombardier Transportation, BAE Systems and Siemens. Together, these companies have committed to forming a cross-sector National 'TES Council' to inspire UK industry.

The strategy sets a clear direction of travel for the UK to embrace changes in behaviours, new business and economic models while exploiting new technologies.

GROWTH OF TES ENABLES INTEGRATION ACROSS SECTORS

The growth of TES will enable more integration between manufacturing, engineering and technology, and business model innovation, across a number of sectors such as aerospace, defence, and energy. TES innovators, including SMEs need to be able to adapt to the changing market more easily, with speed and less risk.

At Cranfield University we are playing our part in delivering the national strategy through the Through-life Engineering Services Institute which works with businesses in long-term partnerships and shorter-term projects.

The TES Institute is developing the next generation of systems needed to manage design, manufacture, operations, life extension and end-of-life of large-scale assets with expected lifetimes of up to 60 years. Cost, safety and environmental impact are considered throughout the lifecycle. Optimised support integrates diagnostics & prognostics, self-aware/sensing systems, and planning and scheduling for maintenance decisions, support and logistics.

As part of the TES mission, we focus on finding ways to manufacture products with the highest levels of reliability and lowest levels of cost over the entire lifecycle. Hosting the EPSRC National Centre for Innovative Manufacturing in Through-life Engineering Services allows us to work with industry on disruptive technologies in this field.

Integrated Vehicle Health Management (IVHM) projects are supporting manufacturers as they make the transition to being service providers selling capability rather than spares. Research is providing a commercial basis by creating the new technologies needed for optimising maintenance.

Our Operations Excellence Institute shares TES activities and knowledge, working with students and clusters of small manufacturing companies in collaborative projects. A virtual reality and simulation suite provides state-of-the-art visualisation of complex engineering data, event and risk simulation. MR

INSTITUTE DEVOTED TO TES

The Through-life Engineering Services (TES) Institute brings together the:

- Through-life Engineering Services Centre
- Pan-university Cranfield-Boeing Integrated Vehicle Health Management Centre
- Operations Excellence Institute.

For further information visit: https://www.cranfield.ac.uk/centres/throughlife-engineering-services-institute

Hosted by Gripple

THE INNOVATION MAPPING ROUNDTABLE: FROM RAW IDEA TO NEW CUSTOMER

INVENTION, PEOPLE POWER, AND PERSONALISATION

Hugh Facey, chairman, Gripple (5)

Nikki Stokes, global strategic PR and advertising, Sandvik Coromant (10)

Ian Lain, new customer and industry sector sales, Sandvik Coromant (23)

Gordon McRae, special projects manager, Gripple (7)

Craig Burton, partner, BDO (18)

Nick van Dijk, research director, ITM Power (13)

Edward Naylor, chief executive, Naylor Industries (15)

Matthew Aldridge, managing director, igus (2)

Matthew Gavins, Evolution Power Tools (21)

Steve Knapman, account manager, Infor (16)

Dr Jamie McGourlay, Rolls-Royce (17)

Julia Fitzsimmons, FBC Manby Bowdler (24)

Simon Winfield, director, Maclellan Rubber (22)

Lee Hibbert, content director, Technical Publicity (19)

Andy Tüscher, regional director, EEF (6)

Giovanni Federico, senior engineer, Ansys (4)

Maciej Ginalski, UK pre-sales manager, Ansys (11)

Prof Sam Turner, chief technology officer, Sheffield AMRC (3)

Gordon Panter, managing director, PMS Diecasting (20)

Tony Hart, managing director, Hart Materials (14)

Neil Lloyd, sales director, FBC Manby Bowdler (9)

David Taylor, operations director, Stelrad (12)

Jen Harley, marketing manager, Infor (1)

Liz Mills, account manager, Infor (8)


Ian Lain


Nick van Dijk


Hugh Facey

Hugh Facey (HF), Gripple: Innovation has always been a driver of the Gripple business. That has been recognised over the last three years, when we have won three Queen's Awards. But we don't call it R&D: we call it ideas and innovation. We have an ideas and innovation department, with 12 engineers, and we invest between 4-5% of our turnover every year in ideas and innovation, ten times the amount that most manufacturers spend.

We have a target that 25% of our sales in a given year should come from products that we didn't have four years before. It is a difficult target to hit. We are running at 16%. At some points we have run at 36%, at others as low as 9 per cent. But it is a target that we keep driving, and driving. Last year we launched 13 new products in the year. So innovation is what it is about. How do we generate new ideas? Our customers. They are the biggest source of ideas. The other thing that makes us different is that we are an employee-owned business. But the difference is that an employee-owned business is their business. They are driving it, they are looking for the ideas, they are looking for innovation.

BRITAIN NEEDS INNOVATION

Will Stirling (WS), Stirling Media: In my view, Britain needs more companies like Gripple, that design and make their own inventions. Does anyone relate to the new product development drive Hugh mentions?

Ian Lain (IL): We also take a long hard look at product lifecycle management. Product lifecycles are getting shorter for products that deliver greater productivity and are able to run at higher speeds and feeds. In our sales operation, we look to measure the sales of products that have been released in the last two years. It is critical to get new products out to the marketplace: these new products are a point of difference between us and our competitors. Generally, we are able to bring new products to market that are innovative, that allow customers to increase productivity and so machine products faster, adding value to raw materials. We believe that sets us apart from our competitors. Innovation is influenced by a number of factors, of which competition is one of them. We act as a market leader, where you have certain responsibilities as the market leader, one of which is to bring in innovative new technology. technology.

Nick van Dijk (NVD), ITM Power: To me innovation is not just product, so you have to look across the whole business model – in terms of sustainability, and in terms of the way we operate. We have to give people the confidence to come up with these ideas. Every day is an opportunity to do something better.

Jamie McGourlay (JM): At Rolls-Royce, there is a legacy and a history of innovation. But the bottom line is that you have to create the right culture, and the right environment, to foster innovation. That extends across the company and its processes. Key elements for being innovative are to not be afraid of failure, to be able to keep an open mind.

Saying to people 'be innovative' is not enough, you need to be able to manage the change innovation offers, and encourage people to look ahead of what's in front of them. We have a 'vision strategy that underpins our innovation': this gives us a view of the challenges and opportunities over at least the next 15 years. We need to have a clear strategy and a culture that supports innovation.

Will Stirling (WS): How do you pool ideas?

JM: At Rolls-Royce we have an approach for doing this internally. But we also look outside and encourage external innovators to contacts us with their ideas. We look for innovation across other industries, and other walks of life. You can't be insular. We invest in external research. We have our partnerships with universi-


Jamie McGourlay


Edward Naylor

Sam Turner

ties and research centres. When you have ideas, you must also be able to drive that technology to maturity.

WS: Is the AMRC becoming a place where companies go for product design solutions, as much as manufacturing process solutions?

Sam Turner (ST), Sheffield AMRC: Yes, it is both. A lot of what we do concerns manufacturing processes. Manufacturing cheaper, quicker – with better designs, or more integrated designs, and more robustly. But really, the biggest opportunities occur at the design stage. There is design for manufacture, but also manufacturing influenced design, where manufacturing informs design. Rather than designing something, and fine-tuning, it is thinking about manufacturing technologies – and how they can enable fundamentally different designs.

Rather than improving a design concept for manufacturability you can think about the functionality you can embed into components thanks to multi-materials or emergent manufacturing technologies. The manufacturing knowledge of choice needs to be brought in here, at the concept design phase. It is bringing manufacturing thinking and knowledge into the design phase much earlier. And manufacturing technology is changing at a rate. Designers may have ideas about manufacturing that are five or ten years out of date.

Maciej Ginalski (MG), ANSYS: If you look at jet engines, the complexity of the design is immense. If we talk about prototype testing, let's not limit ourselves to the traditional ways of conducting experiments of such devices. What we tend to do these days is to allow engineers to build digital twins of their designs. Virtual models can then be tested in ways impossible to accommodate by means of traditional methods. This way we can ensure the product is ready for the market with a higher degree of certainty.

THE DIGITAL TWIN

WS: Are digital twins familiar to everyone?

MG: Ultimately, you want to conduct prototype testing on the physical component, but not necessarily at the design stage. If you look at the nuclear industry, or the healthcare sector, you

Digital Twin: If you look at jet engines, the complexity of the design is immense. If we talk about testing, let's not limit ourselves to the traditional ways of testing through experiment. What we tend to do is allow our people to build digital twins, and try and change the nature of the test.

Maciej Ginalski

really want to make sure that the proposed idea will work before actual testing of the prototype takes place. Manufacturing technology is changing – the same as the methods we use to validate this technology.

The concept of the digital twin is relatively new. With the computer power at our disposal we can build computer representations of very complex physical systems. Certainly, this is an alternative for everyone interested in validating their concepts and ideas. It equips people with the ability to prove their theories at the early design stage. With this extra boost of reassurance, innovation and creativity – so vital in engineering – will thrive more freely. This is particularly important for graduate students with minds filled with great ideas but often lacking the means to prove them.

WS: What about the digital twin and Naylor? Do your designers do a lot on screen before it goes into production Edward?

Edward Naylor (EN), Naylor Industries: When I took over we were making a commodity product, a clay sewer pipe that was losing market share to other materials. We had to innovate, or else were going to die. Once people grasped that, the ideas came flooding in. We turned the situation on its head, and now sell a new range of very high-performance products all over the world. We changed from a commodity UK business in long-term decline to an international business with – for the construction industry – some very high-tech, high performance products. We are becoming more sophisticated.

As a £12 million business you can pass prototypes to your customers and ask them to play around with them, and give you feedback. When you're a £50 million company, it's different. We have recruited people to bring a more scientific approach to technology and modelling. It is partly technology, and partly systems. But we need to bring things to market that are proven.

WS: Do you have targets for solving problems and challenges in terms of innovation at the AMRC?

Sam Turner (ST): No. We're a manufacturing research centre, and that is our bread and butter. Our everyday activity is looking at the challenge the customer

INNOVATION AT SANDVIK PREPARES CUSTOMERS FOR INDUSTRY 4.0

Ian Lain (IL): One thing we've been working on is trying to connect many of the solutions we have in the business that enable customers to make components more cost-effectively. CoroPlus is a platform that we hope will help companies in preparation for Industry 4.0. In a manufacturing environment, there are many aspects that go into manufacturing a component. You start with design and planning, where we have CAD/CAM systems. In CoroPlus there is a tool library that contains all the information about tools and relative tool data. We need as much analytical information and data about the machining process, so we can manage cutting performance and machine tool performance. This is where innovation plays a part in reducing the manufacturing cost per part, where we look to have a platform that our partners can connect in to. We look to import information regarding particular cutting tools – not just tools from Sandvik, but from various different companies. This ensures you get the best from the tool in order to improve your manufacturing capability. We also use simulation software to simulate cutting data, and the performance of the tool in the machine, so when you apply the tool, you have taken everything into consideration. In-machine connectivity involves putting sensors in tools. We use Bluetooth connectivity at the back of the tool to collect and distribute data about the tool, and a dampening mechanism at the front of the tool to eliminate vibration. We use the connectivity when setting the tool up to get the correct centre height position and we feature vibration indication and quality of surface whilst the tool is in cut. You can record and store the data which helps when it comes to quality control, and mapping performance trends for the tool through a batch of components, as well as ensuring you are getting consistent performance of the tool across batches. With a number of tools there is the ability to adjust the cutting parameters though the machine controller. This is ideal if there is a requirement to change the speed, feed or depth of cut of the tool due to data being fed back from the monitoring system. This is real-time process monitoring, where it actually gives us the opportunity to do live monitoring of our tools while they are in cut, which is a big step forward for us, and a big step forward for our customers. When it comes to reducing the cost of the part, we collect lots of data and gain a competitive edge in that we can produce a component at lower cost, making more efficient use of a customer's fixed assets, making us all more efficient and innovative in what we do.

Liz Mills

has, and solving it via innovation. The mix of companies of different sizes and sectors we work with, and solving these problems, creates the right environment for innovation.

WS: I heard you were having more success – and the Catapult centres – in attracting larger companies, rather than SMEs. Is that still the case?

ST: We are making an effort to get out onto the shopfloor of SMEs. That's exciting, looking at where the opportunities lie. It all starts with business challenges. We often find technology is only part of the solution. If it is in terms of agility and cost, there is normally a technological solution.

Liz Mills (LM), Infor: Technology plays a part – but it's important not to overcomplicate it.

MASS CUSTOMISATION

WS: Is there much going on in your business Matthew, in terms of customisation?

Matthew Aldridge (MA), igus: Yes. We do get asked for custom bearings. But this is nothing new, we have been fulfilling these requests for years. I see a change in the way that we support innovation. Traditionally we would modify standard parts, or make a special mould tool for the customer. Now we are increasingly using new and emerging technology to support innovation, in three new ways. First, we use additive manufacturing to make sample parts from advanced materials, or we 3D print a mould tool to manufacture parts in a standard igus material. Second, we work with beta testers for new products and technologies that we are developing. Third, we look in detail at what the customer is trying to do, and see if we can integrate our products in a more intelligent way, reducing assembly time and cost, improving productivity.

Matthew Gavins (MG), Evolution Power Tools: Information like that is very important to us, and the stakeholders throughout the process are very important. But they don't know what they don't know. There are so many facets to what we do. Innovation doesn't necessarily mean bells and whistles: itmight be something in the process. We spend a lot of time on materials at a molecular level to make our products, engineering to a very fine level. That is our innovation. Our customers, B&Q, and Hope Depot, demand innovation – that is what we sell – we don't just sell product. We're selling a cycle, five or ten years down the line. You can do facelifts, up to a point. But technology is moving faster and faster, and manufacturing is advancing at a rapid rate.

Tony Hart (TH), Hart Materials: I am managing director of a company with five people, so how do we innovate? We don't have 40 design engineers. We don't have big teams of people. We have found innovation frustrating. But we have tried to innovate. Myself and the operations director are technical people. The frustrating thing we find in terms of customised innovation is that a customer may decide they don't want the thing they thought they wanted.

We have the technical ability for innovation. But we don't have the time. And it can be frustrating because we could be spending that time knocking on doors and selling standard product. It can be very frustrating for a small company, devoting time to innovation.

Nick van Dijk (NVD), ITM Power: There is innovation in terms of software. There is innovation in terms of making the sales process easier. In terms of innovation, you tend to think a lot about technology, rather than the way that you sell

There is innovation in terms of software. There is innovation in terms of making the sales process easier. In terms of innovation, you tend to think a lot about technology, rather than the way that you sell the technology, or the way you market the technology. Actually we have to be innovative in the way that we sell, in the way that we market it – and that is also what sets us apart in the industry.

Gripple takes another bow

In 2016 Gripple won its **fifth Queens Award**, becoming one of an elite band of businesses that have won all three Queens Awards. Two of the awards are for innovation which is the building block for their success, and two have been for International Trade reflecting the success in selling innovative products on a global stage. The final award is for sustainability which reflects excellence in both the use of scarce resources but in selling products which deliver green benefits to their customer base.

the technology, or the way you market the technology. Actually we have to be innovative in the way that we sell, in the way that we market it – and that is also what sets us apart in the industry. But if you spend money on innovation, sometimes you have to know when to stop. You have to know when to say, 'the product isn't going to work'. The truth of the matter is that the business plan changes when you meet the first customer. Everyone thinks they have a great idea: the art is in really seeing which one is going to be the winner. It is more difficult for a small company. In a big company, you can cover more bases.

Sam Turner: It is important to have exposure to the market. At some point, at the earliest opportunity, test that idea in the market to get some kind of feedback.

Tony Hart: Time is the most precious commodity in industry. You can lose money, and make it back. But you can't get time back. We've been helped by WMG and having them and the universities work alongside us. They support small businesses in the West Midlands area.

(WS): WMG is one of the members of the HVM Catapult. British companies were said to be perishing in the valley of death, without bringing products readily to market. The R&D tax credits are meant to encourage innovation. But do companies know these things exist?

Matthew Gavins: We take full advantage of that: they are fantastic. I think the encouragement is there, it's just whether people get it, and get on with it.

Neil Lloyd: The answer is that people are aware of R&D tax credits – but I don't think they are fully aware of what they can get. What we find when we talk to their accountants is that they haven't actually claimed for everything that they are doing. They think of innovation re: a new product or a design, not necessarily a new process, or some element of skills. And so no, they are not maximising on R&D tax credits So I think there is awareness of it, but not full awareness. Companies do not know what they can actually get.

WS: Innovation in terms of personalisation has always seemed to be more suited to consumer goods, but what about engineering?

ST: You talk about the fourth industrial revolution and we're seeing that it is built upon the two pillars of data capture, and data usage and analytics. That will have a huge effect on product design and product development. We haven't seen it to its full extent as of yet, coming through. Agility and mass customisation becomes possible with Industry 4.0, building on what we already see in automotive when you design and build your own car, you are actually doing it from a quite a narrow set of variants, but the permutations are huge.

On the automotive side, a lady went into Bentley and wanted a car a car the colour of her sequined dress. Bentley now calls that 'Sequin Blue': everything was customised to that one digital customer. Yes, mass customisation is there. It has been there for a number of years, but it is extremely high value. But it is getting it down to the lower value that we are not seeing not yet. MR

Technologies

Filters are used in so many processes throughout the world and here in the UK Croft Filters Ltd of Warrington, Cheshire manufacture the highest quality bespoke filters globally. From Food & Beverage, Oil & Gas, Pharmaceutical industry sectors to Power Generation, Utilities & Waste - Croft supplies all kinds of filter to keep our industries moving.

The Inside Of A Filter, taken by Rob Watkins at Croft Filters in Warrington, shortlisted in the amateur category of the EEF Photography Competition 2016.

SHINING A LIGHT ON MANUFACTURING'S FUTURE

Manufacturing needs a cutting-edge research base in order to thrive. By Professor Philip Nelson, chief executive, the Engineering and Physical Sciences Research Council

Manufacturing industries and technologies play a key role in driving the UK's economic competitiveness, and all industries rely on the products and materials they create.

The fact that the UK is the world's ninth largest producer, with manufacturing accounting for 11 per cent of GVA, 44 per cent of our exports and 2.6 million jobs, demonstrates the importance of the sector to the nation.

As the UK's main funding agency for engineering and physical sciences research and doctoral training, the Engineering and Physical Sciences Research Council (EPSRC) plays a key role, by putting the building blocks in place for manufacturing to achieve sustained, long-term success.

THIS ARTICLE EXPLAINS:

- British engineering on verge of Industry 4.0
- Simulation and digital manufacturing crucial to industry
- Researchers collaborating with industry to underpin growth
- New Manufacturing Research Hubs established
- Engineering talent in UK to be harnessed for future prosperity

We do this through support for cutting-edge research and the development of highly skilled people. Our research and skills programme impacts across all UK manufacturing industries, as well as enabling the creation of new industries and capabilities.

Our manufacturing research draws on the entire EPSRC portfolio, from advanced materials to sustainable energy sources, and is a vital pathway to achieving real-world impact by connecting the research and innovation landscape. We are unique in supporting basic manufacturing research through to the stage where applications can be developed by companies or agencies such as Innovate UK, and the Catapult network it supports. In 2011 we established the Manufacturing the Future theme to coordinate this activity across EPSRC; identifying and investing in new growth areas, and fostering a research community with the appropriate skills and leadership.

DIGITAL MANUFACTURING

EPSRC's Manufacturing the Future theme currently supports 374 grants with more than £435 million of investment, enabling researchers to provide vital contributions in industries such as aerospace, automotive, pharmaceuticals, electronics design, and photonics. We are in the era of digital manufacturing the next phase of a modern manufacturing revolution that has been driven by rising connectivity and computational power and a greater ability to translate digital instructions into reality.

Above: Manufacturing research is supported from its origins through to the stage where products and applications are developed

EPSRC-supported researchers in fields such as additive and digitally-enabled manufacturing technologies are contributing to the development of this rapidly-growing field, and we continue to invest in research and skills development. Our goal is to foster and sustain an environment which allows the UK's world-leading researchers to address the challenges and exploit the opportunities posed by this manufacturing revolution.

Following discussions with the research community and industry, we identified four strategic priorities within the Manufacturing the Future theme, which form its vision for a productive, innovative and competitive manufacturing base for the UK.

First, we want the research efforts we support to generate a suite of flexible tools that enable the manufacturing process to be integrated in the discovery, design and development of those products that will come to define the 21st

century – goods which may be 'smart' and multi-functional. And we must always be alive to new possibilities arising from emerging technologies, such as quantum technologies, where we are overseeing a £270 million investment on behalf of the UK government.

A second theme is digital manufacturing and the ongoing integration of computer-based systems which optimise the design process, allow for simulation and visualisation of processes, and enable fast and responsive control and connectivity of manufacturing systems and their supply chains.

Third, it is important that manufacturing industries are able to meet the needs of current customers and sectors without compromising the ability of future generations to meet their own manufacturing needs, becoming truly sustainable through a transformation of resource usage, resilience and security.

And finally, through the development of alternative machine tools, systems that have the capacity to self-build and alternative supply chains and business models, we can drive the creation of new industrial systems which are more effective than conventional systems at creating and capturing value at a variety of scales.

Collaboration is vital to our approach, as bringing together academia and industry to co-create and invest in research is of paramount importance in addressing the major, long-term challenges facing the UK's manufacturing industries.

THE FUTURE MANUFACTURING RESEARCH HUBS

Our Future Manufacturing Research Hubs are a perfect example of this thinking. Building on the previous investment successes of our Innovative Manufacturing Research Centres and Centres for Innovative Manufacturing, the hubs feature high quality, multidisciplinary research and have strong partnerships with manufacturing industries. The hubs will take a leadership role in their national network.

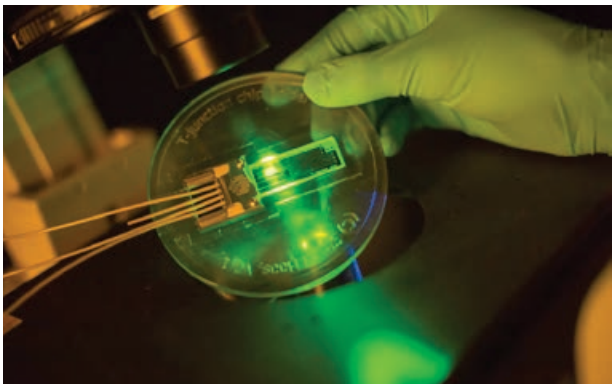
Two hubs are already operational, with the universities of Southampton and Sheffield focusing on high value photonics manufacturing, and Brunel University, Imperial College London, and the universities of Leeds, Manchester and Oxford collaborating on research into future liquid metal engineering.

And a fresh wave of investment will see new hubs established to widen this approach further and impact on a number of different sectors.

EPSRC's £20 million investment in the two established Manufacturing Research Hubs has been combined with £14 million from the universities and £58 million from industry, while future hubs will also lever in large-scale funding from industry.

The 115 Centres for Doctoral Training (CDTs) across EPSRC's entire portfolio are another illustration of our approach to collaboration. Established at higher education institutions across the country, they provide the environment necessary for training the engineers and scientists of the future while at the same time forging lasting links with industry.

Led by 33 universities and backed by 1,100 partnering companies, the CDTs are vital in providing researchers with the skills and facilities they need to conduct world-leading work.



Above left: Prof Phil Nelson and EPSRC are supporting manufacturing through the development of a world-leading research base

Above: The University of Nottingham is carrying out world-class engineering research

HARNESSING TALENT FOR LONG-TERM STRENGTH

The long-term strength of the UK's manufacturing research base depends on harnessing all the available talent and we are committed to supporting people throughout their careers. We offer support to allow the next generation of researchers to realise their enormous potential through a range of different Fellowships across the different career stages, which can be held at any UK university or similar higher education institution that is eligible for Research Council funding.

As an investor in research, we are committed to attracting the best researchers from a diverse population into manufacturing research and innovation careers. Unlocking this diverse talent increases our ability to achieve our ambitions and contribute to the long-term prosperity of the UK.

> "Our current five-year delivery plan, which takes us through to 2020, is designed to ensure that the UK stays at the forefront of science and engineering on the world stage"

All of this has informed our current five-year delivery plan, which takes us through to 2020 and is designed to ensure that the UK stays at the forefront of science and engineering on the world stage.

The Government is supportive of our message that new technology and engineering require strong foundations, and our central intention is for our investments to support four inter-linked outcomes which collectively underpin UK prosperity – productivity, connectedness, resilience and health.

Building success in manufacturing is a long process that requires collaboration, innovation and sustained investment – but the results have far-reaching benefits for the prosperity of the UK, its economy and industry. MR

3D PRINTING IS DEAD: LONG LIVE ADDITIVE MANUFACTURING

In terms of additive manufacturing, the focus has switched from consumer to industrial use. Britain has the technology and the applications to be a world leader in a booming industry, writes Rachel Park

ADDITIVE MANUFACTURING

THIS ARTICLE EXPLAINS:

- Additive manufacturing's true home is in industry
- Metals have been the focus but plastics are coming back
- The sector is high growth and Britain has a lead
- 3D printers are growing in scope and sophistication
- UK must realise economic potential of AM long-term

Laser metal deposition, one of the two additive manufacturing technologies TRUMPF offers. Photo courtesy of TRUMPF.

Metals are the subject of heightened interest from the AM industry but plastics are also making a comeback

The last 12 months have borne witness to the consolidation of a global trend across the additive manufacturing and 3D printing industry, whereby the industry itself, and the media reporting on it, have renounced any illusions of this being a consumer technology — at least in the short- and medium-term.

Apart from a few hysterically negative headlines proclaiming 3D printing is dead, this has served the industry well: the emphasis is now more correctly placed on industrial applications for the entire additive manufacturing (AM) process, and in terms of education.

Throughout 2016, the spectrum of AM processes and platforms has continued to increase in capabilities and number, from both industry incumbents and new market entrants. Adoption is following a similar growth curve, and original applications for the technology are emerging from industrial users large and small.

Similarly, the ecosystem of technologies that drive and support the AM hardware platform is also expanding and driving adoption. Integrated system software for pre- and post-process monitoring is a notable example, with high-end metal machine manufacturers focusing heavily on quality control parameters that monitor builds for errors and provide traceability — a demand from OEM users in the aerospace and automotive industries in particular.

AM WORTH $ BILLIONS

According to April 2016's *Wohlers Report*, by Wohlers Associates, the growth in AM was reported to be in excess of

$1 billion for the previous year. According to the report, the entire industry is worth more than $5 billion this year, up from the $4.1bn quoted in the 2015 report and representing a total growth rate (CAGR) of 25.9%. Wohlers Associates tends to avoid projections, but many other market research firms will offer such figures for the AM and 3D printing industry. MarketsandMarkets estimates that "the 3D printing sector is expected to reach $30.19bn by 2022, growing at a CAGR of 28.5% between 2016 and 2022".

AM with metal continues to develop within the sector as a whole, with the UK's only metal platform developer and manufacturer, Renishaw, faring well among its global competition. GE's bid to acquire two European metal AM vendors — Arcam and SLM Solutions — has also heightened market interest in metal additive manufacturing. However, a recent industry development is pushback against the widespread perception that metal is the only additive technology suitable for production applications. Both 3D Systems and Stratasys are driving manufacturing applications, including final production, with plastic materials. Notable here is Stratasys' introduction of its two 3D demonstrators — the Composite and Infinite-Build; as well as 3D Systems' Figure 4 concept. While not available commercially, the systems have been previewed through 2016 to exemplify the companies' next-generations of production technologies with plastic materials.

Significant developments from other global AM companies include formal product launches from Carbon and HP. Both have developed additive platforms that process plastic materials for manufacturing and production applications, and both are due to start shipping in 2017. A wholly new market entrant in 2016 was US company Rize; with its original augmented polymer deposition process it promises to minimise — if not end — the headache of post-processing 3D printed parts. From Japan, there is also a promise of new machines from Canon (plastic) and Toshiba (metal).

In terms of a global roadmap, the International Organization for Standardization (ISO) and ASTM International have jointly developed and released the Additive Manufacturing Standards Development Structure, a framework that is aimed at meeting the needs for new technical standards around AM.

UK APPLICATIONS OF AM

When it comes to applying additive manufacturing technologies across industry, Britain stands out

CUSTOMISED BIKE IN THE FRAME

Unveiled earlier this year, the R160 enduro mountain bike frame is a prime example of collaborative AM between the Robot Bike Co, HiETA Technologies, Altair and Renishaw. The 'Robot Bike' illustrates the mass-customisation advantages of AM technology, together with unprecedented design freedom, with customised production of bike frames tailored to a customer's individual measurements and riding preferences – with the added benefit that the frame can be constantly improved as new technologies emerge.

HOLISTIC APPROACH TO AM

One British company that exemplifies a holistic approach to additive technology is medical device developer Sutrue. The company's MD has consistently used 3D printing for all stages of the product development process for the firm's innovative suturing devices, including the FormLabs stereolithography process for prototyping and, more recently, the Laser Cusing process from Concept Laser for final production, using compliant metal materials.

COST AND LEAD TIME SAVINGS FOR PPE

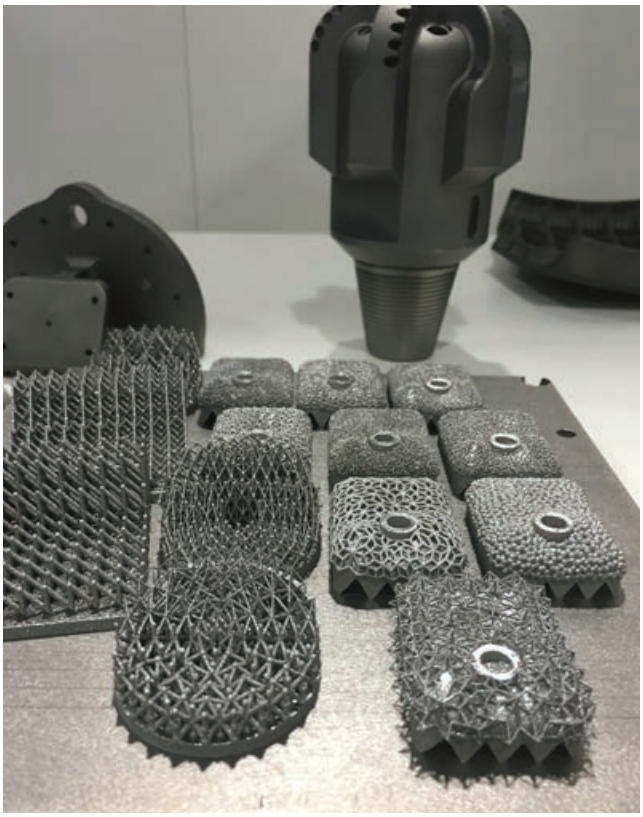
Peak Production Equipment, a UK manufacturer of automated test equipment and test fixtures for clients such as Rolls-Royce, Siemens and BAE Systems, is using a Stratasys Fortus production 3D printer to assist in the manufacture of jigs and fixtures. Since installation of the system, the company has reported a reduction in lead times of 90 per cent, while reducing production costs by 50 per cent.

The Fortus production system means cost savings

Healthcare facility opens its doors

QUALITY HEALTHCARE CENTRE IN CARDIFF

Renishaw has opened a new Healthcare Centre of Excellence at its Miskin site, close to Cardiff, South Wales, UK. The centre will be used for the manufacture of class 3 custom medical devices but also houses extensive facilities for education, training, workshops and lectures. The manufacturing side of the operation makes use of Renishaw's latest metal additive manufacturing machines to enable the precision production of dental frameworks, craniomaxillofacial patient specific implants, jigs and guides. The Healthcare Centre complies with the ISO13485 quality management standard.



The global additive manufacturing sector is high growth, expected to be worth more than $30 billion by 2022

STEERING AM INTO AN UNCERTAIN FUTURE

Most industries in the UK have been re-calibrating following the referendum vote for the UK to exit the European Union. It is the uncertainty of what the next two years of negotiations will bring, together with the unknown version of life beyond the EU in 2019, that has UK organisations looking to cover a number of bases. This is no different for UK 3D printing companies, but, so far at least, major projects are ongoing.

Indeed, the work of the industry-led 'UK Additive Manufacturing Steering Group' has resulted in a roadmap for AM in the UK that will be presented to government in the coming months. *Additive Manufacturing UK*, developed by the steering group and published September 2016, sets out the opportunities and challenges for the UK to fully realise the economic potential of AM, and become established as a world leader in research, technology and application advancement, not to mention investment activities. Outlining a far-reaching vision, importantly, this document is realistic in its strategic approach to the need for investment, public and private, training, collaboration and adoption — within individual vertical sectors and across the entire supply chain.

Leading personnel from the Manufacturing Technology Centre (MTC) in Coventry are on the steering group. At the International Conference on AM and 3D Printing in Nottingham in July 2016, David Brackett of the MTC described the centre's function as "bridging the valley of death". He explains the role of the centre is to act as a conduit between the strong, fundamental and experimental research carried out in academic institutions, and its adoption in industry. This research, says Brackett, is often not properly exploited for — or applied within — industry, and thus often dies.

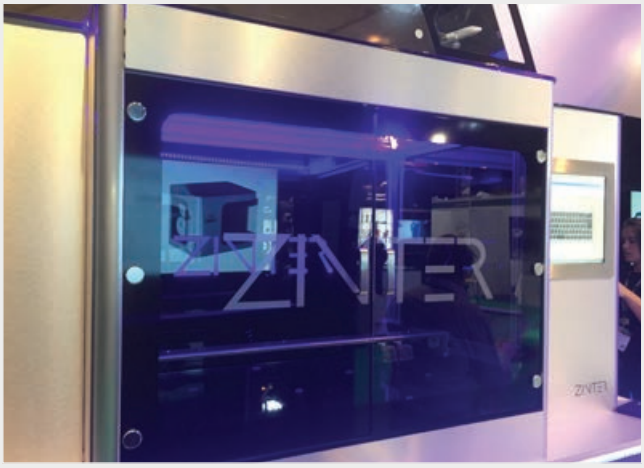
BEST OF BRITISH

RENISHAW

This year, Renishaw has fully commercialised its flagship additive manufacturing platform the RenAM 500M, with shipping due to commence to the first users beyond the beta testing phase. The RenAM 500M is feature-rich, containing new optical systems and in-process qualification. The company has also been undergoing ambitious expansion plans — in the UK and abroad — most recently opening a new Healthcare Centre of Excellence at its Miskin site, close to Cardiff. The centre will be used primarily for the manufacture of class 3 custom medical devices, utilising its metal AM process. It also houses facilities for education, training, workshops and lectures.

ZINTER

Based in the South-West of England, Zinter, legally renamed from Ion Core in September, has produced an eye-catching 3D printer brand since its launch in 2012, with a dual focus on form and functionality. After a year of consolidation within the business and strong backing from investors, the professional Zinter 3D printer range is well and truly established. Production capabilities are locked down in the factory as the company pushes out a dedicated portfolio of 3D printers that meet the demands of its customer base, a large proportion of which are in the aerospace and defence sector, and that drive Zinter's R&D activities. The company's CEO, Shane Nelson, also points to a dedicated aerospace platform that will print in PEEK and Radel materials.



Zinter's range of 3D printers is established for aerospace and defence

Thus a key function of the MTC is applied research to ensure industrial adoption of AM within organisations such as Rolls-Royce, AWE, GE, GM, Meggitt, BAE Systems and Sandvik, to name but a few. In terms of the scope of the project, it's broad, focused on AM for advanced production and digital engineering and considering issues such as fully exploiting the design freedom paradigm, topology optimisation, powder management, qualification and validation, as well as application development. The latest platform to arrive on site in Coventry is the Lumex 25 from Matsuura — a powder bed hybrid machine — and it is the first one operating in the UK.

2017: A MILESTONE YEAR FOR AM?

While the commercial developments in terms of AM in the UK are strong, R&D activities are also continuing apace. Research activities into AM and associated technologies across the UK's universities, as recognised by AM UK Steering Group, are exceptional, with a great deal of collaboration. The dedicated AM Research Group at Nottingham University is perhaps the most visible, but belies the far-reaching efforts of institutions such as the universities of Cambridge, Liverpool, Sheffield, Newcastle, Bath, and Exeter, as well as UWE, Heriot-Watt University, and the University of Bristol.

From the latter, a new conceptual hybrid 3D printer platform emerged in 2016. The OMNI is presented as a multi-functional 3D printing system with the capability to change tools automatically to facilitate milling, component placement and accurate measurement on a single programmable platform. As a result, the team from Bristol has won £20,000 from JISC to further develop the system, as well as a place on a scheme for technology start-ups.

Currently the two AM companies with the longest histories — Stratasys and 3D Systems — are headquarted in the US, and continue to serve global markets via regional subsidiaries and extensive reseller networks. 3D Systems is still closely aligned with corporate giant Canon and has, as expected, extended its reseller relationship further across the globe, including in the UK. Both 3D Systems and Stratasys have undergone a transitional period in 2016, with new CEOs appointed to each. While there have been plenty of exciting developments in the Britain, countries across the world continue to up the ante also — the US, Germany and the UAE are notable among them.

2017 looks likely be a milestone year for the AM industry, as long-awaited platforms enter the market place and raise the bar in terms of capabilities and expanded material palettes. Similarly, industrial growth and significant penetration of AM technologies into key markets for production will likely be a hallmark of next year's activities. Metal will be likely to continue to dominate the industrial sector, even as plastics makes a comeback.

One other UK process that looks set to fulfil its potential, thanks to some long-awaited funding, is the Picsima AM process that produces parts in real silicone materials. With patents granted, a fully working machine has been demonstrated by the Sheffield-based company, Fripp Design and Research. It is definitely one to watch. MR

Read more about additive manufacturing on pages:

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CEL

CEL Robox is perhaps the most prolific UK manufacturer of 3D printers. From the production of a mini desktop machine, the company's CEO Chris Elsworthy, both a leader and an engineer, has driven the development of the Robox brand of 3D printers for product development and prototyping applications. The latest iteration of the Robox — the Robox Dual — was launched in the summer and features an original dual extruder developed by the company to prevent oozing, and ensure fine feature details as required, a notorious problem with FFF??? desktop 3D printers. All Robox 3D printers are designed to be modular, the idea being they can all print in tandem — as featured on the Robox Tree.

CEL Robox is a prolific manufacturer of 3D printers

RPS

RP Support has traditionally operated in the UK as a service and support company for additive manufacturing platforms, primarily for the stereolithography (SL) process. In September, though, the company launched a new SL 3D printer — the NEOS 800. Developed by RPS engineers from the ground up and with considerable IP embedded in it, the NEOS 800 is aimed at industrial users with a large build area of 800 x 800 x 600 mm and, unusually, an open resin system. The company says the main target markets are aerospace and Formula 1 as well as bureau services, where a machine is already installed in the UK.

LPW TECHNOLOGY

LPW Technology, headquartered in Manor Park and with R&D facilities in Daresbury in the North-West, is a global market leader in the development, manufacture and supply of metal powder solutions for AM. The recent recipient of the Queen's Award for Enterprise in International Trade, LPW is also celebrating a £20 million investment round that is set to consolidate the company's rapid growth. This includes plans to build a new facility dedicated to manufacturing metal AM powders by 2018.

NEWS IN BRIEF

'INFINITE BUILD' 3D DEMONSTRATOR DEVELOPED FOR LARGE PART PRODUCTION

Aerospace giant Boeing is using Stratasys's 'Infinite Build' 3D Demonstrator, a "revolutionary" approach to FDM extrusion that increases throughput and repeatability.

Boeing is using the demonstrator to explore the production of low volume, lightweight parts. Ford Motor Company is also exploring innovative automotive manufacturing applications using the demonstrator to evaluate the new technology. "Ford and Stratasys will work together to test and develop new applications for automotive grade 3D printed materials that were not previously possible due to limited size, enabling and accelerating innovative automotive product design," says Stratasys.

The Stratasys Infinite Build 3D Demonstrator is designed to address the requirements of aerospace, automotive and other industries for large lightweight, thermoplastic parts with repeatable mechanical properties. The system has an 'infinite build' approach, which prints on a vertical plane for practically unlimited part size in the build direction.

"Additive manufacturing represents a great opportunity for Boeing and our customers, so we made a strategic decision more than a decade ago to work closely with Stratasys on this technology," says Darryl Davis, president, Boeing Phantom Works.

A NEW MANUFACTURING 'POWERHOUSE'

A new 'manufacturing powerhouse' in precision machining and metal 3D printing has been created following the merger of Newbury-based Progressive Technology and Birmingham's Innovate 2 Make.

The deal creates an end-to-end supply solution for customers looking for low-to-medium volume production of complex components typically used in high performance environments.

It offers a resource rarely seen in the UK, the companies say, and will give Formula 1, aerospace, and medical clients the opportunity to have greater control of quality and reduced lead times when developing products that require both disciplines.

The new business will be called Progressive Technology – Advanced Manufacturing and is targeting more than £2 million of additional sales in its first year, with the possibility of ten new jobs being created.

The aim of the new venture is to blend both conventional and additive manufacturing to offer the best of both for the production of high performance components. Prior to the merger both companies worked in demanding sectors, including Formula 1, aerospace, and medical. By combining know-how and networks, the aim is to offer improved quality control with shorter lead times for low-to-medium volume production of complex components.

NEW ADVANCED TECH HUB IN CHESHIRE

The Science and Technology Facility Council has opened a new advanced engineering technology centre at its Daresbury Laboratory in Cheshire, comprising comprehensive 3D printing facilities. The new Campus Technology Hub is there to provide companies with affordable access to the best skills and facilities in engineering R&D to better compete on a national and international level.

GLOBAL STANDARDS FRAMEWORK FOR AM

The International Organization for Standardization and ASTM International have jointly crafted the Additive Manufacturing Standards Development Structure, a framework that will help meet the needs for new technical standards across this fast-growing field of additive technology development and application. The new structure will help to guide the work of global experts and standards development organisations; identify standards-related gaps in the AM industry; prevent duplicative efforts; ensure cohesion; and improve usability and acceptance among the AM community. The goal is for the standards to be developed at three levels — overall general standards; standards for broad categories of materials; and specialised standards for specific materials and their application.

A BRITISH BRAND OF STEREO

RP Support, a UK-based service and support provider, has developed and launched a new stereolithography (SL) 3D printer. Called the Neos 800, the industrial grade platform has a large build area (800 x 800 x 600 mm) and utilises an open resin system, which means it can be used with any commercially available material and operates with a 2-watt solid state laser that cures materials at 355nm. The RPS platform features a modular design, includes a built-in webcam and offers a scanning resolution of 1 micron with a speed of 10 m/s.

ADDED SCIENTIFIC DEVELOPING NOVEL SOFTWARE FOR LATTICES

UK consultancy firm Added Scientific, based in Nottingham, made its debut appearance at the annual TCT Show this year. Among its capabilities the organisation demonstrated software for the design and modelling of lattice structures, which remains a challenge for the AM industry. The Flatt Pack has been developed to offer a simple method to embed triply periodic minimal surface lattices into common 3D printing file formats such as .stl, bitmap and voxel arrays.

AM INDUSTRY STEERING GROUP PRESENTS ROADMAP

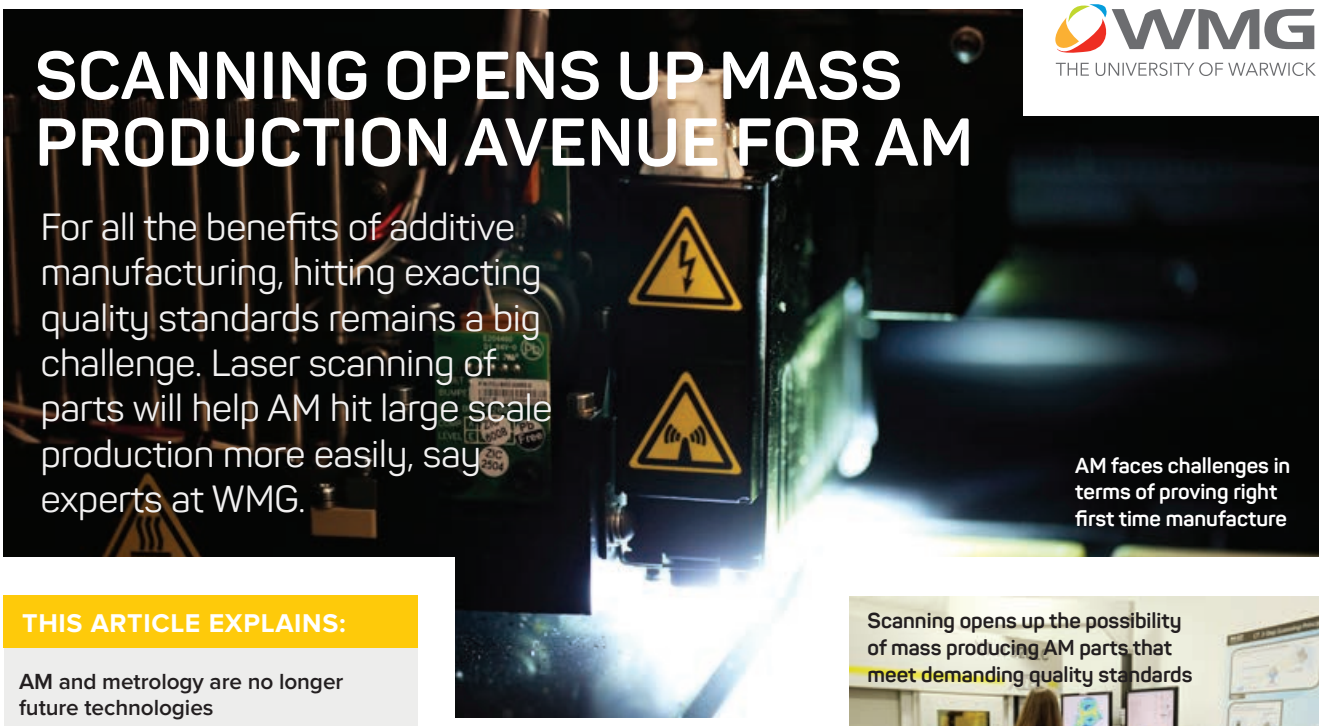
The industry-led UK Additive Manufacturing Steering Group has resulted in a roadmap for AM in the UK that will be presented to government in the coming months. *Additive Manufacturing UK*, developed by the steering group and published September 2016, sets out the opportunities and challenges for the UK to fully realise the economic potential of AM.

See '3D printing is dead: long live additive manufacturing', page 178.

WMG
THE UNIVERSITY OF WARWICK

SCANNING OPENS UP MASS PRODUCTION AVENUE FOR AM

For all the benefits of additive manufacturing, hitting exacting quality standards remains a big challenge. Laser scanning of parts will help AM hit large scale production more easily, say experts at WMG.



AM faces challenges in terms of proving right first time manufacture

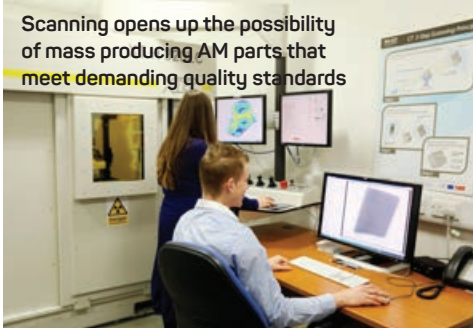
THIS ARTICLE EXPLAINS:

- **AM and metrology are no longer future technologies**
- **Crossover of the pair creates mass production solution**
- **Validation of AM structures will help industry to understand and improve additive manufacturing**
- **Laser and CT scanning to play an important role**
- **Next generation scanning approaches required**

Additive manufacturing (AM) and metrology are no longer technologies of the future, both are now widely used in many sectors: but it's their crossover which will be beneficial for mass manufacturing. Never have there been two technologies which work seamlessly hand in hand in order to advance mass customisation and high performance product manufacture.

Out of the two, it is AM, more commonly known as 3D printing, which has received the most media interest. Yet, it is not a new technology; the first commercial success being Charles Hulls' stereolithography process in 1986. Similarly, metrology – the science of measurement – has been more commonly associated with engineers and manufacturers concerned with quality and reliability as a long established and critical aspect of product design and development. However, put the two together and you've got a solution for taking prototyping to mass production.

That's the novel approach being taken at WMG, University of Warwick. Experts Professor Mark Williams and Dr Greg Gibbons have worked on numerous R&D projects across sectors such as aerospace, defence, food, heritage, and medical combining the use of micro-CT scanning, laser scanning, and 3D printing.



Scanning opens up the possibility of mass producing AM parts that meet demanding quality standards

NO STRANGERS TO PUSHING THE BOUNDARIES

WMG aren't strangers to pushing the boundaries of science and technology, having worked with a diverse range of partners to find solutions to real challenges, which have a tangible impact on society. By bringing these technologies together, WMG are bridging the gap from prototyping to mass low-volume technology.

The key challenge facing the AM sector right now, and one that is stifling the wider uptake of the technology, is the ability to demonstrate fit for purpose, right first time manufacture. Unlike mass production, where quality sampling can be used to demonstrate adherence to specification. sampling methods are not possible for AM, where production volumes of one are common. Defects often occur internally within an AM structure, which cannot always be detected using other methods, and this is where the non-destructive and invasive technology of micro-CT scanning makes it an ideal method of validation. CT is also the perfect tool to validate complex internal architectures that are achievable using AM, often in safety critical products, such as medical implants and aerospace components.

3D laser scanning allows the complex external geometries of the AM structures to be analysed, using a Cartesian coordinate system that helps to document and model a real-world environment. Then combining the data sets from the laser and the CT scan a full interior and exterior characterisation can be produced. The result is a 3D 'point cloud' that can be used to recreate a virtual model for future analysis. Being able to validate AM structures at the micro and macro level will help industry to understand and improve AM, accelerating the route to mass customisation and high performance products.

The most significant innovation in AM over the next few years will be the emergence of higher production rate systems using novel technologies, such as glimpsed in HP's Multi Jet Fusion process, offering higher build rates and enabling the technologies to be more accessible to industry, including SMEs.

This presents a significant challenge for the integration of AM with CT since scanning a part currently takes hours, and is thus impractical. Thus next generation CT scanning technologies and approaches are required, including rapid scanning technologies to enable in-line inspection of AM parts. MR

METAL AM TECHNOLOGY USED FOR MOUNTAIN BIKES

The Robot Bike Co's designs took off via additive manufacturing

Metal additive manufacturing technology from Renishaw has enabled Robot Bike Co. to produce a novel design of mountain bike customised to match the size and riding style of the rider

IN BRIEF:

- Customised bike manufacturer turns to AM
- Robot Bike Co. partners with Renishaw, Altair and HiETA
- Carbon fibre and titanium bikes personalised for each customer
- Parts manufactured at Renishaw AM centres
- 'Bike of the decade' is ultimate result

In 2012, Ben Farmer had the 'lightbulb' moment, when he came up with the basis for the novel design that Robot Bike Co. is now producing. He came up with the concept of using the two technologies to make the 'ultimate' bike.

The new design uses a series of carbon fibre-reinforced tubes for the frames, which are joined by titanium lugs. This approach takes full advantage of the capabilities of both materials. Carbon fibre-reinforced tubing is well suited to simple loads and shapes, while titanium performs well in complex areas with complex loads.

Most high-end mountain bikes have frames made from carbon fibre-reinforced resins. Because the frames have to be moulded, even the most expensive mountain bikes are normally available in only two or three sizes.

Unless the rider is very lucky, they have to compromise on the size of their bike, one of the most important aspects determining its performance and the quality of the ride. In contrast, Robot Bike Co. produces every one of its mountain bikes specifically for a customer. The angles used in the design of the titanium joints are varied, together with changes in the lengths of the sections of tubing, to produce a unique bike configuration to match the size of the individual customer.

BIKE MANUFACTURER TURNS CONCEPT INTO REALITY

To turn the new design concept into reality, Robot Bike Co. entered into partnerships with Altair, HiETA and Renishaw. Work with Altair allowed the design approach to be finalised using the company's expertise in topology optimisation. Topology optimisation is a perfect fit with additive manufacturing as many of the extreme design concepts generated by the software can actually be manufactured.

At the same time as the frame design was being optimised, Robot Bike Co. used its relationship with HiETA to develop the methodology needed to create the optimum bike design for each customer. Together the companies used advanced CAD and simulation tools to produce a parametric CAD engine for mountain bike design.

The parts generated by the software are then manufactured on Renishaw's advanced metal additive manufacturing (AM) systems at one of Renishaw's AM Solutions Centres. These centres provide a pre-production workspace where users of AM can prove out processes and buy time on dedicated Renishaw AM systems, with support from Renishaw expert engineers and technicians.

The titanium and carbon fibre frame of the 'bike of the decade' is customised to each rider

The novel design methodology has received extensive coverage in the bike media, including the accolade of 'most important bike of the decade' on PinkBike, the biggest mountain bike website in the world. A sample mountain bike from Robot Bike Co. has been put through a new European EN test regulation that has just been introduced; EN 14766. Accreditation comprises a set of stringent tests that each manufacturer should put their bike or frame through in order to show compliance with the latest regulations.

TEST & MEASUREMENT

A vibrant sector with an exciting future and strong M&A opportunities

The Test and Measurement (T&M) sector is focused on the development, production and use of equipment designed to detect, measure and control a variety of factors in manufacturing processes such as power, flow, temperature and vibration. T&M also includes Testing, Inspection and Certification services[1].

The global T&M equipment market is forecast to grow at a compound annual growth rate (CAGR) of 5.2% during the period 2016-2020[2]. Key drivers in the T&M market include:

- Increased regulation
- Industry standardisation and sophistication
- Globalisation and increasing industrial output and innovation
- The ever-increasing complexity of products, materials and supply chains
- A continuing need for efficiencies and cost reduction in the production process
- An increasing 'cost of failure'
- Outsourcing
- Technological advances.

INDUSTRY CONSOLIDATION CONTINUES

The T&M sector is broad and highly fragmented but industry consolidation is continuing, fuelled particularly by the M&A activity of large global players.

- Transaction activity slowed a little in the first half of 2016, which is unsurprising given market uncertainties during that period.
- However, UK deal flow remained resilient across both quarters, with 34 deals involving either a UK seller or buyer, accounting for 27% of deals worldwide. The US and Canada saw the most deal activity over the period, with 41% of all targets and buyers.
- Cross-border deals are a key feature of the market, accounting for 43% of all transactions in H1 2016. However, this varies by target geography: 43% of UK targets were sold to overseas buyers compared to 72% of targets in mainland Europe. 63% of targets in Asia-Pacific were sold to European buyers, and just 17% of North American businesses were sold to international purchasers.
- Private equity continues to invest in the sector, funding 17 transactions in H1 2016, representing 13% of total activity.
- Quoted company valuations and transactions in the sector both consistently achieve double digit EBITDA multiples.

SPOTLIGHT ON MEMS TECHNOLOGY

The global trend towards miniaturisation of devices and components is a key driver of innovation in the Test & Measurement market.

Micro-Electro-Mechanical Systems, or MEMS, are miniature devices comprised of integrated mechanical (eg levels, springs, vibrating structures, etc) and electrical (resistors, capacitors, inductors, etc) components, designed to sense, report and interact. Examples include airbag deployment in vehicles, and motion and orientation detection in smartphones.

In less than 20 years, this technology has developed from being an interesting academic pursuit to gaining a stronghold in the automotive sector, becoming an integral part of many common products, both improving functionality and disrupting the status quo.

The MEMS sector is expected to grow at 8.9% CAGR to 2021, increasing in value from USD 11.9bn in 2015 to USD 20bn in 2020[3]. Over the same period, the CAGR of units shipped is expected to be 13%, reflecting falling prices.

Commoditisation is a key challenge in the sector: the consumer market is now highly competitive. Despite this trend, the future of MEMS is rich with commercial possibilities, including the trillions of MEMS sensors envisioned to be used as the eyes and ears of the Internet of Things, ongoing demand from the smartphone and wearable device markets, and increasing opportunities in the automotive sector with the rise of driverless cars. Industrial, environmental and medical applications will also spur development.

Key innovations surfacing include:

- Identifying new applications and component combinations (eg combined environmental sensors that can detect more than one gas, and also incorporate pressure, particle, humidity and temperature sensors)
- Ongoing miniaturisation of inertial sensors (eg accelerometers, gyroscopes)
- Embedding software to increase functionality and create value
- Decreasing power consumption, especially for mobile device applications
- Advanced packaging to decrease sensors' footprint

Major trade players are looking to take advantage of these trends and continued M&A activity is likely. The future for sensing, measuring, and reporting has rarely looked so strong.

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Notes and sources:
1. Our analysis of the T&M market includes testing, inspection & certification, instrumentation and equipment, and associated markets, but excludes life sciences 2. Ibisworld; 3. Yole

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BDO

NEW TECHNOLOGY FOR AN EVOLVING WORLD

CATAPULT High Value Manufacturing

AM parts from the Sheffield AMRC, part of the High Value Manufacturing Catapult

Additive manufacturing can play a key role in rebalancing the economy but Britain needs a world-class industrial strategy for 3D printing, says the High Value Manufacturing Catapult

THE UK ADDITIVE MANUFACTURING STRATEGY

- AM strategy to be published in 2017
- Britain to be a leading country in terms of AM exploitation by 2025
- AM to create approximately 63,000 additional jobs
- Standards, codes and measurements for AM to be established
- Cybersecurity for AM to be enhanced and intellectual property protected

THIS ARTICLE EXPLAINS:

Challenges of environment and ageing population call for new technology

Additive manufacturing has potential to transform product development, design and production

3D printing now makes everything from orthopaedic implants to biological cells

Strategy for AM needed to make it a key part of the British economy

Potential of the technology has only been scratched in its 30-year history

Our world is evolving rapidly. A growing, longer-living global population, a generation of 'digital toddlers', a changing climate, and dwindling natural resources, are just some of the challenges we face.

Technology will be at the heart of our response. The speed and way in which we develop new technologies to a position where industry can reap the full benefit of their potential will be critical to building a successful and balanced UK economy. It is also at the core of what the High Value Manufacturing Catapult is set up to do.

Additive manufacturing (AM) – the process whereby materials are joined, usually layer-upon-layer, to make objects from 3D model digital data – is a prime example of a new manufacturing technology with enormous potential which, when fully realised, will transform product development, supply chains and manufacturing as we know them.

While the process isn't exactly new – it has been around for some 30 years – it has only relatively recently found real and growing industrial applications, making it one of the key technology innovations in the fourth industrial revolution.

AM, also known as 3D printing, has long moved on from merely producing bright coloured plastic gadgets, and is now used to produce anything from stainless steel lightweight aerospace components to titanium orthopaedic implants to nylon catwalk creations – and growing replacement organs by printing hydrogels and living cells. The MTC has created one of the world's largest 3D printed-aerospace parts, which is now undergoing flight trials.

BUILDING OPPORTUNITIES

We still have much to discover about the full scale of opportunities AM can bring in terms of design freedom, use of materials and localised production. There are also inherent threats related to cybersecurity and protection of intellectual property. What we can say with confidence, however, is that those businesses and economies that fail to engage with this technology will also fail to reap its benefits.

So it's significant and encouraging that leading figures from UK industry have joined forces with academia and government – under the chairmanship of Neil Mantle of Rolls-Royce – to establish the UK Additive Manufacturing Steering Group.

The group's vision is for the UK to be a leading country in terms of exploiting AM by 2025, not only in terms of producing additive manufactured parts, but also in using and developing associated technology and know-how across the whole of the process chain.

Additive manufacturing has the potential to transform design and product development

3D printed parts from the Manufacturing Technology Centre, Coventry

To put this into context, the global market for AM was worth £3.59bn in 2015, and the UK's market share is around 5%. If we manage to maintain this market share, this could be worth an estimated £5.6bn by 2025. If we manage to increase our market share to an ambitious – yet realistic – 8%, we are looking at approximately 63,000 additional jobs, and further growth. In order to make this vision a reality, the Steering Group is working towards the publication of a UK National Additive Manufacturing Strategy in 2017.

A STRATEGIC APPROACH TO DESIGN

A strategic approach will be taken with regard to key aspects of AM such as design. AM opens seemingly limitless new design options, allowing for complex, multi-material, integrated designs that are impossible to make using conventional manufacturing methods. There is a lack of easily accessible up-to-date information and support for designers and businesses.

As the range of materials used in AM continues to grow, we need to capture best practice and lessons learnt from current practitioners in processes and materials in order to improve AM applications and help build and strengthen the UK supply chain for AM. Skills are also an issue. The urgent demand for more STEM students and engineering apprentices in the UK is well-documented. In the case of AM, we need to work with schools and providers of higher, vocational and professional education and learning, to generate more suitable candidates to work with AM technologies.

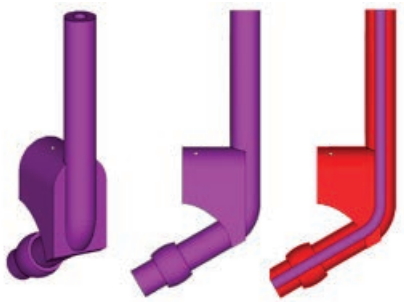
Securing finance for innovation remains a challenge in the UK. AM, which is still relatively new and of which many investors lack understanding, is no exception. Sharing success stories of AM investment to industry, and providing innovative and sophisticated funding mechanisms, may help overcome this issue.

Advances in encryption and security, potential refinements in intellectual property law across the globe, and the development of specific high-level skills will help us mitigate threats in cybersecurity, and protection of intellectual property. As the AM industry develops and matures, it also needs to strengthen areas such as standards, regulation, certification, inspection, testing and quality control in order to obtain the level of confidence it deserves.

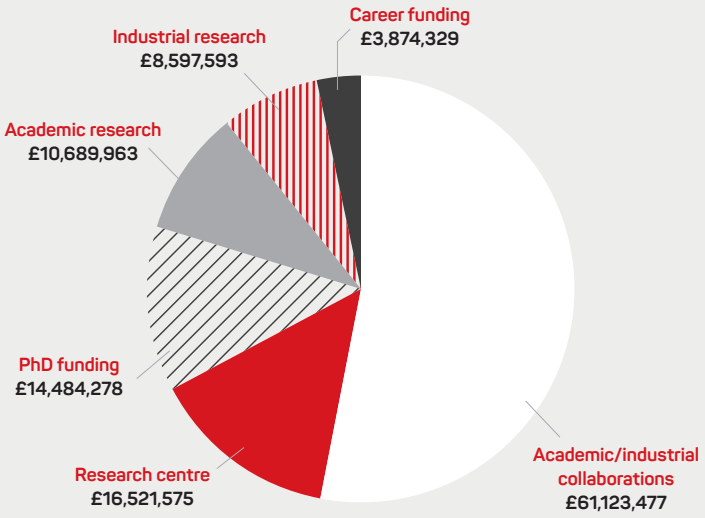
A robust national strategy, underpinned by sector-specific economic plans, and supported by industry, will be invaluable in setting out the path towards maintaining and growing our market share in this disruptive technology, and could serve as a template for other promising technologies.

This is an excellent example of industry, academia and government working together to give the UK a competitive edge: no other country has an explicit national strategy for additive manufacturing in place. MR

BAE Systems worked with 3T RPD to develop 3D printed cabin breather tubes



TYPES OF AM RESEARCH ACTIVITY BEING FUNDED



Source: Additive Manufacturing UK, September 2016, Leading Additive Manufacturing in the UK

HOW DOES IT WORK?

AM is a method of making production parts and products directly from design data, building accurate components by adding layers of material to obtain the final shape with minimal waste, and no expensive dedicated tooling. It permits radical product re-design and creates new material properties. It is recognised as one of the main manifestations of the Fourth Industrial Revolution. The UK is a world leader in additive manufacturing capability, and has been at the forefront of developing this technology. However, there is a globally competitive race underway with major government-backed programmes already established in the US, Japan, Singapore and Germany.

MORE RESOURCES

To find out how you can support the development of the strategy, visit: http://www.amnationalstrategy.uk/

To find out more about the HVM Catapult, visit: www.hvm.catapult.org.uk

DIGITAL TECHNOLOGY FOR MANUFACTURING?

2016 was the year that the digital and manufacturing worlds intertwined. Digital technologies to help companies achieve more with less, help them mass customise production, to reduce errors and to be more flexible have descended in force. There was a profusion of conferences, media articles and examples of companies using technology getting close to the "Industry 4.0" or "4IR" nirvana of cyber physical systems, where products talk to machines and humans don't interfere.

This special 32-page section reveals some of the new digital technology in use and what's coming next, the attitude of British companies to 4IR and examples of UK firms 'doing Industry 3.9' – if not full fat I4.0.

CONNECTED FACTORIES

THE QUIET REVOLUTION

Industry 4.0 does not necessarily mean radical technological upheaval. Smaller, incremental changes driven by business need are just as effective. By Malcolm Wheatley

THIS ARTICLE EXPLAINS:

- Industry 4.0 can be a 'quiet revolution'
- People tired of showcase factories
- Change can be incremental and gradual
- 'Gaping hole' in terms of understanding of Industry 4.0 among manufacturers
- Process should start with business needs

At Lancashire-based workwear fabric manufacturer Carrington Workwear, a quiet revolution is underway. The largest producer of workwear fabrics in the UK, with a global customer base, the company produces over 35 million metres of fabric annually.

And now, says IT manager Simon Hiles, real-time tracking using iPads linked to Carrington's ERP and recently-installed finite capacity planning system is transforming work-in-progress visibility, while simultaneously increasing efficiency, improving quality, improving due-date performance, and enabling better communication with customers.

"The iPads are mounted at each work centre, and job ticket numbers can be typed in or scanned using a QR code, updating the ERP system immediately," he explains. "There was some reluctance to use them at first, because people had previously used pen and paper, but this soon ended."

AUTOMATED INSPECTION NEXT IN LINE

Next in line is the automated inspection of fabric rolls, identifying the precise location of faults on each 5,000-metre roll. Once again, connecting this to the factory's planning and ERP systems will enable Carrington to maximise fabric yield, cutting each roll into the lengths that customers require, at minimum waste.

"Going from having almost nothing to having something is always going to be a challenge," says Hiles. "But as more pieces fall into place, the easier it becomes – and now we are seeing insights and connections that we simply never saw before."

To one school of thought, Carrington's advances hardly merit the description Industry 4.0, despite the undoubted connectivity that they display. Industry 4.0, goes the logic, must embrace such emerging technologies as Big Data, the Internet of Things, advanced analytics, modelling and simulation, and virtual reality-based visualisation.

Hayward Tyler's £20 million centre of excellence, opened in July 2016, represents a 40 per cent increase in its manufacturing capacity. The business has targeted innovation in each area of Industry 4.0

But to another school of thought, Carrington is very much the way that an Industry 4.0 initiative should look: needs-based, gradual, and a journey, rather than a destination.

"A lot of people are getting tired of going to presentations about Industry 4.0, and seeing the same old showcase factories presented as exemplars, and hearing the same old hype about the coming revolution," says Carl Perrin, a former head of technology at a Rolls Royce joint venture developing and manufacturing aero-engine turbine coatings, and professor and director of the Institute for Advanced Manufacturing and Engineering, a collaboration between automotive manufacturer Unipart and Coventry University. "Industry 4.0 will


Ipads in use at Carrington Workwear

happen, but probably not as a revolution. Instead, it will probably be much more grounded, and based on real business problems, and using real data to find answers and deliver value."

Nor is Perrin alone in these views. A survey published by business advisers BDO and the Institution of Mechanical Engineers in June 2016 spoke of a 'gaping hole' in the understanding of Industry 4.0 among UK manufacturers, with only 8 per cent of UK manufacturers having a significant understanding of Industry 4.0 processes, despite 59 per cent recognising that the so-called 'fourth industrial revolution' will have a big impact on the sector. Moreover, a quarter of those surveyed said that they had no plans to invest in Industry 4.0, with 44 per cent of these respondents ascribing this to a lack of understanding.

In theory, this might not be a problem, says Richard Wilding, professor of supply chain strategy at Cranfield University School of Management. It can be perfectly rational, he points out, for firms to hold back from investments in Industry 4.0, with the intention of seeing how other firms adopt it, learning from their experiences about what works and what doesn't, and then moving to Industry 4.0 as a 'fast follower', rather than an early adopter.

"The danger with this strategy – which tends to match what we're actually seeing happen within industry – is that if not enough manufacturers become early adopters, then there won't be an Industry 4.0 impetus to follow," he argues. "UK manufacturers need a proper 'fast follower' strategy, as well as encouragement to be early adopters."

DIFFICULTY WITH ATTITUDES TO INDUSTRY 4.0

Ken Young, professor and technology director of the Manufacturing Technology Centre, who served as chair of the British Automation and Robot Association for ten years, sees another difficulty with present attitudes to Industry 4.0.

"The big challenge is that everybody is

> "Industry 4.0 will happen, but probably not as a revolution. Instead, it will probably be much more grounded, and based on real business problems, and using real data to find answers and deliver value"
>
> **Carl Perrin, Institute for Advanced Manufacturing and Engineering**

PTC AND GE TEAM UP WITH IOT SOFTWARE

When it comes to aspects of Industry 4.0 such as the Internet of Things, it's easy to say 'start small and build from there', but rather harder to make that start, says software firm PTC.

To help firms begin the journey, PTC is working with GE Digital to expand a strategic alliance to bring integrated solutions to the industrial Internet of Things market. The companies are developing a ThingWorx for Predix technology suite that will make it easier for joint customers to use PTC's Internet of Things development software ThingWorx to develop custom applications to run on Predix, GE's industrial internet operating system. ThingWorx application enablement tools allow for rapid drag-and-drop development of IoT solutions that readily incorporate industrial automation connectivity, machine learning and predictive analytics, remote service, and augmented and virtual reality (AR/VR) experiences.

The fourth industrial revolution is defined and driven by the IoT, and the convergence of digital and physical resources in the factory.

coming at it from a technology point of view, whereas what they ought to be doing is starting with a real business need, and going forward from there," he says. "Unless there's a firm and identifiable business case, it just won't happen."

That said, Young's own Manufacturing Technology Centre has had a hand in helping one such business to be an early adopter: Siemens Motion Control's factory in Congleton, Cheshire, where virtual reality is now being used in three separate ways – trialling new product concepts, simulating alternate factory layouts, and mocking-up production flows.

The impetus for the project came from a visit to the MTC's virtual reality suite, established as part of its mission to encourage the take up of digital manufacturing methods in order to save time and money.

"The MTC's virtual reality suite gave us the confidence that VR technology was not a short term technology gimmick, and that it has real business value and benefit," explains Carl German, advanced manufacturing strategic lead at Siemens Motion Control. "Its benefits are clear all the way through the product lifecycle process, from product definition and design through to the actual manufacturing processes."

That said, adds the MTC's Young, virtual reality is another part of Industry 4.0 where manufacturers are struggling to find compelling 'use cases' with which to drive adoption. "With virtual reality, it is possible to model an environment, drop half a dozen people into it, and see how it works in a way that can't be done by just looking at drawings and screens," he enthuses.

"The challenge is that it is impossible to predict what virtual reality will deliver in advance: you can't tell what you will find until you find it, and this makes building a business case difficult."

"The big challenge is that everybody is coming at it from a technology point of view. What they ought to be doing is starting with a real business need, and going forward from there. Unless there's a firm and identifiable business case, it just won't happen"

Prof Ken Young, technology director, MTC

ENCOURAGING SIGNS

Yet gradually, say observers, encouraging signs are emerging that may herald a change of thinking in regards to Industry 4.0, making it easier to build Industry 4.0-friendly business cases. The

first sign, says Kannan Sivasubramanian, executive vice-president of research analysts Aranca, is that the focus of Industry 4.0 initiatives is starting to move away from cost-cutting and operational efficiencies to revenue generation and added value. Leveraging the Internet of Things and Big Data to launch new services based around different business models or servitisation isn't new, he stresses, but now the approach is going mainstream, rather than being restricted – as with many aspects of Industry 4.0 – to a few high-profile showcases.

"Today, the major Industry 4.0 case studies are mostly around operational efficiency, but that will start to change," he says. "Now, businesses are starting to say, 'How can we generate revenue with this technology?'"

Second, adds Sam Turner, professor and chief technology officer at the University of Sheffield's Advanced Manufacturing Research Centre, companies are starting to see that Industry 4.0 need not be a major investment. With low-cost cloud technology and off-the-shelf hardware and software technologies become more readily available, he points out, almost no budget is too low.

"A data capture project to gather operational intelligence is fairly inexpensive, and a company can build outwards from there," he points out. "That said, rather than feeling your way piece by piece, it's better to have a plan, and one that is informed by the business's strategy – but Industry 4.0 certainly can be done on a 'start small' basis."

So will 2017 be the year that mainstream manufacturing business takes the plunge, and starts to adopt Industry 4.0? We'll have to wait and see. MR

CASE STUDY: HAYWARD TYLER

Certified to ISO Class 9, and granted both ASME and nuclear accreditation, Luton-headquartered undersea pump and motor manufacturer Hayward Tyler opened a £20 million centre of excellence in July 2016, representing a 40 per cent increase in its manufacturing capacity, complete with single piece flow lines embedded with lean manufacturing methodologies and dedicated clean assembly areas and test pits.

"The driver wasn't Industry 4.0 explicitly, but to differentiate ourselves from the competition, and offer industry-beating lead times, product quality and cost," says Martin Clocherty, Hayward Tyler's chief adoption officer for processes, people and systems. "The idea was to be able to build more complex and challenging products."

To do so, he explains, the business consciously targeted innovation in each area of Industry 4.0 – equipment, strategy, finance, people, data, and operations. The result is an operation that is claimed to be the world's most advanced facility for specialist fluid filled motor manufacture, enabling next-generation technology to be delivered at unrivalled quality and in Class 5 cleanroom conditions – necessary when the company's products must work reliably 3,000 metres under the sea for periods of ten years.

Notably, the Centre of Excellence also uses Lanner's Witness simulation software for scenario planning – an unusual application for the tool, but one that is starting to become more common, says Lanner's chief executive David Jones.

"With the Witness system, we can run multiple 'what if' scenarios in seconds, right across our order book and pipeline, making different assumptions about launch dates, headcount, skills, and shift patters," says Hayward Tyler's Clocherty. "Trying to do the same thing with ERP would take hours."

INDUSTRY 4.0 – AND WHAT IT WILL DELIVER

RENISHAW
apply innovation™

Paul Maxted, director of industrial metrology applications at Renishaw, discusses current trends in data-driven manufacturing, and how they contribute to the transition to the next industrial revolution

THIS ARTICLE EXPLAINS:

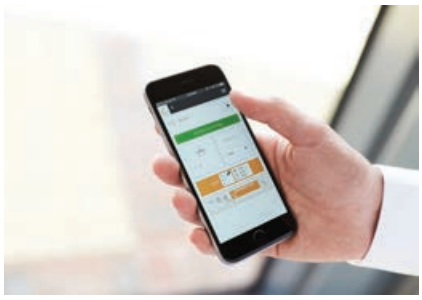
- Transition to intelligent factories taking place in Industry 4.0
- Data capture critical to process
- Data can be used for continuous improvement
- Manufacturers to digitally network machine tools 24-7
- Intelligent processes promise high productivity

Industry 4.0 predicts a transition to intelligent factories where waste is eliminated and efficiency is improved through optimised, automated processes. The capture of data from multiple sensors and the ability to analyse and control processes automatically are key enablers of Industry 4.0.

Industry 4.0 promises increased quality and efficiency in all aspects of the manufacturing sector. Currently, only a small percentage of manufacturers have access to instant, real-time status updates from all systems in their production lines. Those that do not have access are missing out on the opportunity to streamline their manufacturing processes and achieve optimum efficiency.

At the end of the 20th century, lean manufacturing was focused on eliminating waste and bottlenecks in production processes. Industry 4.0 technology enables manufacturers to gather and analyse data for continuous improvement in an automated and ever more efficient manner. The availability of sensors to measure a broader range of parameters in real-time, coupled with predictive analytics, reduces the reliance on reactive and unplanned activities. This improves both process stability and machine availability.

Integrated sensors for performance monitoring and control are essential to the successful implementation of automation. Robotic systems and advanced machine tools deliver consistent product quality and clear visibility of status and performance. Smart machines detect faults and diagnose problems with production through intelligent process control.



Industry 4.0 promises a digital revolution for manufacuturing processes

Renishaw's technology performs a critical role in ensuring components meet exacting quality standards

PRODUCTIVE PROCESSES

Most manufacturers evaluate the performance of their machines after production through measurement of the parts produced. However, understanding machine performance is most important during the process itself. The integration of probes on- and off-machine to measure key process variables and part features during manufacturing is the only cost-effective way to control automated manufacturing processes. They give machines the intelligence they need to make their own decisions, keeping the process centred consistently, and eliminating the adverse effects of process drift.

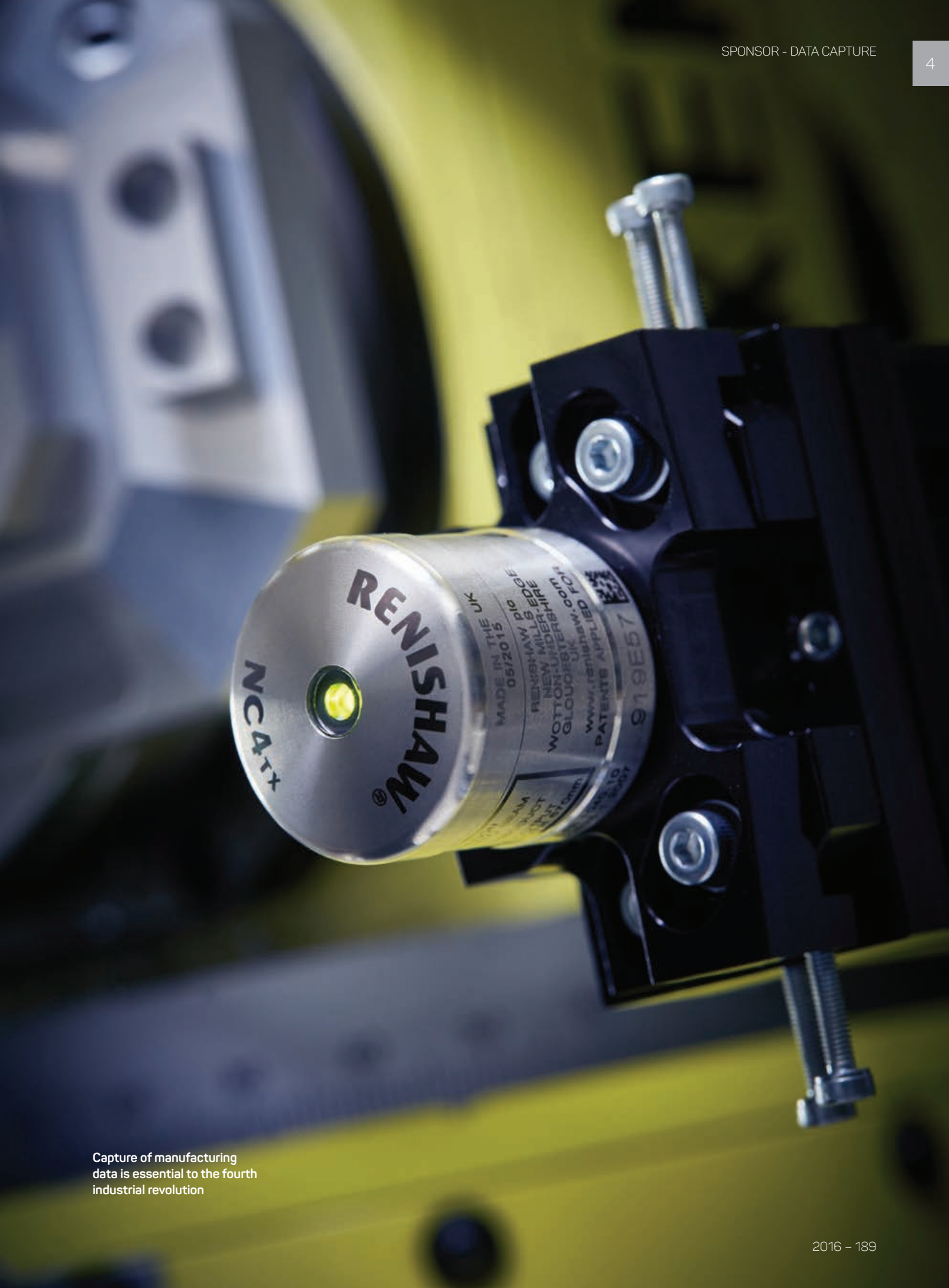
The data collected through in-process measurement can also be used for continuous improvement. It allows manufacturers to understand what causes adverse effects during manufacturing and consider the key variables when developing new processes.

Manufacturers can only make the most of their collected data if they have the means of using it when required. The next step towards Industry 4.0 is for manufacturers to use computer networking to ensure data is available around the clock across different digital platforms.

Computer networking has existed for more than 50 years, but machine tools could previously only communicate through serial ports and cables. Many manufacturers did not have the knowledge in-house to run and maintain large amounts of hardware and software, so there was a barrier to the adoption of the technology.

Today, most machine tools are equipped with networking hardware and have more accessible architectures, making it simpler to facilitate communication between systems. As integrating sensors and programming automated intelligent systems becomes easier, more manufacturers will be able to exploit the benefits of Industry 4.0.

From consumer electronics to aerospace components, products have shorter life cycles than ever before. Manufacturers have to develop new products and processes much quicker to remain competitive. Intelligent processes allow high productivity and high quality output despite the reduced process development window. MR



Capture of manufacturing data is essential to the fourth industrial revolution

SENSORS

THE GREAT BRITISH SENSOR SECTOR

Sensors are widely used in everything from consumer electronics to screening biochemicals to anti-terrorism – and the UK is a world leader in the technology. Peter Marsh reports

THIS ARTICLE EXPLAINS:

- **Sensors 'unsung workhorses' of industry**
- **Sensors in millions of items and industries such as agriculture, medical, and oil and gas**
- **Cambridge, Oxford, Durham, Harrogate and Edinburgh important clusters for sensor development**
- **Internet of Things relies on sensors**
- **Global market for sensors measuring radiation in the atmosphere could rise to $1 billion**

They are the unsung workhorses of the industrial and consumer world, buried inside hundreds of millions of items from ocean monitoring instruments to iPhones. Mainly invisible to all but the technical people producing and installing them, sensors are driving on developments in industries as diverse as agriculture, medical equipment and oil and gas.

Playing a part are several hundred UK manufacturers involved with sensors, either making them or using them to produce bigger and more recognisable pieces of equipment such as analytical instruments or industrial control systems.

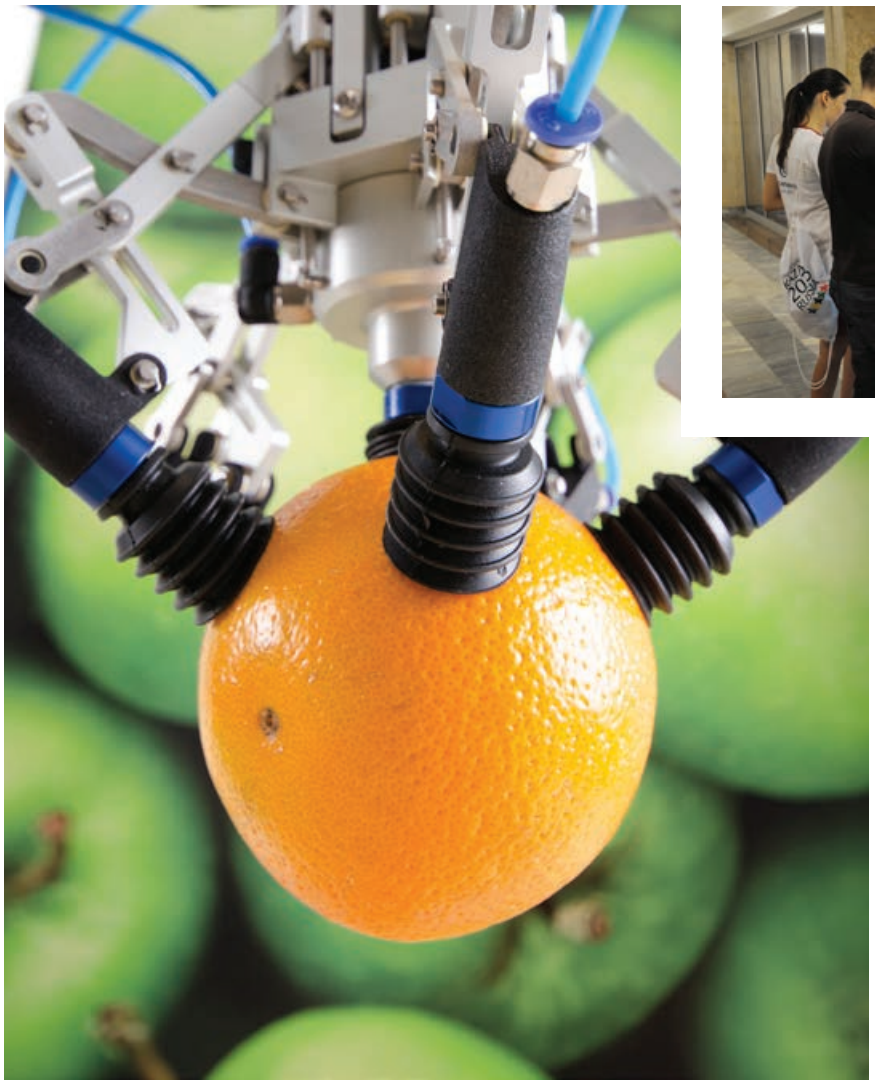
Most of the UK sensor companies are small-to-medium sized and are far from household names – a reminder that much of UK manufacturing comprises little known businesses working in niches. However, their clients include many of the world's industrial giants in sectors such as aerospace, pharmaceuticals and automotive.

Sensors and the measuring systems that they make possible are key components in the new digitisation processes becoming more important in 'IT enabled manufacturing', or Industry 4.0. Sensors play a big part, for instance, in new developments in robotics, driverless cars and networks of interconnected machines – the so-called Internet of Things.

Above: Hertfordshire's Blacktrace is a pioneer in flow chemistry – carrying out complex reactions using tiny amounts of chemicals while the materials flow along thin tubes

NEW WAYS TO AUTOMATE PLANT

Among the top companies in UK sensor development is TTP, a manufacturing and consultancy group based near Cambridge. Andrew Baker-Campbell at TTP says: "Many companies are devising new ways to automate their



Left: Cambridge Consultants demonstrates a robot picking up an orange thanks to positioning sensors

Above: Newcastle-upon-Tyne's Zytronic makes devices that monitor changes in electrical behaviour of surfaces

"It's conceivable that in the next two to three years our thin films could be in 50 million to 250 million consumer devices"

Jon Stark, Peratech

plants – they are trying to combine autonomy and flexibility and reduce the need for labour. As they go down this route they find they need new sensors and sensor systems."

Baker-Campbell provides as an example TTP's development of a machine for dicing onions without human intervention, for use in making supermarket ready meals. The equipment is now operating for a food chain that TTP does not want to name.

"Anyone who's ever peeled an onion in their kitchen knows how many shapes and sizes they come in, plus the variation in the way different layers of skin can be peeled off. To ensure the machine worked effectively, we had to use a lot of different sensors while also developing some complex algorithms," says Baker-Campbell.

Another company that is a big user of sensors and which counts among its customers many much larger businesses is Blacktrace, which has 125 employees and is based in Royston, Hertfordshire. It is a pioneer in flow chemistry – carrying out complex reactions using tiny amounts of chemicals while the materials are flowing along thin tubes. Keeping track of the reactions can help determine new ways for making industrial products such as catalysts. It can also produce insights into the structure of molecules useful in fields such as medicine or crop protection.

Mark Gilligan, chief executive, says Blacktrace uses in its products "tens if not hundreds" of different sensor systems, many of them developed or adapted to suit the requirements of a customer. "We have a breadth of knowledge from deep physics, maths and chemistry, through to mechanical, electronic and software engineering, and are willing to attack pretty much anything [in challenges from customers]."

100 VARIETIES OF SENSOR

According to Sens2B, an online marketing platform for the sensor industry based in France, there are about 100 basic types of sensor. They measure variables that range from the straightforward (such as temperature, velocity or position) to complicated (such as infrared absorption patterns or levels of gamma-radiation). There is likewise a wide spectrum of measurement methods, including for instance using lasers to scan moving objects, and monitoring changes in electrical behaviour of specific materials. Sens2B lists 26 industries where sensors have a big role – from shipbuilding to industrial weighing.

Important clusters for sensor development and use are around Cambridge,

Oxford, Durham, Harrogate and Edinburgh. Many of the businesses have strong links with university research departments.

The enterprises can be divided into three groups depending on their main products: standalone sensors; instruments and measuring equipment; and items such as electronic labels and displays that can be combined with sensors in networks.

In the first category, many UK companies have moved away from simple sensors measuring pressure or capacitance for instance. Such devices are widely available globally and are regarded as commodities.

But there are some good example of UK sensor makers with technology that makes them stand out. Banbury-based Sensor Technology has for instance developed a range of innovative torque sensors, such as for measuring the load on cranes.

Silicon Sensing is a joint venture between the US's United Technologies and Sumitomo Precision Products of Japan. It has one of its two global centres in Plymouth, the other being in Japan. The company has a strong position in so-called MEMS inertial sensors used in positioning, such as in gyroscopes.

It has introduced new highly accurate and low-cost MEMS sensors developed in its UK operations. The sensors are seeing use in early versions of driverless cars and in monitoring the position of oil and gas drilling pipelines.

Zytronic, with its head office near Newcastle-upon-Tyne, makes devices that monitor changes in electrical behaviour of surfaces. They record very slight movement, and are used in touch-sensitive display screens. In a related field, North Yorkshire-based Peratech has created a way of recording force by measuring changes in electrical resistance in thin films of specialised nano-particles, using an effect known as quantum tunnelling.

Jon Stark, Peratech's chief executive, says the biggest opportunities lie in smartphones and other connected gadgets. "It's conceivable that in the next two to three years [our thin films] could be in 50 million – 250 million consumer devices."

In the second category of the UK sensor industry, companies that integrate sensors into larger pieces of equipment include Valeport, a Devon business that is a leader in instruments for the marine industry.

The systems do jobs such as measuring sound waves and salinity in water. They are used in industries such as oil and gas, defence and water treatment – partly because of their use in calibrating other devices such as sonar systems for detecting underwater objects.

Matt Quartley, managing director, says many sensors are already so accurate there is "no mileage" in adding to their sensitivity. What really matters, he says, is creating ways to make the best use of the data from the sensors as well as how to combine groups of different sensors in a single instrument.

Paul Maxted of instruments and probe manufacturer Renishaw echoes the point. "In this industry the 'one size fits all' approach often isn't effective. You have to adapt the instrument to meet the requirements of the customer. This means creating different combinations of sensors plus the software to make them work". Renishaw sells its products to a range of manufacturing customers for doing jobs such as highly accurately recording the shape of metal parts while they are being machined. Other customers are in shipping and dentistry, where the equipment is used in areas such as monitoring of ships when docking or checking on measurements for new

OPPORTUNITIES OPEN UP IN THE INTERNET OF THINGS

Durham's Kromek makes sensors for detecting nuclear material

Sensors are playing an increasing role in emerging applications of the Internet of Things – clusters of connected machines and products which require the continual shuttling of data between sensors of and high speed computers. One of the leaders in this field is Cambridge Consultants, a group which works on new technologies in a range of industries.

Simon Jordan, senior physicist at the company, says a key to designing such networked systems is to decide on the "balance of power" between the sensors at the "edge" of the system and the computers or servers at the centre. "The edge [the sensor] is able to decide what matters and what doesn't, and send only the most relevant information. The centre [the servers] are able to steer the sensors to report different aspects of their environment, and critically, build up a picture of 'what's normal' across thousands of machines. In this way, the sensors form a linked 'police force' across the entire user base, reporting on what's different, what's changed and what's unexpected."

Cambridge Consultants has used this approach in such fields as connecting street lights to central computers. The sensors monitor natural light and weather conditions, so helping to determine the amount of illumination needed, and to stop energy being wasted. A strong competitor in the same field of networks based on street lights is Telensa, part of Cambridge-based consultancy Plextek.

Both SSE and Telensa want to move further into "smart city" systems so that, for example, street lights also house other sensors for jobs such as keeping a watch on parked cars, traffic movement, and pollutants in the atmosphere. In another example of Cambridge Consultants' work in networked sensors, it has created a special fabric called Xelflex. The textile is lined with fibre optic sensors that send signals to a nearby computer. Clothes made with Xelflex are worn by athletes or people recovering from limb problems. Since the sensors monitor movement, the so-called "smart garments" can help in training or rehabilitation.

Lambert – an automation company in North Yorkshire working in fields such as consumer goods and healthcare – is also developing ideas based on the internet of things. Sales director Matthew Cox says that among the challenges in using these systems in factor concerns cyber security: making sure data do not leak out to competitors or even criminals.

Another example of a networked system is an ambitious set of equipment – based around sensors made by Kromek based in County Durham – that will gradually enter operation in the US over the next few years. The sensors will monitor large cities for the presence of nuclear material – radiological 'dirty bombs' for instance – that security chiefs worry could form part of a potentially deadly terrorist threat.

In the networks sensors – measuring small concentrations of gamma rays – will be worn by police officers and other government employees. They will record minute levels of radiation in the atmosphere, raising the alarm if readings suddenly rise without explanation.

Arnab Basu, Kromek chief executive, says the annual global market for sensors of this sort could rise to about $1 billion. He is also looking at how Kromek could use its expertise in networks to move into other fields such as pollution monitoring.

implants. The company has about 900 people working on new developments in measuring systems and sensors – one of the UK's biggest groups in this field.

Malvern Instruments is a leader in analytical equipment for measuring particle size. The Worcestershire-based business has a strong position in selling to the pharmaceutical industry – a sector which David Higgs, Malvern's head of marketing, says has recently had to adapt to meet big changes. These include increased competition from makers of cheap generic or 'me-too' drugs, and the rise in importance of new processes and products based on biochemistry. The requirement for cutting costs has pushed Malvern into developing a new series of instruments for applications in online process control – a way to make manufacturing more efficient. Also the increased importance of biotechnology has led Malvern to step up its efforts to develop new hardware expressly linked to this field, for instance for protein analysis.

In a related field Sphere Fluidics, based near Cambridge, makes instruments for screening large volumes of biochemicals in research applications in the drugs industry. Many of the instruments made by the company use standard sensors called charged coupled devices that it buys from other businesses. The key to Sphere Fluidics' approach, says Frank Craig, chief executive, is arranging these devices in special configurations to make the machines operate at high accuracy and speed.

In the third key area in the sensor industry, Worcestershire-based Fairfield Labels and DisplayData of Bracknell offer specialised electronic labels that can be used in sensor based networks in environments as diverse as factories and supermarkets. Two Cambridge companies – Flexenable and Pragmatic Printing – produce low-cost displays made by printing electronic circuitry on plastic. The displays can form part of networks in fields such as biometric identification, packaging and electronic games. MR

Read more about sensors on pages:

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FENDING OFF THE DIGITAL PIRATES

Manufacturers are not doing enough to protect themselves from potential attack from hackers, says manufacturers' organisation the EEF

By Andy Collier, Director NDI, a part of EEF

Protecting data is a live issue for manufacturers in the wake of high-profile corporate security breaches

THIS ARTICLE EXPLAINS:

- Tesco Bank and Talk Talk breaches illustrate cybersecurity problems
- Businesses underestimate the value of their data
- Disruption because of cyber attack costs time and money
- UK MoD has introduced cyber protection requirements
- Threat is real, present and now

If you are one of the recent unfortunate customers of Tesco Bank, or own the Talk Talk mobile network which just lost £60 million in a prolonged and largely undetected cyber-attack, then you will probably now know something about cyber security. To most of us the knowledge that we've changed our password, have some form of firewall and keep our PINs safe is enough to feel the threat from cyber is covered. That is complacency of the highest order and exposes our lack of understanding of the threat which exists.

The risk from cyber-attack is real both at an individual and corporate business level. It takes the form of straightforward extraction of cash from accounts, theft of IP, or just the expensive and time consuming issue of having a business disrupted through loss of files and corrupted data. The attack may come from a foreign state, with Russia and China firmly fingered as playing in this arena, through to the reclusive youth operating from the dark recesses of an adolescent's bedroom. All unedifying images, but all posing a very real and more often than not costly threat.

CYBERSECURITY ERRORS

The starting point for making errors over cybersecurity begins with an underestimation of what you as an individual or business may hold on IT systems which has value to others. If you are engaged in developing the Dreadnought-class submarine, F1 racing car designs, or hedge fund trading, you're probably alive to the issues. But most businesses and individuals are woefully out of touch when it comes to making this initial assessment, and even the large companies don't always get it right. In October 2015 British Gas suffered a hack which resulted in the compromise of 2,200 customers' email and password details, with a similar event happening at Marks and Spencer. This resulted in poor publicity, associated reputational damage and a certain denting of confidence among online customers. All expensive in terms of time, business loss, and the cost of introducing remedial measures.

On a recent visit to an established engineering SME in northern England I engaged the MD in a conversation regarding cyber security. His response was to look briefly around the office and then without pause tell me he had nothing of worth on the systems. This overlooked the fact that he was part of an integrated supply chain working directly into a leading OEM; his build to print designs were in soft copy; his CAD and CNC systems were totally networked and he had regular e-mail correspondence direct with his OEM points of contact. This last fact alone made him a potential portal through which hackers and others could mount an attack on the prime and, indeed, whole supply chain using his systems and connectivity. On top of this his pay roll, employer insurance and other confidential banking business was all held in the system. Despite a naive approach to IT security he was ahead in being almost a paperless office; one might say an early adopter, but with no realisation of the exposure which came with it.

CYBER THREAT IS REAL

Clearly the cyber threat is real, and partly because of this and an expected worsening of the threat, the UK MoD has introduced cyber protection requirements in all new procurements from 1 January 2016. All suppliers in MOD supply chains must hold a Cyber Essential Certificate prior to contract or subcontract award. The full designation is – Cyber Security for Defence Suppliers (Defence Standard 05-138). It is of vital importance that companies factor in this requirement as it would be a catastrophe if perfectly good suppliers were excluded from the tick box selection process for the want of some very simple and cheap precautions.

We are working hard to spread the awareness of the need for Cyber Essentials and good cyber practices in general, and this year have entered into an associate partnership with MASS aimed at delivering the Cyber Essentials training and accreditation. Through provision of this service we seek to ensure our members enjoy new and continued participation in MOD and other government contracts. In addition, working in partnership with insurance brokers Howden, we are making it possible to receive help in qualifying for government innovation vouchers and access advice on insurance cover.

The threat in cyber space is real and here now, and getting it wrong in this arena has catastrophic consequences for business. Once the threat was from fire, flood or strike: now it could be that string of virus data, nonchalantly tapped into a PC anywhere in the world, and directed at you. MR

eef The manufacturers' organisation

UK COMPANIES DEPLOYING "4IR" IN 2016

What is 4IR? It is about connecting manufacturers to data to create value. It's about linking physical networks with cyber networks as one system, to allow real time information flow. This will allow insights to be discovered and acted upon quickly, boosting the value-add to customers.

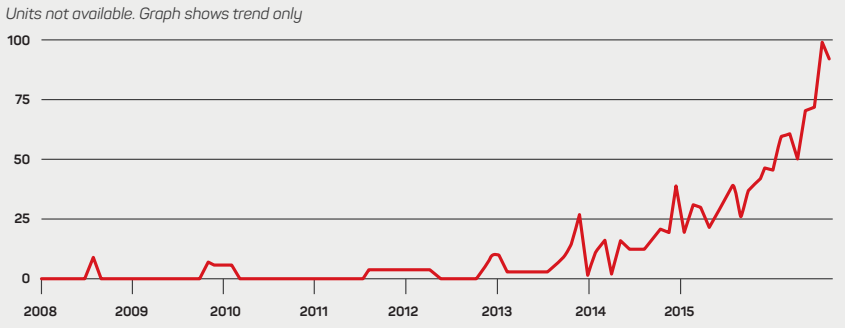
Here are some companies in the UK using this technology to improve manufacturing and business processes.

Meggitt's CLAAW: Global engineering group Meggitt has a huge product inventory, producing thousands of certain components as well as one-off spare parts for discontinued aircraft. It has developed a Closed Loop Adaptive Assembly Workbench (CLAAW), which aims to take a big step not only in production output but quality, repeatability and traceability using guidance via lasers, display screens and 'smart' tools.

INTELLICO: A big part of 4IR is embedding sensors in products to collect data for product traceability. The INTELLICO project set out to realise the opportunities of distributed intelligent components throughout the manufacturing supply chain. The project looked at developing technologies for real-time processing, wireless communications and intelligent components that are embedded within products.

Lambert Engineering - enabling customization: Automation equipment company Lambert Engineering has developed a new feed system that works in a completely different way using robotics and vision systems. The brand new design allows the system to be flexible in what it can feed. "Now a single part, one of many, can be two different sizes with 30 different colours or patterns and the machine will know which one it is processing at any one time," enabling more mass customisation for customers, says sales director, Matthew Cox. MR

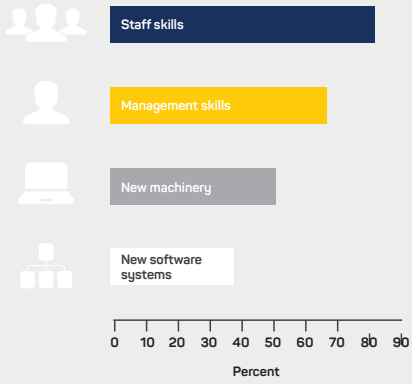
TAKE OFF 2016: REFERENCES TO "INDUSTRY 4.0" ON THE INTERNET



Source: Google Analytics

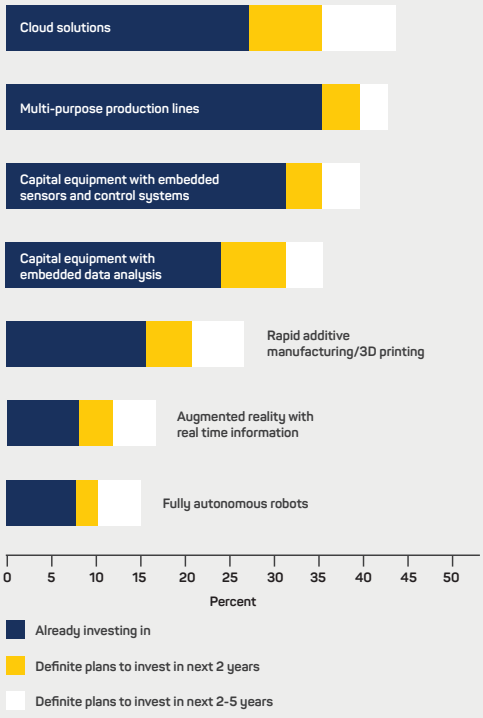
4IR WILL NEED NEW SKILLS AND UNDERSTANDING

What manufacturers say they will need before adopting advances in technology



Source: EEF Manufacturing Outlook Survey Q1 2016

MANUFACTURERS WILL BE INVESTING IN 4IR



Source: EEF Manufacturing Ambitions Survey April 2016

DELIVERING AN ENRICHED CUSTOMER EXPERIENCE

Customer-centricity is a critical factor to differentiation for manufacturers

infor

Manufacturers must respond to the demands of customers over new channels, creating a satisfying experience for them

Customers have access to more channels than ever before. They are researching products and services, doing their own competitive analysis, and drawing their own conclusions before making any purchase decision or even contacting a vendor. If you want to attract and maintain their loyalty, you need to create a satisfying, consistent customer experience across all of your channels. Technology has given rise to online shopping, social collaboration and product personalisation, and as a result, customers now expect more – and they're not afraid to go elsewhere to find it.

BETTER PRODUCTS FOR LESS

Customers are demanding better products for less, and want their products delivered sooner rather than later. For example, when your customers are e-shopping for a product you deliver, they may find that other suppliers are providing cheaper raw material. And when that happens, you are going to get pressure to lower your prices. With a customer-centric approach, you build better relationships, respond better to customer demands, optimize production, become more agile, and ultimately speed up the pace at which you do business.

What does this mean for manufacturers? It means that in order to succeed, tracking your customer across the lifecycle of their relationship with your product is critical. By developing data-driven analytics, predictive models to find new customers that match your best customers' profile, and a clear view into what key channels they are using to communicate with your brand, you can strategically anticipate key touchpoints along the customer journey to ensure a consistent and positive experience.

Are you ready for the shift to a customer-centric business model? Do you have the tools in place to truly deliver a customer-centric strategy? In order to maintain a heightened state of readiness and responsiveness to your customers, it takes both a holistic strategy that puts your customers first, and the tools to help make it a reality. Modern customer relationship management (CRM) solutions, collaborative tools, online portals, and product configuration abilities all help to provide customers with a positive experience.

Key applications include:

- CRM–Allows you to maintain a comprehensive customer, vendor and supplier database, easily track transactions, integrate with back-office systems to access manufacturing data, and leverage advanced analytics to manage supply and demand
- CPQ–Provides real-time visualizations of products, collaboratively creates quotes and improves the overall process with accurate orders while automatically producing a seamless flow of information from quote to order with a configurator that easily integrates with ERP, CRM, and e-commerce systems
- CLM–Streamlines the creation, negotiation, execution, and management of contracts throughout their development.

Leveraging these tools will help you integrate customer data across the enterprise, accelerate customer engagement, drive profitability and ultimately deliver on the promise of a customer-centric approach.

IMPROVED EXPERIENCE

Measuring the impact of an improved experience:

20% Satisfaction increase

15% Projected revenue gain

McKinsey & Company, "The three Cs of customer satisfaction: Consistency, consistency, consistency"

DID YOU KNOW?

2020 By 2020, customer experience will overtake price and product as the key brand differentiator [1]

54% of consumers **shared bad experiences** with more than five people [2]

6 to 7x times more expensive to obtain a new customer than retaining an existing one. [3]

33% of customers tell their friends about a positive experience. [4]

[1] Walker Info. [2] Dimensional Research. [3] White House Office of Consumer Affairs. [4] Dimensional Research

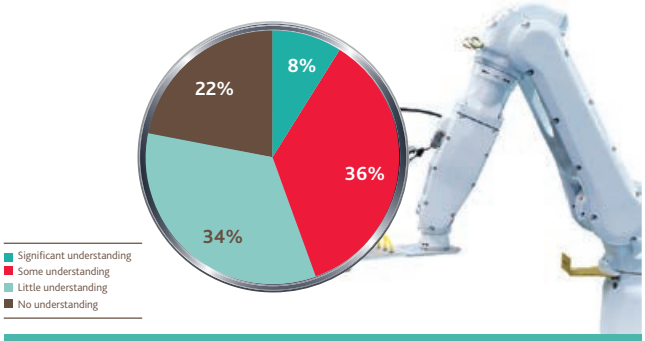
INDUSTRY 4.0

THE FOURTH INDUSTRIAL REVOLUTION

Brought about by the rapid developments in information technology and greater connectivity between machines, operating systems and customers. Industry 4.0 has the potential to radically change manufacturing processes. But just how much is known about Industry 4.0 and what are companies doing about it? BDO partnered with the Institution of Mechanical Engineers (IMechE) to find out the extent of knowledge and use of Industry 4.0 in UK manufacturing.

Below are some of the findings from our survey, you can download the full report at: https://www.bdo.co.uk/en-gb/insights/industries/manufacturing/industry-4-0-report

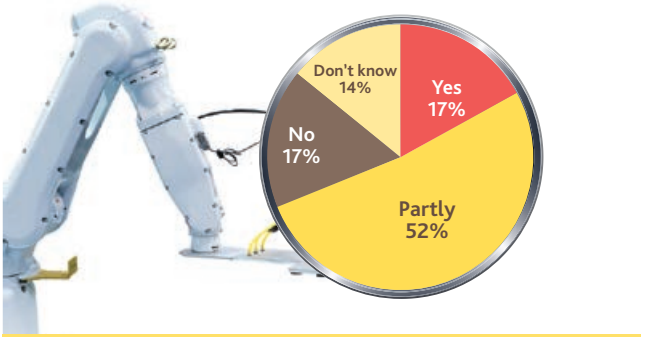
AWARENESS OF INDUSTRY 4.0 IN THE UK MANUFACTURING COMMUNITY



HOW WOULD YOU DESCRIBE YOUR LEVEL OF KNOWLEDGE OF INDUSTRY 4.0?

If you accept that Industry 4.0 is the future business model for manufacturing, awareness generally is very low. Over half of those surveyed (56%) had little or no understanding of the term 'Industry 4.0' and 8% had 'significant understanding' of it. A more respectable 36% have 'some understanding' of it.

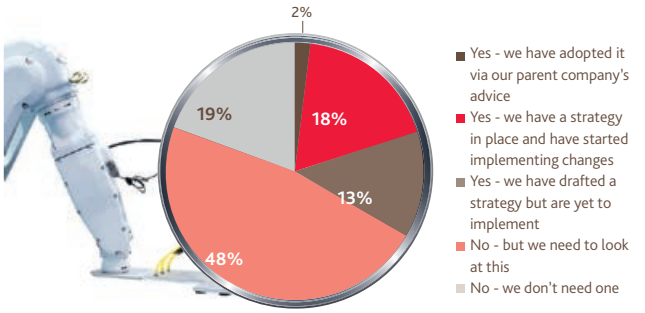
SKILLS



DO YOU HAVE THE RIGHT STAFF/SKILLS TO INCORPORATE INDUSTRY 4.0 INTO YOUR BUSINESS?

Over half the survey (52%) said that their company had some of the right skilled people to implement Industry 4.0 into their business. 17% said yes they had the correctly skilled people for Industry 4.0, and 17% said they did not. On balance this seems a stable position for digital factory skills as the evolution progresses.

STRATEGY



DOES YOUR BUSINESS CURRENTLY HAVE A STRATEGY IN PLACE TO IMPLEMENT INDUSTRY 4.0 INTO YOUR BUSINESS?

CYBER SECURITY AND INVESTMENTS

73% said the use of industry 4.0 will **increase the risk of cyber security breaches**

44% cited **lack of understanding** as the main reason for not currently investing

43% planned **some level of investment in automation** over the next 24-months

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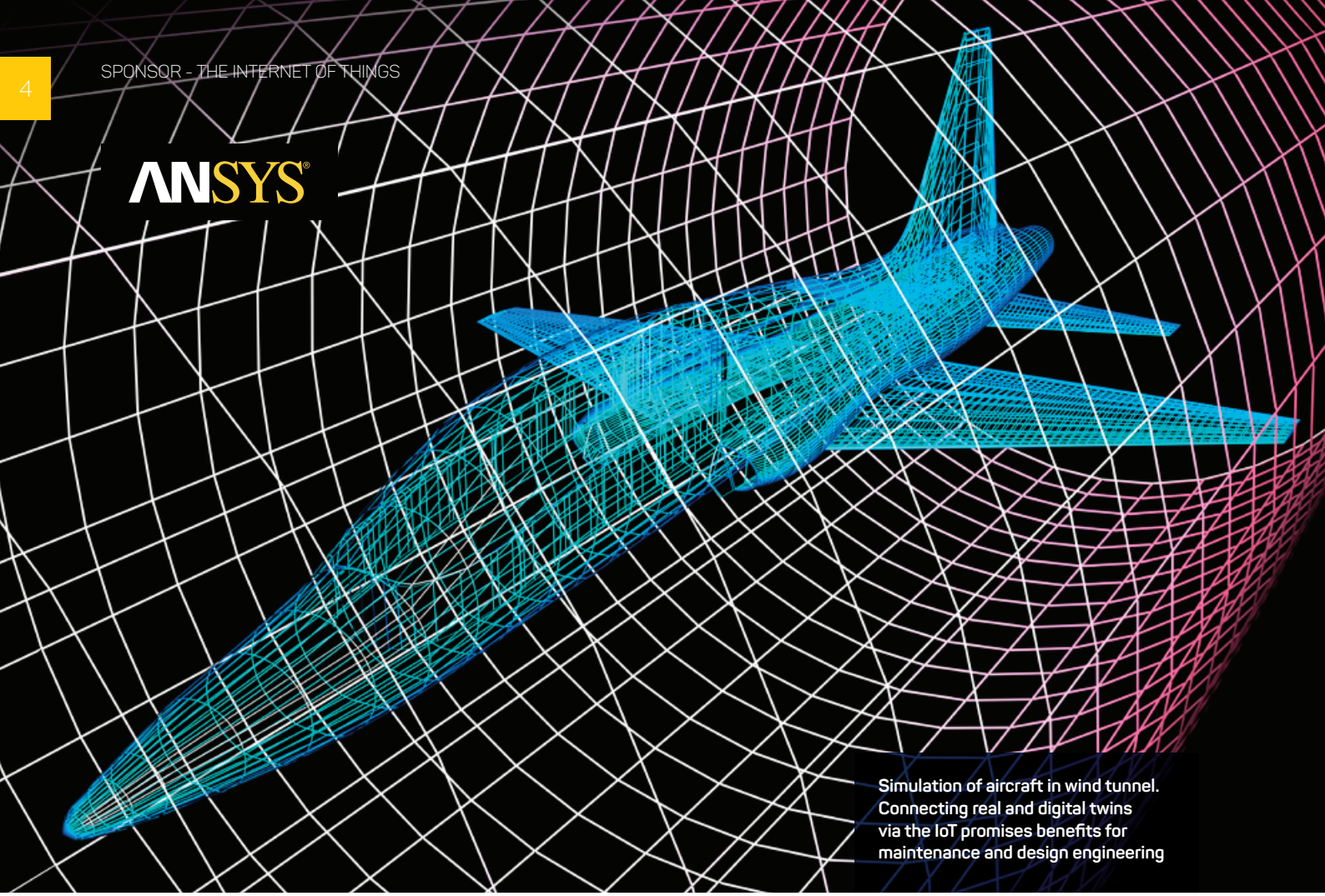


Simulation of aircraft in wind tunnel. Connecting real and digital twins via the IoT promises benefits for maintenance and design engineering

CONNECTING THE VIRTUAL WORLD

The Internet of Things will have an impact on many areas, not just manufacturing. For engineering firms, it means the chance to improve MRO and product design via simulation

THIS ARTICLE EXPLAINS:

- The Internet of Things will touch every part of the economy
- Simulation is critical to the IoT
- Digital twins used to improve maintenance and design
- Firms should consolidate on single simulation platform
- Complexity of products and engineering has increased

Virtually no aspect of the global economy will be left untouched by the 'collect-connect-correlate' value of the Internet of Things (IoT). According to analysts' estimates, by 2025 there will be up to 30 billion connected devices, representing a market opportunity approaching $11 trillion.

However, for many manufacturers, IoT, presents profound challenges. Many design teams are now being tasked to begin the journey from a 'product' to a 'smart connected product' that requires technology and skills from outside traditional domains of expertise.

THE ROLE OF SIMULATION

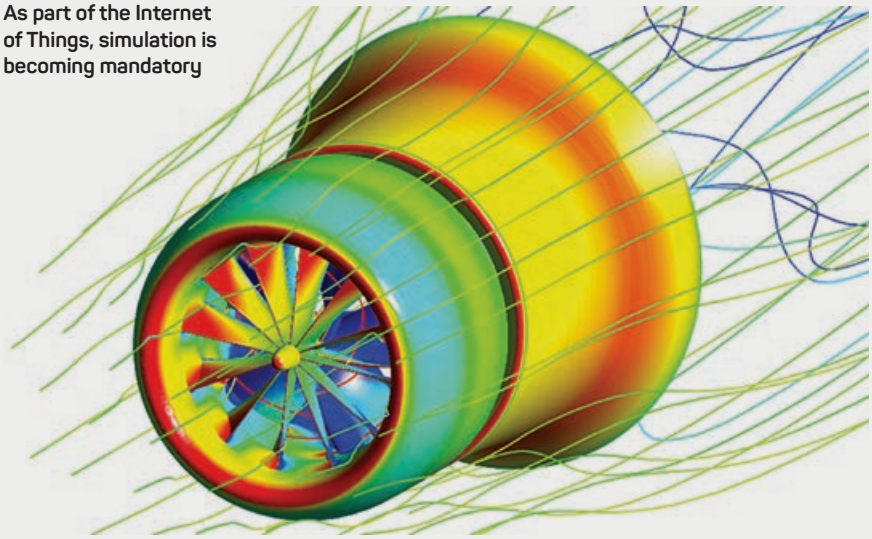
As part of the industry response to this challenge, simulation is already proving crucial to IoT product development. In a recent report, the Boston Consulting Group listed simulation as a critical success factor in the connected economy.

Why is this? First, the transition from mechanical to electronic systems, including millions of lines of software, has added huge layers of complexity. The density of wireless connections, transistors, and software has added additional challenges. Elsewhere, companies building the IoT infrastructure are dealing with multi-faceted issues that require higher levels of reliability, precision, robustness and innovation — all at reduced cost.

To achieve these goals, companies cannot rely on traditional build-and-test methods, or they will simply be out-innovated. Simulation has become mandatory.

Using simulation, a few engineers can virtually prototype and refine their ideas in days: going beyond traditional engineering discipline boundaries, using multi-domain and multi-physics analyses – and causing profound disruption. As a result, industry leaders like GE and PTC have already developed platforms that can connect to simulation tools to optimise the performance of assets and drive future innovation.

One way of optimising IoT performance is to use "digital twins" whereby a physical thing has an accompanying virtual double — a digital twin. Actual performance data collected from the thing is then compared in real-time against the model predictions of the digital twin to identify possible performance issues and take preventative maintenance action. The same data can also be used to drive design and simulation of next-generation products.



As part of the Internet of Things, simulation is becoming mandatory

"If you went to bed last night as an industrial company, you're going to wake up this morning as a software and analytics company"

– Jeff Immelt, CEO, General Electric

DIVING DEEPER

In the context of IoT, there are five key engineering challenges that simulation is tackling:

1. **Size, weight, power and cooling**
   Whether designing planes, cars or smartphones, engineers need to optimise products for size, weight and energy efficiency. The addition of IoT technologies, such as pervasive connectivity and sensing, brings with it a higher density of electronic components, leading to additional size, weight, energy and thermal challenges.

2. **Sensing and connectivity**
   Connected products are 'smart' because they can sense their environment, connect with other electronics, and enable decisions. For example, unlike previous generations, the engineers designing modern cars need to pay added attention to reducing electromagnetic interference that may wreak havoc on the electronics. Maintaining signal and power integrity at all times is crucial; with some drivers relying on these systems to make critical decisions, false reporting could lead to bad outcomes.

3. **Reliability and safety**
   Reliability is vital if the economic argument for the benefits of connected products is not to be outweighed by the cost of maintenance or lack of uptake by the market. Many products, such as those in the automotive, aerospace and medical industries, will be in safety-critical environments, and will need to meet relevant reliability and safety standards.

4. **Integration**
   As the complexity of products has increased over time, engineers have broken down the design process into smaller pieces. While this methodology allows for very thorough component level verification, significant late-stage issues arise when the components are assembled to create the system. The complexity of IoT devices, the environment in which they will operate, and the need for higher safety and reliability mean that engineers' late-stage integration challenges have increased significantly.

5. **Durability**
   One of the attractions of the IoT is that trillions of sensors and communication systems will be deployed to collect and share useful information 24 hours a day, seven days a week. These systems will be expected to perform reliably not just in their intended environment, but also in extreme, harsh conditions that are difficult to define in advance. Exploring and ensuring performance in a variety of operating environments is a core engineering challenge.

SIMULATION AS A SOLUTION

Research has shown that product development teams that consolidate their simulation-driven product development capabilities on a single platform are 24 per cent more likely to meet product launch targets and 37 per cent more likely to decrease the length of their product development time. It also highlights that best-in-class companies who adopt simulation-based approaches early in their product design cycle are able to make better decisions throughout the process. This enables these leaders to drive higher quality and lower cost products, as well as deliver the innovations and features that differentiate their products. Ultimately, this pays off in a 15 per cent increase in profit margins on new products, three times that achieved by their peers.

These are critical metrics that can define whether IoT product development efforts succeed or fail in this highly disruptive and competitive business environment. MR

INDUSTRY 4.0 PRINCIPALES IN MANUFACTURING

REALISING THE FOURTH INDUSTRIAL REVOLUTION

igus

igus director Justin Leonard looks at some of the technical challenges of applying Industry 4.0 principles across manufacturing environments

Increased automation and data exchange in the manufacturing sector is often referred to as Industry 4.0, or the fourth industrial revolution. While it's been a slow adoption process, there's no doubt that manufacturers are now feeling the benefits of this trend in terms of cost and risk reductions, performance improvements and enhanced flexibility. This is especially so in the automotive industry, and other high end manufacturing environments, where Industry 4.0 techniques are being applied on a regular basis.

Certainly, the desire to manufacture custom products quickly and inexpensively are the main attractors to Industry 4.0 for low-volume manufacturing. Fundamental to this is the realisation of a cyber-physical system (CPS) that links all levels of the value chain in real-time; not only in the production environment but also the internal and external communication channels – from incoming orders, design, customisation and then finally delivery requires a seamless communications channel.

To support this the autonomous platforms for IT (Information Technology – the office) and OT (Operational Technology – the factory floor) are converging. Originally built on separate technology stacks, protocols and standards, the world of OT is progressively adopting IT-like technologies that meet the ruggedness and reliability standards industry requires. The share of installed Industrial Ethernet nodes is increasing steadily and every device manufacturer offers Ethernet interfaces in their portfolio.

The level of automation must continue to rise and this will inevitably call for a higher level of reliability in the communications network – right down to moving parts of the machinery. Under these conditions, the traditional Ethernet cables used for fixed installations can only achieve very limited service life. In addition, machine builders are increasingly downsizing the footprint of their equipment, which is driving for more compact designs. igus was one of the first cabling companies to develop Ethernet CAT5/6/6A/7 cables specifically for continuous movement applications.

Another major challenge for machine builders is to reduce the vibration of the machine components, which will not only reduce factory noise significantly but improve the accuracy of the manufacturing process. Both the surface quality and the dimensional and geometrical accuracies of the machined work piece can be adversely affected and at the same time process stability can be reduced. This leads to low manufacturing quality, high tool wear and ultimately machine downtime.

Low vibration energy chains are often overlooked in the battle against machine vibration. When the energy supply system rolls, a polygon effect can occur – that is, the chain doesn't roll in a perfect arc – which results in vibrations

that can lead to high oscillation amplitudes and even resonance. Most producers of high quality energy chains rely on a small chain link pitch to reduce the polygon effect.

The more advanced energy cable offerings pursue this same design principle but instead use an elastic spring interconnect for the chain links that improves arc shape; this results in extremely low noise and an almost vibration-free running of the energy chain, even at high accelerations.

Energy-efficient machine components are also required to ensure competitiveness. The more mass is required to be accelerated, the more energy is required. High acceleration energy is also required for the change of direction of masses. Lightweight construction is increasingly vital for manufacturers of machine tools, particularly with highly dynamic applications.

To drive the alternating strokes of an energy chain, the driving power must be applied in the form of push-pull force. Lightweight energy chains, which can be up to 30 percent lighter than similar products with equivalent dimensions and yet remain robust, require less driving power so contribute to energy efficiency through low power consumption potentially leading to smaller drive requirements.

The volume of data required for Industry 4.0 will only increase - it is likely therefore that the issue of EMC protection as well as speed and length limitations of copper-based cables may be more of a focus. Perhaps it is worthwhile planning for the system-independent future today?

Fibre optic cables enable safe communication that is independent of the system. If households of today are equipped with fibre-to-home connections already in major cities, then why settle for anything less in the industrial environment? Fibre optic cables tested for millions of strokes in small radii that are twistable for 3D robotics applications may prove to be an interesting alternative to copper.

Machine builders will benefit by taking a closer look at their physical communications network. More attention to the criteria for selecting cables and energy chains will help improve service life and therefore process reliability in addition to realise the cost and risk reductions, performance improvements and enhanced flexibility that the Industry 4.0 concept promises. MR

PRODUCT FOCUS: EASY ONLINE ORDERING SERVICE FOR 3D-PRINTED ENGINEERING PLASTICS NOW OFFERS AUTOMATED PRICING

Industrial tribopolymer filament delivers form and function for moving applications

Igus has been quick to realise the opportunity offered by advancements in additive manufacturing, having undertaken extensive research and development into 3D printing filaments in order to offer its industrial customers more freedom in their product design and prototyping. The result is the world's first structural plastic filament for use in 3D printing, designed specifically for moving applications. Customers can purchase the filament for use in their own 3D printers or specify and order parts direct from igus via its easy online ordering and 3D printing service, which now offers automated pricing.

Using the tribo-filament, it is now possible to create 3D-printed plain bearings that deliver both form and function. 50 times more wear-resistant than conventional 3D printing materials, it was developed for engineers that need to create structurally robust prototypes or even small batch samples for real-world testing. The lubrication-free, abrasion-resistant iglidur tribo-filament has exceptional strength, even when compared to parts made traditionally via machining and injection moulding.

The process of purchasing parts made with igus tribo-filament materials is now even easier via the igus 3-step online ordering and 3D printing service. Customers can drag and drop .stl files into the igus configurator. With the 360° viewer, they can check their models and enter the units of measurement required. It's then possible to select a suitable tribo-filament, the required quantity, and to place the selection in the shopping basket to instantly receive a quotation.

"Thanks to 3D printing, the prices are competitive for making both prototypes and small batches for production," says igus director, Robert Dumayne. "Depending on part complexity, completed 3D-printed components can be delivered in as little as 24 hours."

igus also offers a service to 3D print injection mould tools, enabling rapid and cost effective production of custom parts. This new service complements a range of products and services igus now offers across the design, prototyping, testing and manufacturing cycle, from 3D printing parts and machining stock bar, to supplying tribo filaments and SLS powders to 3D print with or tribo polymers for traditional injection moulding.

"Injection moulding tools, or moulds, usually manufactured from steel or aluminium for high volume production, can have relatively high costs, with longer lead times," says Robert Dumayne, director, igus. "With 3D-printed plastic moulds, igus is providing more options for design engineers and manufacturers seeking a cost-saving alternative for prototyping or low volume production."

For parts with simple geometries, the 3D printed injection moulds can be produced with short lead times, using the SLS (selective laser sintering) printing process. The moulds are for use in existing injection moulding machines and are capable of withstanding these high temperatures for up to several hundred uses (depending on the iglidur material used). Injection moulded parts can then be produced using a wide range of proven and tribologically-optimised iglidur materials. Engineers can also still easily iterate on the design, quickly and inexpensively 3D printing new moulds.

TWIN DOUBLES UP WITH SENSORS IN PRODUCTIVITY PUZZLE

How simulation, the IoT and the digital twin concept can improve product and process performance

Simulation has long been used to improve the design of physical products, process or to model different operating scenarios. The emergence of the Internet of Things (IoT) has created the potential for a transformational step, in which such a simulation model is tied through the Internet to sensors capturing data and to actuators controlling its operation.

The result is a 'digital twin' of the physical product or process that can be used to analyse and diagnose product operation and optimise performance and maintenance in real time:

DIGITAL TWIN DECISION MAKING

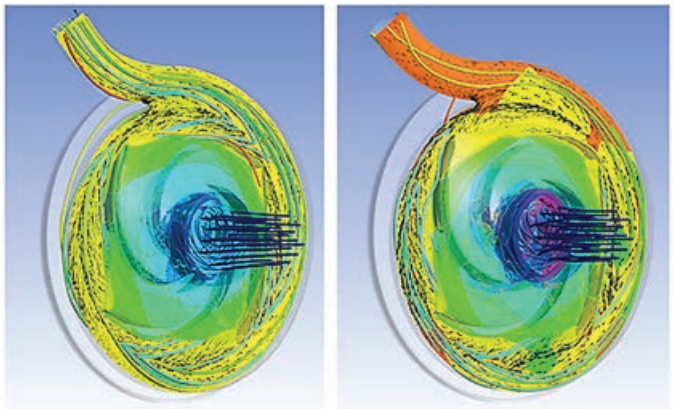
Early IoT applications focused on relatively simple applications, such as determining the state of assets and issuing basic commands. But a hybrid IoT / simulation system can perform diagnostics and troubleshooting in real time, anticipate breakdowns and determine the optimal point to perform maintenance. It can even tune the product to optimise performance, and capture information that can be used to improve the next-generation design.

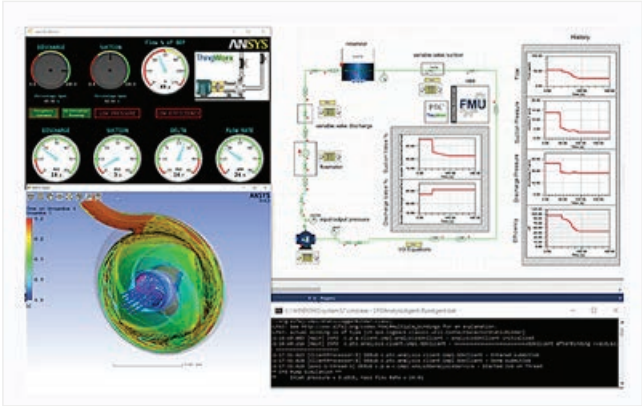
HOW FAR CAN SIMULATION AND IOT GO TOGETHER?

Digital twins can include a simulation model that has been developed to duplicate the current condition of the product or process, such as incorporating wear or degraded performance. The data from sensors are used to provide real-time boundary conditions for the simulation. The results can then

THIS ARTICLE EXPLAINS:

- The IoT creates potential for 'transformational step' with simulation tied to data capture
- Digital twin used to analyse and diagnose product operation
- Combination of IoT and twin to performance maintenance in real time
- Pump models demonstrates how system can work
- Gains in efficiency and productivity the result





Above left: Digital twins combined with sensor data can diagnose problems with products in real time and correct them

Above right: ANSYS software links simulation to the IoT to give engineers more predictive information

be calibrated based on the operation of the actual product or process.

The predictions made by the digital twin can then be used to determine the root cause of performance problems, and evaluate the potential results of different changes being considered.

The digital twin can also provide information about the product or process that cannot be measured with sensors, such as flow velocities through internal passages.

These enhancements to the digital twin improve its predictive capabilities far beyond what can be obtained in the product design process. The result is that digital twins can be used to substantially increase the performance and reliability of the product or process while reducing its operating cost.

THEORY INTO PRACTICE

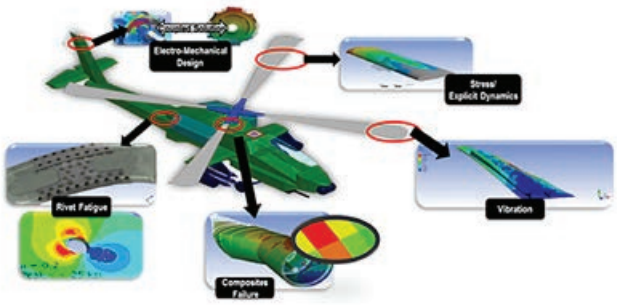
ANSYS recently demonstrated how a simulation model can serve as a digital twin to fix problems and optimise performance over the IoT. The demonstration showed a motorised pump operating in a hydraulic system with valves on the suction and discharge sides. The motor and pump were instrumented with sensors to measure key operating parameters. Actuators on the valves were used to control the pump operation based on instructions from the simulation model.

An operator introduced an anomaly by closing the suction valve to 50 per cent. The sensor readings on the physical product immediately indicated that something was amiss. Inlet pressure, outlet pressure and flow rate through the pump decreased drastically, while pump noise increased. But the sensor readings provided minimal diagnostic information, and it was not possible to look inside the pump and see why it was vibrating. Furthermore, the sensor readings provided no guidance in determining what would have happened if various actions were taken to solve the problem.

The digital twin was used to address these challenges. The sensor readings from the demonstration unit were used as boundary conditions for the simulation. The twin immediately began exhibiting the same symptoms as the physical model. The digital twin then enabled engineers them to look inside the virtual product. The digital twin showed that the fluid in the interior of the pump was cavitating. The drop in pressure inside the pump was forming vapour cavities – essentially bubbles – where the pressure was low. In locations where the liquid was subjected to a higher pressure, the voids imploded and generated noise. Next, engineers used the digital twin to evaluate the impact of changing the operating conditions. After evaluating the effect of different valve settings, they determined that opening the suction valve to 100 percent would restore pressure and flowrate to normal levels.

The simulation-based digital twin can help companies analyse smart machines in real-world operating conditions and make informed decisions that will improve their performance.

The resulting efficiency and productivity gains could have a dramatic effect on an organisation's bottom line. The combination of machine connectivity with engineering simulation will enable organizations to perform diagnostics and trouble- shooting, determine the ideal maintenance program based on the characteristics of the individual asset, optimize the performance of those assets, and generate insightful data that can be used to improve the next generation of the product. MR



Multiple physical properties in a complex assembly can be assessed simultaneously

The manufacturing toolkit now encompasses digital tools

Machine tools feature sensors inside the flute

CUTTING TOOLS SET FOR DIGITISATION

Göran Näslund of Sandvik Coromant explains where the future lies when it comes to machining in the digital factory

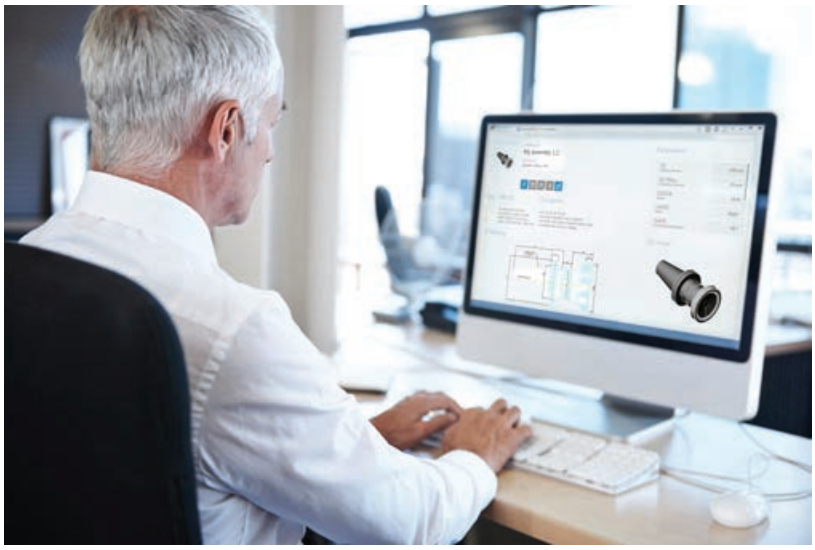
THIS Q&A EXPLAINS:

- Cutting tools with embedded sensors enhance machining
- 'Industrial Internet of Things' cloud-based solution to manufacturing woes
- Advanced ICT will shorten cycle times
- Machine utilisation will improve
- Digital factory will serve customisation

Göran Näslund

Metal cutting tools are being developed with sensors inside the cutting edge or the flute. What does the sensor measure, and why is this useful to the customer?

Beside the accuracy of machines, the skills of the process planner and operators are of vital importance to secure good component quality, component cost and secure machining processes. The machining process is usually monitored by operators using all senses such as vision, hearing, smell, and so on. However, this is very much dependent on the operator's experience, access to the right information and knowl-



Sandvik Coromant has developed novel IT technologies for in-process monitoring

Cyber physical systems will shorten cycle times

edgem and ability to make quick decisions. Implementation of various sensors in cutting tools, and machines utilising advanced signal analysis combining different sources of process data, provides quick and accurate decision-making support for machines, systems and human resources in manufacturing. The cutting tools with embedded electronics and sensors can measure process behavior such as temperature, 3D vibration, forces, torque and deflection in the harsh environment of machining. These will be documented and through closed loop systems support various actors at shop floor- and enterprise level. The decisions made by operators, process planners, systems and machines will be much more reliable, utilising the embedded knowledge and advanced information and communication technology.

Apart from sensing metal hardness, and the cutting properties inside the tooling, how else is Sandvik Coromant using digital factory (or 'Industry 4.0') technology?

Sandvik Coromant has developed a novel technology combining various sources of data and in-process monitoring which enables comprehensive analysis, continuous improvements and optimisation. It supports reduction or elimination of dimensional error and form error of the parts through adaptive tool deflection control, and tool life monitoring, while obtaining a uniform surface finish, as well as building knowledge needed for further optimisation. Sandvik Coromant considers this cloud-based solution to existing manufacturing woes as an 'Industrial Internet of Things', or IIoT.

To develop a smart and reliable manufacturing system there is a need for integration of three essential areas: device computing, factory computing – as well as cloud computing. Device computing incorporates digital signal processing, communication interfaces, shop floor connectivity, local networking, remote updating and configuration, hot data analytics, and interfacing with tools and/or machines. Factory computing also includes digital signal processing and remote updating and configuration, but also incorporates semi-hot data analytics and interfacing with the cloud. Finally, cloud computing covers cloud-to-cloud integration, shop floor monitoring, cloud connectivity, security, analytics, and pre-, in- and post-machining data. Industry 4.0 is all about using digital tech to make places which are costly to manufacture, like the UK and Scandinavia, more efficient and therefore competitive.

How does the suite of Sandvik Coromant's digital manufacturing technology actually save customers money? Does it shorten cycle times, or give longer tool life?

Yes, utilising the proposed cyber physical systems and advanced ICT will efficiently shorten the total cycle time of the machining process. This covers planning, the actual machining of parts, verification and quality assurance. It leads to tremendous cost savings for manufacturers and supports the low threshold manufacturing start-up with much lower costs. A number of sources for waste through the chain of manufacturing will be eliminated. Among these identified sources of waste are: lacking ability to optimise design due to poor input data quality; low utilisation of individual machines, typically 50 per cent; only 1/3 of energy used for actual forming of manufactured parts; key intelligence captured in experienced industrial practitioners, who cannot process data as effectively as algorithms; only a fraction of data recorded – and even if recorded, even less analysed and used for improvement and prediction.

What do you see coming in 2017 and beyond in this field? Fully "lights out" manufacturing? Operating a factory remotely on a tablet? What are the most important gains for you in the next 1-3 years?

To meet the ever-increasing need for customisation of products, services and processes, in combination with the need for better monitoring and tracing assets during manufacturing, the following needs will be fulfilled by applying ICT during the coming years; embedded virtual modeling; real time diagnostics and maintenance; autonomous adjustment/control; process learning and close-loop diagnostics; utonomous quality control and feedback; remote diagnostics and support. MR

ThingWorx is purpose-built for the Internet of Things, with tools, APIs, and marketplace extensions that lower costs, increase developer productivity, and speed time-to-market.

With the ThingWorx IoT Platform, you have access to a powerful development engine and a broad set of innovative technologies that extend the power of the IoT:

- CONNECT to any Thing
- CREATE Apps for all Users
- ANALYZE Machine Data
- EXPERIENCE all Things through Augmented Reality

Learn more about how the ThingWorx IoT Platform is the right choice to power your organization's digital transformation.

http://www.thingworx.com/go/IoTFoundations

ptc

DIGITAL MANUFACTURING – A 'VIRTUAL' REVOLUTION

At Cranfield University

Virtual representations of factory environments are created

IN BRIEF:

- Informatics behind new manufacturing tools
- Cranfield working with industry to overcome ICT barriers
- Virtual factories digitise workers' skills
- New human-machine interfaces to be created
- Factories redesigned for improved competitiveness

Informatics – the science of computers and computer information systems – is essential in Cranfield University's research and development of the new tools needed in manufacturing to translate data into business improvement.

Manufacturers need to be efficient, flexible, responsive and form part of sustainable and collaborative supply chains to succeed in the modern global marketplace. Information and communications technology (ICT) can help in creating the necessary foundation of information and communications networks for analysis, insight and decision making.

We are working with industry to overcome barriers to using ICT and deliver proven systems of modelling, simulation and automation in manufacturing.

Mindful of the needs of the manufacturing sector and aware of the opportunities presented by new technologies, we aim to extend the reach of informatics into high-value manufacturing. This is, for example, by digitising and automating skill-intensive manufacturing processes using new human / machine interfaces and sensing systems that adapt to complex or changing situations.

STATE-OF-THE-ART RESOURCES

Our state-of-the-art resources, in a 'laboratory' environment, include the latest hardware and software for capturing, digitising and visualising manufacturing operations and their interactions with human workers.

> "Our ambition is to digitally record and learn from the physical response of humans to both expected and unexpected events on the manufacturing shop floor, potentially leading to increased productivity in skill-intensive manufacturing tasks"

Complementing this work is the Through-life Engineering Services Centre here at Cranfield with its Augmented Reality (AR) laboratory. Our Augmented Reality research is looking at how AR can transform the way maintenance tasks are carried out, tackle obsolescence and support remote maintenance.

Our ambition is to digitally record and learn from the physical response of humans to both expected and unexpected events on the manufacturing shop floor, potentially leading to increased productivity in skill-intensive manufacturing tasks.

Digitised interactions between humans and the workplace could help overcome skills shortages in the future

In addition, virtual representations of factory environments could be created which can be used to predict and evaluate the impact of different factors on production efficiency or for people to virtually 'meet' and 'walk through' the environment.

Analysing the digitised human / workplace interactions could provide information useful for productivity assessments and redesign of factories to boost competitiveness, in the short term. Also, the skills of experienced workers could be digitised and transferred to apprentices via skills demonstrations, reducing the need for long apprenticeships.

Longer term, human skills models generated by capturing and modelling human / workplace interactions could provide the intelligence behind automating such tasks, helping to overcome the current shortage in skilled and semi-skilled workers. MR

CLOUD-BASED CONNECTIVITY FOR PRISTINE PROCESSES

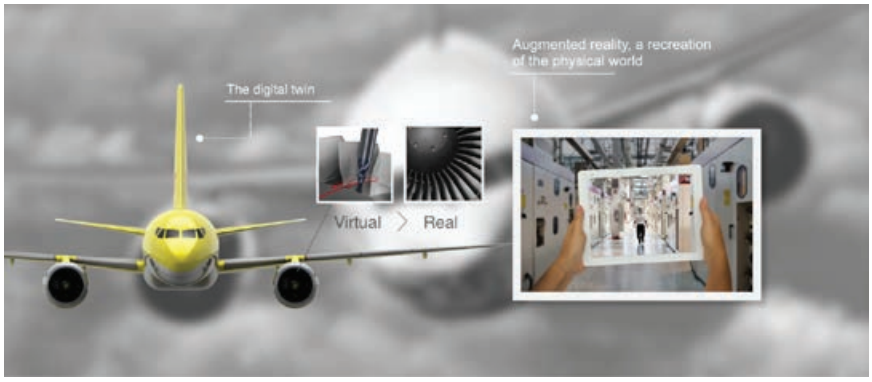
SANDVIK COROMANT

Manufacturers should turn to the latest ICT technologies to integrate, streamline and improve their production techniques, says Sandvik Coromant

Despite economic downturns and changing working environments, manufacturing remains a core provider of employment, and a substantial revenue generator globally.

Although much has been done to secure component quality, and boost efficiency throughout the production process, there are still major sources of waste that have not been dealt with. The result is that levels of operational expenditure in manufacturing remain stubbornly high, but there are significant opportunities to transform this situation through digital, cloud-based solutions.

Information and data play a vital role in process planning, machining and quality evaluation. By managing these elements more accurately and comprehensively, while broadening access and controlling them remotely, it will be possible to optimise manufacturing processes so expenditure can be significantly reduced. At the same time, by analysing high volumes of different types of information at high speed, and delivering precise feedback on in-machining process characteristics, manufacturers will be able to improve the accuracy and quality of every single component.



Breaking down the boundaries between virtual and real

ELIMINATING ERRORS

Errors and erroneous processes will be eliminated for future implementation, and, once problems are removed from the manufacturing process, they will never return. The ultimate goal is to build systems that can 'self-optimise', with little or no programming or operator intervention.

One of the main sources of waste in the metal-based manufacturing industry is poor quality input data, which prevents optimisation of production. Individual machines can have utilisation levels of below 50%, while only 33% of the energy that flows through machine tools in the factory is used in the actual formation of manufactured parts. Finally, only a fraction of process data available are recorded. Even less data are analysed and used to enable predictions and improvements.

Today's process planning suffers from various data-related issues. These include discontinuous delivery of process data, which highlights the obvious necessity for semi-automatic data transfer. There is a distinct lack of feedback loops in process planning, which has a direct impact on quality and efficiency throughout the manufacturing process. Quality assurance of data and knowledge is a challenge, while a worrying lack of model-based knowledge transfer makes it difficult to access the right knowledge at the right time. Indeed, knowledge-sharing per se is notably poor, as is the level of collaboration between teams involved in the manufacturing process.

NO LONGER JUST IT

If managing data and information is the answer to minimising inefficiency and maximising productivity during the manufacturing process, IT is no longer sufficient. There must be a move towards the adoption of enabling technologies such as information and communication technology (ICT), combined with cloud-based data management. This level of digital transformation – which actually delivers on the promise of intelligent data gathering and sharing – will ensure 'smarter' manufacturing becomes a reality. Reconfiguring the value chain in this way, so that low machine utilisation is consigned to the past, is one of the key functions of a network-centric approach, backed by a cloud-based, ICT-driven, solution.

For the smart factory to become operational, it is essential that the availability of resources is not jeopardised. Existing enterprise resource planning (ERP) systems, product lifecycle management (PLM) systems, manufacturing execution systems, and other types of operational business systems, must be fully integrated with all machines and people within the factory – and beyond. This level of total integration does not happen to anywhere near the extent it should.

Globally, plant efficiencies will depend on integrated ICT via the cloud

With data managed through a cloud-based system, it will be possible to create true end-to-end solutions that ensure accuracy, consistency and connectivity from human-to-human, human-to-machine, and machine-to-machine.

As well as the cloud above the intelligent factory, there are two more key elements to delivering optimum process quality control and feedback. These are open application program interface (API) technology – so that different machines and systems communicate and interact seamlessly with each other – and sophisticated sensors and other data collection units that need to be embedded in every stage throughout the manufacturing journey for each component. Only with these tools in place can a cloud-based manufacturing environment effectively ensure optimised asset tracking and asset management, as well as the ability for all stakeholders in the production process to access and analyse data to facilitate performance monitoring and diagnosis, while continually enhancing the quality of all the products that the factory makes.

This continuous loop of manufacturing process data includes computer aided design, process planning and computer aided manufacturing in the pre-machining stage, process monitoring during machining, and quality evaluation at the post-machining stage. By integrating pre-, in- and post-machining data – driven by process feedback and control – the end result will be maximum optimisation at every stage of production. Through continual process feedback and analysis comes learning. Through learning comes greater efficiency and, ultimately, lower expenditure.

Only by implementing integrated ICT can manufacturers achieve an actively networked, collaborative value chain. In terms of asset, material and product logistics, the specific factors that deliver on that goal are tracking, management and autonomous control. Manufacturing set-ups will have to provide customised product solutions and processes that are equally as efficient, no matter what the material variations and machine centre adaptations are. Other factors that will influence the adoption of integrated, cloud-based manufacturing environments of the future include virtual modelling, predictive diagnostics, autonomous quality control, feedback and adjustment, remote diagnostics and support, and effective process learning.

ACCURATE INFORMATION, INSTANTLY

While 'big data' can be collected and shared across multiple production lines or even multiple manufacturing sites, equally important is the ability to drill down, and access accurate information instantly on localised issues – such as the efficiency of a single machine, or even the wear of an individual tool. For example, Sandvik Coromant has identified a novel methodology, that, through combination of various data sources and in-process monitoring, enables comprehensive analysis, continuous improvements and optimisation. This will assist in avoiding excessive cutting forces on the tool, spindle bearing failure due to excessive loading, and tool breakage. It will help control dimensional and form error on the part through static tool deflection, and extend tool life, while obtaining a uniform surface finish, as well as building knowledge needed for further optimisation.

Sandvik Coromant considers this cloud-based panacea to existing manufacturing woes as an 'Industrial Internet of Things', or IIoT. Essentially, this consists of three areas which will be essential within any intelligent factory of the future and will all be integrated – device computing, factory computing, as well as cloud computing. Device computing incorporates digital signal processing, communication interfaces, shopfloor connectivity, local networking, remote updating and configuration, hot data analytics, and interfacing with tools and/or machines. Factory computing also includes digital signal processing and remote updating and configuration, but also incorporates semi-hot data analytics and interfacing with the cloud. Finally, cloud computing covers cloud-to-cloud integration, shopfloor monitoring, cloud connectivity, security, analytics, and pre-, in- and post-machining data.

> "Ultimately the boundaries between virtual and real-time machining processes will simply disintegrate"

Managing data more effectively across process planning, in-machining and quality evaluation will result in a manufacturing process that is optimised so effectively that factory expenditure will reduce. Customers will benefit from taking delivery of components and products they know have been produced with world-beating accuracy and efficiency. This reassurance is increasingly valuable in a wide range of industries – not least the extremely demanding aerospace sector – where quality, reliability, traceability and speed of delivery are requirements that are non-negotiable.

Digitalisation via the IIoT will be able to connect virtual and real-time machining processes in a way that has never been possible before. Ultimately, the boundaries between the two will simply disintegrate. MR

IN BRIEF

- 'Self-optimising' manufacturing processes are on the horizon
- Data managed through a cloud-based system will improve productivity and efficiency
- An Industrial Internet of Things will integrate computing for manufacturing with the cloud
- It is not just about collecting data, but about using that data to optimise processes and production

Read more about Cloud-based Connectivity on pages:

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MACHINE SHOP 2020

a clear vision into the future of manufacturing

Digital manufacturing is rapidly transforming machine shops as smart innovations and technologies are coming into digital maturity. Four years from now, the industry will be well on its way to transforming traditional machine shops from cost centers to profit center.

DIGITAL MANUFACTURING EXPLAINED

Connecting our virtual & physical worlds

Digital manufacturing uses smart sensors to enable communication between human, computer & machine

Thousands of industrial sensors are installed and placed optimally to ensure uninterrupted data collection

Millions of data points are extracted from these sensors allowing efficient monitoring, real-time adjustments and post-machining analysis

7x RETURN IN EFFICIENCY

Investment can result in 7x efficiency gains/year

SENSOR TECHNOLOGY IS INTEGRATED INTO OUR DAILY LIVES

Rolls-Royce uses smart sensors to remote-monitor airplane engines & flight conditions for their Power-by-the-hourTM engine leasing service.

Everyday devices such as refridgerators and cars are fitted with sensors to make you aware of information such as temperature & oil or battery life

Google Nest enables you to stay connected to and monitor your home's thermostat, security cameras & smoke detectors.

GETTING STARTED WITH DIGITAL MANUFACTURING

digitizing your machine shop with a step-by-step process makes it easier to transform

20% increase in savings & revenue by 2020

SHORT-TERM

evaluate current resources & implement pilot projects

MID-TERM

install sensors on current machines & start data collection

LONG-TERM

digitize enterprise autonomous control, machine learning & vertical chain integration

BY THE YEAR 2020

1 IN 5

machine shops will be investing 10% of their revenues towards digital manufacturing.

up to 50% increase in production rates

INSIDE THE SHOP

digital manufacturing addresses common pain points with benefits no shop can afford to miss out on

over **50%** of potential machine utility is **wasted**

digitizing a shop cuts down on idle time with efficient production runs and implementing fixes based on advanced data analytics

THE NEED FOR MASS PRODUCTION OF CUSTOMIZABLE PRODUCTS IS INCREASING

automated custom jobs reduce time and overhead costs, giving ability to diversify services

JOBS ARE OFTEN DISRUPTED DUE TO SMALL PROBLEMS SUCH AS TOOL REPLACEMENTS

predictive diagnostics and real-time adjustments prevent minor production issues

Sources: McKinsey Internet of Things, 2016/ PWC Global Industry 4.0 Survey, 2016/ GE Industrial Insights Report, 2015

TOGETHER WE SHAPE THE FUTURE OF MANUFACTURING

www.sandvik.coromant.com

SANDVIK Coromant

MADE HERE NOW

A programme designed to change perceptions of **UK manufacturing**

Get involved at
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THE DIGITAL MANUFACTURING ROUNDTABLE

Hosted by the Manufacturing Technology Centre, part of the HVM Catapult

INFRASTRUCTURE, SKILLS AND RISKS FOR THE CONNECTED FACTORY

FRONT ROW, l-r: Adam Payne, Lina Huertas, Alan Norbury, Olivia Kelly, Laura Jones, Justin Leonard, Paul Walker, Rachel Lawley, Andy Pye
BACK ROW, l-r: Chris Greenough, Chris Brown, David Thomas, Paul O'Donnell, Tim Jones, David Preece, Martin Strutt, David Bott

Following the conclusion of the Digitising Manufacturing Conference at the Manufacturing Technology Centre (MTC) in Coventry on 15 November, 16 experts debated some of the key opportunities and threats to business from increasing digitisation.

Scan this QR code to access the full transcript of this debate

The participants were:

David Bott, principal fellow, Warwick Manufacturing Group

Chris Greenough, commercial director, Salop Design and Engineering

Lina Huertas, Head of Digital Manufacturing, Manufacturing Technology Centre

Rachel Lawley, Tim Jones, Olivia Kelly – all Siemens Digital Factory

Justin Leonard, director, igus UK

Laura Jones, FBC Manby Bowdler

Alan Norbury, Central Technology Officer, Siemens

Chris Brown, business development manager, Made in the Midlands

Paul O'Donnell, head of external affairs, Manufacturing Technology Association

Adam Payne, consultant, TCMUK

David Preece, partner, FBC Manby Bowdler

Martin Strutt, consultant director, EEF

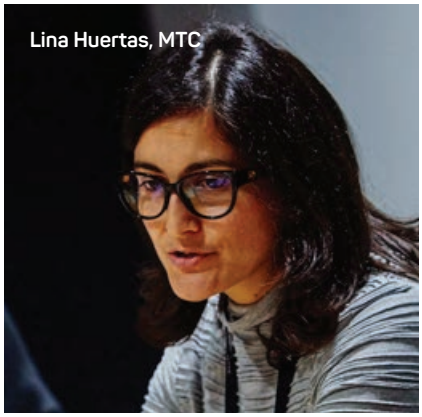
David Thomas, manager, Siemens Digital Factory

Paul Walker, managing director, Autins

Andy Pye, moderator


David Bott,
Warwick Manufacturing Group


Andy Pye, moderator


Lina Huertas, MTC

The discussion was opened by Dr David Bott of the Warwick Manufacturing Group (WMG) and moderated by Andy Pye, Consulting Editor of Controls, Drives and Automation.

David Bott from WMG gave an overview of the rise of digitisation in industry:

"My views on digitisation in manufacturing range from the mildly cynical, to the philosophical to what we can learn from history.

"I have lived through a number of disruptive changes. I have found that people love the concept of disruption and step change, but they are really bad at predicting what they are and when they come. That's my cynicism for the evening.

"Manufacturing is a physical thing. However, over the past decade, as computers have become more common and more powerful, we have created a parallel industry where people turn raw data into useful information. This has radically changed the business model. Often it is the new insurgent companies that have been more successful at navigating the change than the sitting tenants. That's the philosophy.

"Now the history! When I started my career in the chemical industry chemical plants involved a lot of pipes and lots of people changing valves. When it went wrong somebody knew how to fix it, but also there was the beginning of modelling chemical processes. I remember a chap from Imperial college who had a piece of modelling software which ran in batch mode overnight on an ICL 1904 and it could tell you roughly what would happen in a chemical process if you gave it 24 hours' notice.

"Since then, computers have doubled in processing power every 18 months, and modelling rapidly became a real-time process. Then it got faster still, so you could predict in advance all the things that could happen in a chemical plant. In reality, this is running a computer game – a simulation - which models all the possible outcomes based on the control parameters. And so chemical plants are now managed by just two or three people sitting in a room with a coffee machine and the occasional person who goes out to maintain things.

"Now, there is no part of the manufacturing supply chain that cannot be affected by this change. Everything can be monitored, controlled or logged digitally. It starts with a product specification stored and communicated as a digital file. A modern digital factory may only need management and maintenance - and even those are being taken over by artificial intelligence and robots.

But despite the risks, I assert that we would be crazy not to continue the evolution into digital factories large or small."

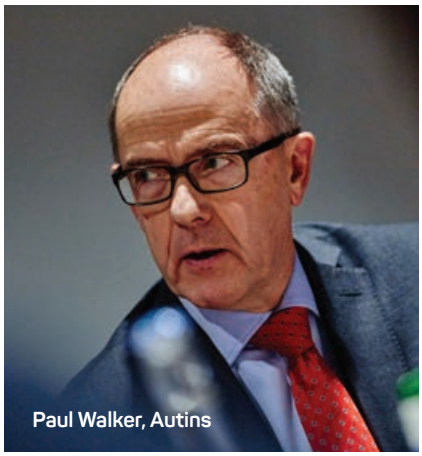
THE IMPACT ON THE SMALL FIRM

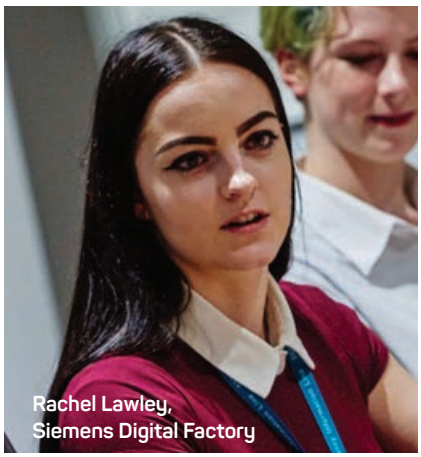
Andy Pye: Are we generally more comfortable with digital factories or more fearful?

Lina Huertas, MTC: "There is huge enthusiasm and a recognition that digitisation can have a huge impact and present a massive opportunity. It is moving fast - even three years ago, companies were uncertain. They didn't know where to start or understand the business benefits. This has slowly changed."

Paul Walker, Autins: "While this is fine for larger companies, it represents a huge challenge for an SME. One of my key raw materials suppliers does not even possess a single computer! Delivery notes are handwritten; accounts are done in pen and ink in ledgers. It is so 'dark ages' it's hard to comprehend. When I introduced mandatory labelling for my products, I had to send them barcodes to photocopy and place on their raw material. That's how far behind some SMEs are in this country. There are hundreds of them who would listen to this discussion and shake their heads wondering what we are talking about."

Rachel Lawley: "The point is not just about SMEs, but down to individuals in both small and big companies. A lot of people don't like change."


Paul Walker, Autins


Rachel Lawley,
Siemens Digital Factory


Chris Greenough,
Salop Design and Engineering

Chris Greenough, Salop Design: "Digitisation has been pushed through the large OEMs and First Tier companies and that hasn't filtered down to the SMEs. Yet, this is where the biggest potential improvement is."

Pye: Is it still not really recognised that the SME economy is so vitally important to the nation?

Adam Payne, TCMUK: "It is recognised – as Chris says, it is easy to roll it out to the OEMs, they have the investment and teams. But it is the manufacturing SMEs that can make the biggest difference – they can get so much out of it - energy savings, remote monitoring. Therefore, we need to see a proper manufacturing policy, which involves everyone, so we all get to the same end goal."

Justin Leonard, igus: "With SMEs, we need to approach Industry 4.0 in small steps. For example, we can introduce smart products that can indicate how long they are going to last (say, warning 50%, 75% of the way through the lifetime). Users of these products don't have a lights-out factory, but they are already using Industry 4.0 technology, they just don't realise it."

Martin Strutt, EEF: I completely agree. People in the food and drink sector are using it to get closer to their customers and understand what their demand is."

Paul O'Donnell, Manufacturing Technology Association: "I also agree with Justin. It is much easier for an SME to look at the technologies in a piecemeal way. An SME is not going to dedicate an Industry 4.0 change team and transfer processes overnight."

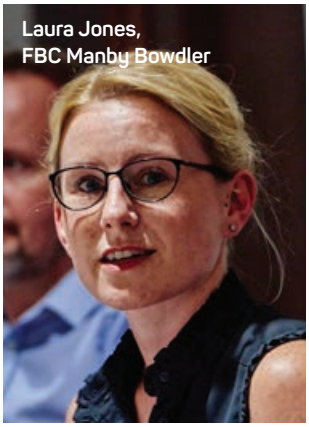
Walker: "One company I know has 24 dumb machines and for them TPM (Total Productive Maintenance) and OEE measurement is really difficult, so the next step is to start data gathering. It's not a revolution – they will still die-cut with operators standing by the machines. It is about having more information to make decision-making easier."

Huertas: "There is a group being formed called the Digital Engineering and Manufacturing Group, which has 20-30 industrial members. It is trying to bring together as many stakeholders as possible to outreach to the SME market. It is a key topic because 99% of our primary businesses are SMEs. The key thing is understanding where you are starting from and break down the journey into small steps, such as digitising CAD drawings."


Adam Payne, TCMUK


Justin Leonard, igus


Paul O'Donnell, MTA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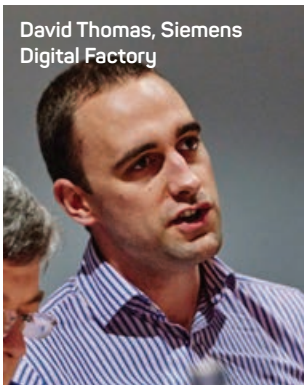
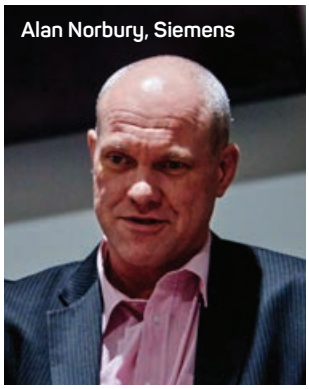

David Thomas, Siemens Digital Factory


Alan Norbury, Siemens

Chris Brown, Made in the Midlands: "Technology has its place and its application. But I visited a company this morning which does anodising and NDT. They are not going to automate their process because they won't replace their machinery anytime soon. What could such a company do to embrace this technology?

David Thomas, Siemens: "There is a big responsibility for a company like Siemens to work with our SME community. Another problem is that the Lexicon of Industry 4.0 boggles people.

Alan Norbury, Siemens: "To answer Chris, I'll give you a good example – at Siemens, we engage with the supply chain to help our Congleton factory. One supplier used to come in and then replenish tote bins containing fasteners if they were empty. Now, they use a remotely-accessible weigh-scale and know whether or not they need to come in and replenish. What did it cost their business – nothing! The supply chain saves money and they own the stock, so everyone wins."

Laura Jones, FBC Manby Bowdler: "We see similar challenges in the legal profession. Our business is all about people and bring them with us, we need to educate those who are reluctant to change and translate the lexicon into plain English."

BUSINESS RISKS

Pye: Is it true that as far as risks are concerned, the financial side of the business is better catered for than the manufacturing side?

David Preece, FBC MB: "My concern is that while we rush to make a factory smart, we will not keep pace with the new risks to which a business opens itself up. If companies are still using the same IT systems that they were 10 years ago, they leave themselves open to intrusion."

Pye: "The cyber companies are beginning to be aware that there is a market on the manufacturing shop floor. Manufacturing computers are not always part of the system, not managed in the same way. It is easier to bring a mobile onto the shop floor, so there is a huge opportunity for providers of IT solutions, seeing new developments in security specific to machines, rather than for a business system or network."

With flow of data up and down a supply chain, who owns it?

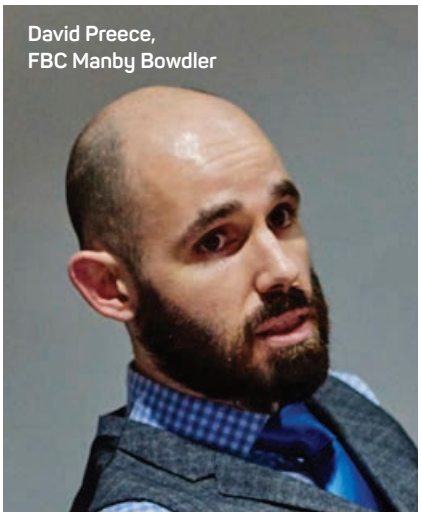
Preece: "This is a commercial issue, rather than one of security. Normally, the customer owns the data."

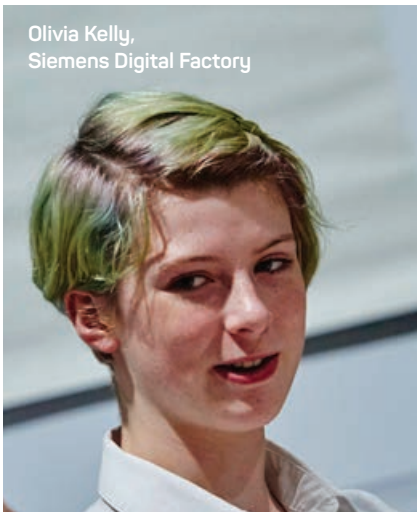
Bott: "We must not lump risk together in one basket. There have always been commercial risks in business. They are different to legal risks, such as data protection and cybersecurity. People who make the most money are the ones who get ahead of the curve."

Norbury: We use the cloud-based Mindsphere to store data – the answer is that the customer owns it. We offer a service to help SMEs to optimise their machines – it needs specialist algorithms. We have a legal arrangement with the customer, so after many years we agree to delete the data if they want us to."

Greenhough: "I can see the benefit of that, but the potential legal issues haven't been fully sorted out. We are diving Into Industry 4.0 before we have the management in place to handle it."

Strutt: "But we must accept that some commercial risks we will get wrong. It's a change of culture and not just for small companies - take a risk, try something; if it doesn't work, try something else."


David Preece,
FBC Manby Bowdler


Olivia Kelly,
Siemens Digital Factory


Tim Jones,
Siemens Digital Factory

Huertas: "We need to give tools to SMEs to recognise and identify the risks. The might say they are happy to take that risk."

Pye: Does digitisation favour manufacturing large or small volumes of product?

Tim Jones, Siemens: It depends on where you are coming from – all processes are different. With Industry 4.0, we can actually make anything on any line. It allows more flexibility – we can change the entire flow of the factory to just make one. The customer orders something on an app or smartphone. That's where we are going."

Walker: "At JLR, each individual vehicle is customised for each individual buyer. To do this with current systems is hugely complex – the smart factory will make it much easier for that size of operation to customise every vehicle. In the small business sector, it is more about the machinery – we are still stuck with press tool changeover times."

JOBS AND SKILLS

Payne: "I believe we are on the cusp on one of the biggest issues we have jobwise. The number of people that will become unemployed due to autonomous vehicles is phenomenal. While in Japan, there are restaurants that even have robots as waiters."

Bott: "This is true - if you look at record stores and bookshops, they are dead. There will be a lot of companies killed by the digitisation processes. It gives an opportunity to the people capable of embracing innovation and moving. But if you want to stay with handwritten ledgers, you will die."

Thomas: "We need to address the problem of how we safeguard work. People need to understand how to exploit automation successfully while measuring its effect on employment and how companies can prepare for that."

EDUCATION AND TRAINING

Greenhough: "We need to get into schools and teacher training colleges and train the people who are to fill the new jobs. Teachers now don't know what manufacturing is yet, they are teaching it to the next generation."

Brown: "We are seeing progress in JCBs and WMG academy. But rapid rate of change is always going to be important."

Norbury: "It is vital to support colleges, because the national curriculum isn't keeping up to speed with developments. Technology is changing at such a rate and we need to find a way of addressing that. Meanwhile, the disciplines of IT, gaming and engineering are merging."

Lawley: "IT is such a big part of it - more sub-level IT is needed – how to do coding and so on. Most colleges don't touch on this but just focus on Microsoft Office skills!"

Thomas: "Through the Siemens Junior Factory, our young engineers know a lot more about how the operational management side of the business runs than I did when I was a production engineer."

Olivia Kelly, Siemens: "I came out of education recently and am just 20 years old. I learned CAD at college. I know that in five years 50% of traditional jobs will be gone. But there will be a new set of people who will have Industry 4.0 skills, brought up with IPads and IPhones. So when we come into an engineering business we expect to see digitisation, and not handwritten ledgers.

"Younger people do have the skills, while older people are more fearful. I can put on an IPad on a machine and control it and they say 'Why can't we just push buttons on the machine instead?' A lot of it is trying to make them understand why we are doing it, then they realise that it's not a bad thing and they will not use their jobs.

"We decided within the Junior Factory to give real life engineering experience within our variable speed drive plant - full autonomy to manufacture that part - engage with the supply chain, employ somebody to make it. Yet Rachel and I have not touched any PLC or coding. By being MD and FD we have learned new skills and want to push it into Industry 4.0.

Our generation is really interested in it!"

Andy Pye: And on that optimistic note, I'd like to thank everyone for their valuable time and continue our discussions over dinner. MR

For a full transcript of this debate please go to http://www.ukmanufacturingreview.com/2016/roundtables

AUTOMATION & ROBOTICS

AUTOMATION – UK IN THE SLOW LANE

The Internet of Things (IoT) is making the modern plant a hive of automated data transfer, facilitating lean manufacturing, quicker decision-making and smarter maintenance regimes. But Britain is lagging competitors overseas. Andy Pye reports

THIS ARTICLE EXPLAINS:

- German industry is ahead of other countries when it comes to IoT
- Penetration of automation in British manufacturing relatively low
- Robotic workforce poised for dramatic growth
- Many UK manufacturers yet to understand Industry 4.0

At the last SPS, the German automation show held every autumn in Nuremberg, it was easy to believe that the Internet of Things – otherwise known as Industry 4.0, or the IoT – is thriving. But while German industry is well advanced and prepared, and SPS was bulging with IoT-ready technology, in the UK it is generally being viewed with a mixture of excitement, and trepidation.

Industry 4.0 emphasises the idea of consistent digitisation and linking of all productive units in an economy. Based on new and radically changed processes in manufacturing companies, data is gathered from suppliers, customers and the manufacturing company itself and linked up with real production. Integrated networks of sensors coupled with actuators, data federation, big-data analytics, and fast autonomous decision-making will change the world.

Today, there are some daunting technical problems to overcome, among them incompatible front-end device connection protocols, the management of billions of intelligent endpoints, low-cost/low-volume data transmission options, security issues and business models. But all these technical and business problems are solvable and companies already exist with solutions.

GERMANY IN THE LEAD

In stark contrast, and coinciding with the third and final day of SPS, an event entitled 'From Industry 4.0 to Digitising Manufacturing – an End-User Perspective' took place in pre-Brexit Britain at

Industry 4.0 relies on automation with data capture. In Europe, Germany is leading the pack

Photo courtesy of FANUC

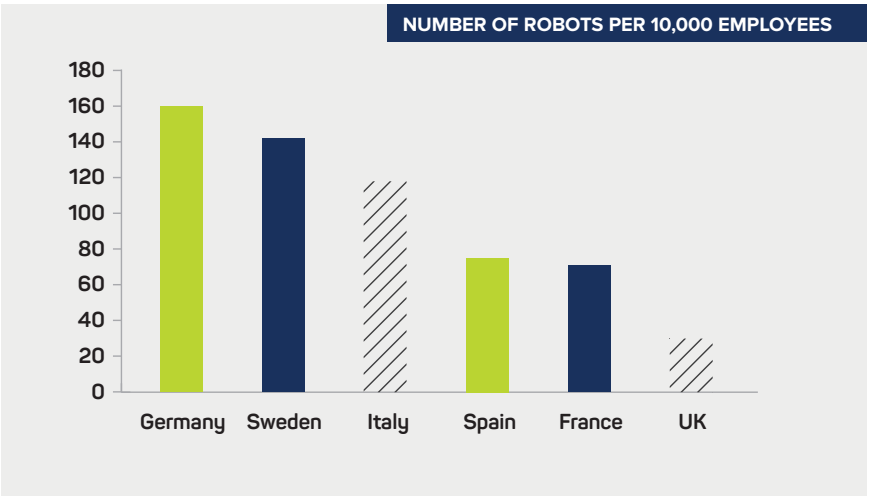
BIG DATA MEANS BIG ENERGY USAGE

A new report by Mark Mills – the CEO of the technology and investment advisory firm Digital Power Group – claims that a medium-sized refrigerator uses about 322kWh a year. The average iPhone, according to Mills's calculations, uses about 361kWh a year, once the wireless connections, data usage and battery charging are tallied up.

Perhaps of even more concern is the growth of remote digital sensors and devices that are being connected to the internet under Industry 4.0. This, according to Lancaster University researchers, has the potential to bring virtually unlimited increases in energy consumed by smart technologies. There is autonomous streaming of data by 6.4 billion connected IoT devices – and it is estimated the number could reach 21 billion by 2020.

"The internet is consuming an increasing portion of global electricity supply, and this growing consumption is a significant concern in global efforts to reduce carbon emissions," says Dr Mike Hazas, senior lecturer in the university's School of Computing and Communications.

As our lives migrate progressively to the digital cloud — and as more and more wireless devices of all sorts become part of our lives — the electrons will follow. And that shift underscores how challenging it will be to reduce electricity use and carbon emissions even as we become more efficient.



Source: IFR World Robotics 2015

the Lloyds Bank Advanced Manufacturing Training Centre on the MTC campus at Ansty Park, Coventry. About 150 European engineers, business people and academics heard how digitised factories will be developed in Britain and across the world, in a more collaborative, connected way.

Given the leading position adopted by Germany, it was fitting that the opening address was given by Dr Peter Ammon, the German Ambassador to the UK. Ammon says that manufacturing accounts for 22% of GDP in Germany, employs 15 million people, and is a major driver of her exports, but that Germany could not rest on its laurels. "Making digital information and communication technology usable for industry will be key to maintaining our competitiveness internationally. 80% of German businesses think their value chain will be substantially digitised by 2020," he said at the MTC event.

But according to The MTC's Dr Lina Huertas, many UK manufacturers are failing to see the same business benefits: "Many manufacturers in the UK don't know what Industry 4.0 means, or understand its potential impact on industry, and they don't know how to respond to the technological implications," she argues. "The conversation has been dominated by the technology and software providers and the manufacturers feel they have been left out. They don't see the benefits, they fear the risks, and they don't know who to turn to for reliable information and support."

Anne-Marie Sasson from DG Connect highlights an Industry 4.0 'readiness index'. Countries are divided into four groups, with Germany shining as a frontrunner, along with Ireland, Sweden and Austria. The UK falls into the 'Potentialists' group, along with Norway, Netherlands, Denmark, Belgium and France.

ROBOTICS AT THE READY

For decades, robots have performed a multitude of pick and place functions in many industries that would have previously been filled less efficiently by human workers, even outside traditional


Photo courtesy of Harmonic Drive AG

Robots that work alongside human beings – cobots – are the latest trend in automation technology


Photo courtesy of ABB

There are almost 17,000 robots in the UK – dispersed around 5,000 active sites

ROBOTS IN BRITAIN


Photo courtesy of ABB

According to the *IFR World Robotics Report 2016*, there are 16,935 robots in the UK, dispersed around 5,000 active user sites. There are 1,200 large UK manufacturing companies and 87,000 SMEs – between 10,000 and 20,000 of these are potential candidates for robotic automation and/or Industry 4.0, according to the report.

The 2015 Barclays report *'Future-proofing UK Manufacturing'* estimates that a modest investment of £1.24 billion in automation would raise the value added to the UK economy of the manufacturing sector by a whopping £60.5 billion. In turn, this would be expected to generate around 33,000 manufacturing jobs by 2020 and 73,000 by 2025.

Of course, the jobs would be of a different nature to those replaced, perhaps with more for computer analysts than shopfloor workers. Dean Phipps, ABB Robotics' service sales and training manager – UK and Ireland, agrees: "Of 1,000 people who attend our courses each year, the most popular courses are those aimed at upskilling shopfloor workers," he says.

application areas, such as the automotive industry.

According to Harold L Sirkin, Michael Zinser, and Justin Rose, robotics use is reaching the takeoff point in many sectors. The share of tasks that are performed by robots will rise from a global average of around 10 per cent across all manufacturing industries today to around 25 per cent by 2025. Big improvements in the cost and performance of robotics systems will be the catalysts. In several industries, the cost and capabilities of advanced robots have already launched rapid adoption.

By 2019, more than 1.4 million new industrial robots will be installed in factories around the world – that's the latest forecast from the International Federation of Robotics (IFR). In the race for automation in manufacturing, the European Union is currently one of the global frontrunners: 65 percent of countries with an above-average number of industrial robots per 10,000 employees are located in the EU. The strongest growth drivers for the robotics industry are found in China; however, in 2019 some 40 per cent of the worldwide market volume of industrial robots will be sold there alone.

The number of industrial robots deployed worldwide will increase to around 2.6 million units by 2019. That's about one million units more than in the record-breaking year of 2015. Broken down according to sectors, around 70 per cent of industrial robots are currently at work in the automotive, electrical/electronics and metal and machinery industry segments. In 2015, the strongest growth in the number of operational units recorded here was registered in the electronics industry, which boasted a rise of 18 per cent. The metal industry posted an increase of 16 per cent, with the automotive sector growing by 10 percent.

The strongest growth figures in Europe are being posted by the central and eastern European states – the rise in sales was about 25 per cent in 2015. The biggest climbers in sales of industrial robots are the Czech Republic and Poland.

In a worldwide comparison, the European Union member states as a whole are particularly far advanced in terms of automation. Half of the top 10 nations with the most industrial robots per 10,000 employees belong to the European Union. The robot density in the big western European economies is still currently ahead of up-and-coming

China. The largest gap in this respect is with Germany – but the smallest is between the UK and China.

In the last 12 months there has been a noticeable uptake in robotics in the UK food processing sector. Although way behind the rest of the EU and US markets in terms of sales, global food security, volatile commodity prices and the much reported grocery price wars are all driving manufacturers towards the same conclusion; efficiency is paramount and introducing robotics provides that all-important competitive edge.

According to Mike Wilson, sales and marketing manager – general industry UK & Ireland at ABB Robotics, further uptake in robotics in the UK requires three factors to be addressed: "We need to bridge the skills gap by implementing more training; make robots easier to operate, maintain, supervise and own; and make the economic case for robotic automation more persuasively."

There is a steady move towards standardisation in the way information on food and drink packaging is presented, supplemented by legislation to ensure absolute traceability through the supply chain. The European Food Information to Consumers Regulation No 1169/2011 (FIC) brings together EU rules on general food labelling and nutrition labelling into one piece of legislation.

The majority of the requirements of the new legislation applied to pre-packed foods from December 2014, and mandatory nutrition declarations for most pre-packed foods came into force December 2016. New rules on country of origin information for meat from sheep, pigs, goats and poultry have applied from April 2015. Topics covered by these regulations include dates of freezing of meat, compositional standards for minced meat, water content, caffeine content and even font sizes for labelling.

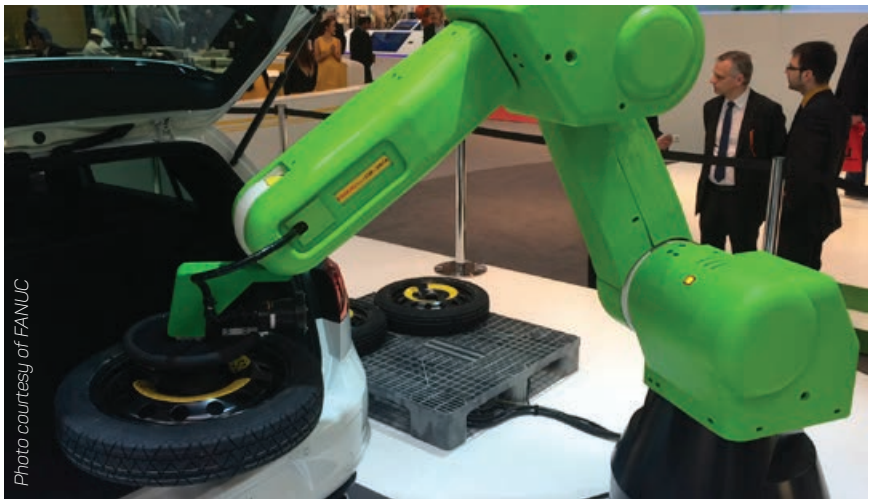
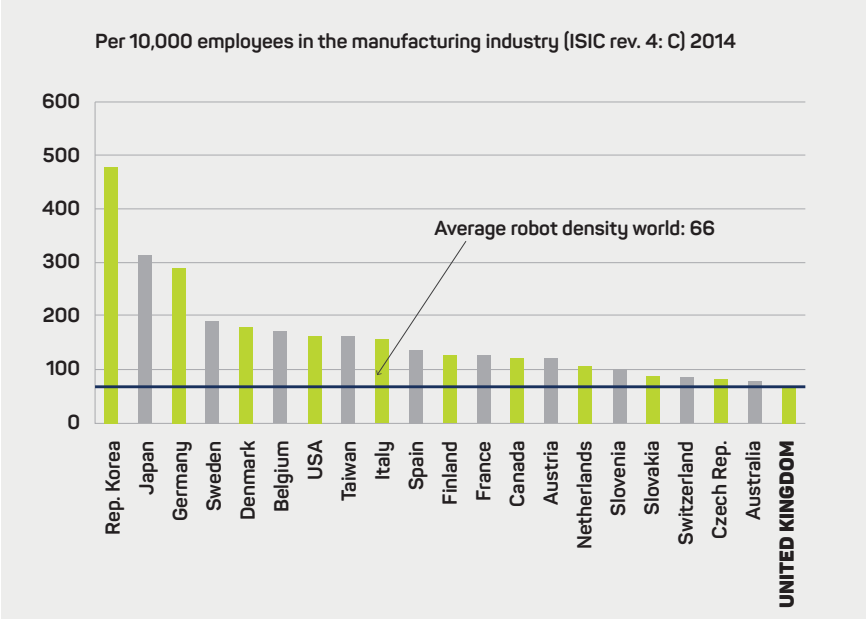


Photo courtesy of FANUC

Traditionally the automotive industry has led the large-scale use of robots

NUMBER OF MULTIPURPOSE INDUSTRIAL ROBOTS (ALL TYPES)



Source: IFR World Robotics 2015

AUTOMATION PROVIDES PERSONALISATION

Traditionally, we view automation as a means of making high volume manufacturing processes more efficient, with production lines running fast and efficiently with minimal human intervention.

But automation also provides the flexibility that is needed to progressively reduce product batch numbers down to the smallest levels, and ultimately to a single unit – reaching the utopian goal of product personalisation. This idea of using serialised, code-based sorting by robots to customise a product range down to a batch number of a single item, specifically aimed at a particular customer, depends crucially on the quick changeover capability that automation provides.

The demands of highly regulated market sectors, such as pharmaceuticals, medical devices - and increasingly, the food industry - are particularly well served by this approach: automated systems can also manage shape recognition, in-factory quality measurements prior to packaging, and check that the right pack and the right label are married with the product itself. Serialisation codes make it possible to track and trace products from the beginning of a process through to the end.

Dennis Verhoeven, European industrial market manager, life science, at Omron, believes this is increasingly important in the food and beverage industry. "Such flexibility is essential in the face of evolving consumer preferences – new tastes are arising due to health consciousness and cost. We now have organic, gluten-free, sugar-free, low-fat, high-fibre, low-sodium and caffeine-free variants of many products. Food firms and retailers demand a broadening range of portion sizes and packaging formats," he says.

"At the same time, consumers are demanding more information about the origin and content of products. This is reflected not just in sell-by and use-by dates, but in information on allergens, nutritional values, producer details and country of origin, to name a few."

ENERGY STORAGE POISED FOR RAPID GROWTH

ENERGY STORAGE

2016 was a key year in the development of Britain's energy storage industry. Industry participants hope that progress will not now be stalled by Brexit. Jane Gray reports

In October 2016, RedT, a UK manufacturer of vanadium flow batteries, completed the installation and commissioning of a 1.69 MWh system on the isle of Gigha. Here, RedT team members celebrate completion of system testing at the Power Networks Demonstration Centre, Glasgow

THIS ARTICLE EXPLAINS:

- Energy storage poised for rapid growth
- Market reform process stalled by Brexit
- Pressure on government to remove barriers
- British storage firms attracting investment
- Storage firms line up to provide frequency response

There's no doubt 2016 has been a formative year for the energy storage industry, in the UK and internationally.

The cost of key technologies has continued to tumble, investment has grown and deployments have moved forwards as, around the globe, nations and communities realise just how valuable this technology can be in enabling decarbonisation of energy.

Perhaps most critically in the UK, 2016 has seen the signing of landmark commercial contracts for storage services to National Grid. It has also brought long-awaited commitments from government to review market and regulatory barriers to storage deployment, potentially making way for much greater market growth in the near future.

PRESSURE MOUNTING ON GOVERNMENT

Pressure had been mounting for a few years for UK government to acknowledge the various quirks of energy market regulation which obstruct the sustainable commercialisation of energy storage. As technology providers became more confident about the maturity of their products and the significant role they could play in enabling decarbonisation, so their frustration with issues which undermine the economics of storage deployment – like double charging for grid connections because storage is classified as both a generator and system 'user' – grew.

In January 2016 the legitimacy of these complaints was backed up by a key report from the National Infrastructure Commission. The Smart Power report set out a vision for the delivery of flexible low carbon electricity in the UK and recommended that government and the energy regulator, Ofgem, work swiftly to enable three key areas, including Interconnection, demand-side response, and energy storage.

A clear roadmap for deployment of all of these will be essential if the UK is to meet its national climate change mitigation goals in a way which also supports prosperity, said the report.

Government accepted the weight which Smart Power added to an already vociferous energy storage lobby. It committed to investigating current market barriers and to consulting with industry on way in which these might be altered or removed in a way which does not err towards 'picking winners'. In line with the NIC's recommendations, the Department for Energy and Climate Change (Decc) assured that these activities would be completed by the end of the year with a view to publishing a definitive list of market reforms in the spring of 2017.

THEN CAME BREXIT

But then came Brexit. Following the June vote for the UK to leave the EU, Decc was abolished and merged into a newly formed Department for Business, Energy and Industrial Strategy.

The inevitable consequence of this action – about which the energy industry was broadly optimistic due to its scope for enabling energy policy which joins up with national economic ambitions – was that the market reform process for storage stalled.

Months behind schedule, the smart systems consultation – including issues relating to energy storage – launched in early November and included government's thoughts on how to address barriers to deployment including; methods for connecting to the grid and associated market arrangements (i.e. contracts for balancing services to the grid); system charging rules; the need for a new and separate license type for storage (defining it as distinct from both generator and users); and consumption levies (which cause similar issues to double system charges).

The consultation also shared thinking around whether Distribution Network Operators – which operate under regulated monopolies and are currently barred from owning certain asset types – should be allowed to own and operate energy storage.

STOP PRESS:

While at the printers with UKMR, researchers at the University of Surrey announced the discovery of new materials for an alternative to battery power, proven to be between 1,000-10,000 times more powerful than the existing battery alternative – a supercapacitor. The new technology is believed to have the potential for electric cars to travel to similar distances as petrol cars without the need to stop for lengthy re-charging breaks of between 6-8 hours, and instead re-charge fully in the time it takes to fill a regular car with petrol.

TIME TO ACT SWIFTLY ON STORAGE

The challenge for government now will be act swiftly on industry responses to its call for evidence. Philip Graham, chief executive of the NIC, says that he wants BEIS to stick to its deadline of spring 2017 for publication of storage market reforms, despite this summer's disruption. He says there is "no point in looking backwards" and urges the department to "stay within the timescale it set" by picking up "acceleration and pace". Graham adds that resolving issues on storage and demand flexibility – another smart systems consultation focus point – is "crucial" if these are to compete "on a level playing field" with other methods of generation and system balancing.

Crucial though these reforms may be however, the storage industry has not stood still while waiting for government and regulator interventions. 2016 has seen some major technology and application announcements, proving investor and market appetite for a range of storage solutions at both domestic and grid levels.

On the domestic front, for instance, British storage manufacturer Powervault announced in May that it had smashed its target to raise £750,000 via crowdfunding to support commercialisation of its solar PV compatible storage system. Investors poured in almost £1.5 million. Meanwhile, Moixa – another leading UK provider of domestic energy storage – also had a strong year. In June, it announced a new partnership to pilot its systems with 47 of Scottish Power's energy customers and in October, it launched a bullish new product which offers consumers the chance to buy and install a 2kWh smart battery, combined with a 2Kw solar PV system for a total cost of £4,995 – a competitive price point.

Another key development for consumer-facing energy storage propositions in 2016 has been the splurge of announcements from automotive manufacturers that they too are building storage business models. These include plans to give old EV batteries a second life as domestic – or commercial – energy storage installations, but also to develop 'vehicle-to-grid' energy storage offerings which turn electric cars into mobile storage and demand response units.

The first car maker to come out with a strong energy storage proposition this year was Nissan, which announced its intentions in London in May. It said then that it expects to shift more than 100,000 of its xStorage units – made from repurposed EV batteries – within the next five years as consumer appetite grows and first early generation EVs come to the end of their expected life on the road.

For companies with aspirations to provide storage services at grid level, the biggest event of 2016 was National Grid's tender for 200MW of enhanced frequency response (EFR). Nominally a 'technology neutral' tender, it was enormously oversubscribed with bids from hopeful energy storage providers. It ended in awarding eight contracts worth almost £66 million to seven companies, all energy storage providers, including EDF Energy Renewables, Vattenfall, Element Power, and Belectric.

This success provided a major confidence boost to the market and showed that the grid's system operator is willing to engage with energy storage for the provision of essential balancing services. However, while industry commentators universally welcomed the EFR contracts, many were also swift to point out that a boost for seven companies is not enough to provide certainty for an entire market. Additionally, BEIS' head of energy storage, Rachel Cooper, said at an event in September that she was unsure whether the contracts would prove profitable. The prices awarded by National Grid were "lower perhaps than we were expecting to see," she observed.

2016 has laid the foundations for assertive growth in the UK's energy storage market and seen providers of many shapes and sizes begin to express ambitious plans. Delivering on these now depends on some swift government action to eradicate "undue barriers" to commercialisation. There is also need for enhanced communication between new technology providers and incumbent energy system operators at both transmission and distribution levels. MR

ENERGY STORAGE: 2016 TIMELINE

JANUARY: Publication of the National Infrastructure Commission's Smart Power report. It found that widespread deployment of energy storage is one of three key components in the future of low carbon, reliable power

MAY: Nissan announces its intention to enter the energy storage market with a post-EV life domestic energy storage proposition and a 'vehicle to grid' storage offering

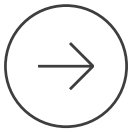
JULY: Department for Energy and Climate Change axed post-Brexit vote. Consultations on removing barriers to storage stall with the creation of the new Department for Business, Energy and Industrial Strategy

AUGUST: National Grid agrees eight contracts for Enhanced Frequency Response, all with energy storage companies. The contracts are worth £65.95 million in total

SEPTEMBER: Camborne Energy Storage confirms the first installation of Tesla's grid scale energy storage offering in Europe will be in Somerset, UK. The 1MW battery will be coupled with a solar PV site

OCTOBER: BEIS and Ofgem launch smart systems consultation (behind schedule due to post-EU referendum departmental reform) including proposals to remove "undue barriers" to storage deployment)

Read more about energy on pages:



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WMG
THE UNIVERSITY OF WARWICK

THE ELECTRIC REVOLUTION ROLLS ON

WMG's Energy Innovation Centre is one of the resources available to automotive manufacturers and suppliers in Britain looking to drive the electrification of powertrains. By Professor Dave Greenwood

THIS ARTICLE EXPLAINS:

- EV manufacturers need lighter, cheaper, safer vehicles
- WMG at the forefront of EV research
- Battery costs must come down
- Energy Innovation Centre researching battery improvements
- UK well-placed to take advantage of technology breakthroughs

Are we any closer to electric vehicles transforming the automotive industry? It may seem a simple question to ask, but it is something both the major OEMs, and their supply chain, are still working on – and not something they can solve by themselves.

In order to manufacture electric cars that will appeal to a mass market, rather than a niche one, automotive manufacturers need to research how to make their products lighter, affordable and safe. Not an easy task, and one which requires considerable investment in R&D. Both the government and the automotive manufacturers are investing in projects to research the materials, manufacturing processes and product design necessary to deliver an attractive and profitable product.

Over the last few years, and this year particularly, the sector has moved more quickly than anticipated towards electrified powertrains. Automotive manufacturers still have their core product lines, but as we've seen from the recent announcements of Jaguar Land Rover, manufacturers increasingly see EVs as a future part of their product portfolio.

At the forefront of EV research is WMG, which is working collaboratively with many automotive manufacturers, and their supply chains, to solve the current, and future, technological challenges that exist within the EV industry.

Through their Energy Innovation Centre, experts are researching how they can reduce the cost of batteries as well as how to get more range. The Centre, which has multiple funding streams, focuses on low carbon mobility seeking to understand how design, materials and manufacturing processes work together on such things as performance and cost.

ONE STOP SHOP FOR BATTERY CHEMISTRY

This leading facility is a one-stop-shop for battery chemistry and materials, cell manufacture, module and pack manufacture, which has benefited from a number of government and industry-funded research programmes this year. Working with Jaguar Land Rover, Nissan and stakeholders from across the supply chain, the challenges facing battery development are being explored.

Another challenge for the sector being addressed by WMG and industry, is that of delivering electric motor and power electronics which are suitable for the increasing electrification and hybridisation of all vehicle types. Currently the major challenges for industry include the cost and power density of electrified powertrains compared to conventional engine choices; the need for improved integration of electrical and electronic components into system architectures; and the ability to manufacture components in sufficient, cost-effective quantities, while maintaining essential levels of quality, performance, robustness and safety.

"All major automotive manufacturers now have EV products in market, or in late stages of development. For the UK, with our expertise in these technologies, this represents a bright opportunity. With consistent government support, and help from WMG, manufacturers and supply chain companies are well placed to scale-up for the challenge"

Professor Dave Greenwood

But it's not just cars experts at WMG are researching: they are also working on R&D projects looking at electric motorcycles, marine vessels, off-highway vehicles, buses, trains and sportscars, as well as considering how energy storage can be connected to domestic, industrial and grid scale energy systems.

So what does the future landscape look like for EVs? It's definitely looking bright for EV production, with sales doubling year on year in many markets.

All major automotive manufacturers now have EV products in market, or in late stages of development. For the UK, with our expertise in these technologies, this represents a bright opportunity. With consistent government support, and help from WMG, manufacturers and supply chain companies are well placed to scale-up for the challenge. MR

WMG'S ELECTRIFYING VISION FOR AUTOMOTIVE

Warwick Manufacturing Group sees Coventry as Britain's own Motor City – and is carrying out world-class automotive research and development to match. By Professor Lord Bhattacharyya, Kt, CBE, FReng, FRS

WMG, at the University of Warwick, is supporting manufacturing research with a special focus on automotive. This is where we see the most growth coming in manufacturing industry in the short-to-medium term. Having enticed Tata to come and buy Jaguar Land Rover (JLR), it is in our interests that the company succeeds, and succeeds well. Automotive manufacturing remains one of the biggest manufacturing sectors in this country. We have to have a strategy to succeed and grow, which is why I've said that 10,000 new jobs should be created in the West Midlands automotive sector.

We are investing in R&D and skills, and ensuring that youngsters are being trained for the future manufacturing industry. We want to make Coventry the Smart Motor City of the UK. We have already created employment for about 10,000 by increasing the footprint of JLR's R&D and manufacturing activities. We are now discussing producing electric batteries here, which are needed for full-scale manufacture of electric vehicles. This is not random activity – it is thought out via our Energy Innovation Centre. We will have types of products coming through in the future that require different methods of design and fabrication. We have to rethink car design. The Energy Innovation Centre is leading this, as well as the National Automotive Innovation Centre.

We must ensure that not only car companies, but SMEs, are using this technology. At WMG, we focus on helping the SMEs, often free of charge. We are trying to help them and advise the smaller companies, especially in the West Midlands. We have our Advanced Steels Research Centre, opened this year, because if you are going to develop lighter vehicles you need new types of thin steel, and coated steels. You have to know how to fabricate these thin types of steel, and how to develop them via different suppliers, combining them with composites and reinforced polymers – and not just doing it in the laboratory.

People say, 'Isn't this just university research?' But when I develop these initiatives, there is a purpose to it. People ask, 'Where is the contribution to the economy, where is the job creation?' From day one, when I started WMG, my purpose and my mission has been to make an impact in terms of job creation. The economic impact those jobs generate for a region and for the country is substantial.

For the National Automotive Innovation Centre, the total investment is about £1 billion. The building alone is £300 million. These are state-of-the-art facilities and the largest of its kind in Europe. Everyone says, look what is happening in Germany, look what is happening in the US. I can tell you, once this centre is finished, it will be the best in the world. We are going to do state-of-the-art research where industry and academia will work side by side. Unless you have a facility like that, people will not believe in you. We are designing new types of cars. Future cars will be totally lightweight, whether they are hybrid or electric. If you look at cars today, nothing has fundamentally changed. But now we are at a crossroads where everything will change when we talk about hybrid and electric, and CO_2 is the big issue.

If Britain is to export, we have to be right at the frontier. On the first day of the new government, industrial strategy was enshrined in the title of the business department. Britain is a small country and we cannot do the strategy piecemeal. We have to make sure productivity improves, but it is not rocket science. There must be the energy, and the infrastructure and skills must be in place. The industrial strategy is not just saying, 'We'll give you money' – it is giving companies the skills and infrastructure they need to succeed, for the benefit of the UK as a whole. At WMG we are playing an important role in this. MR

"Everyone says, look what is happening in Germany, look what is happening in the US. I can tell you, once the National Automotive Innovation Centre is finished, it will be the best in the world. We are going to do state-of-the-art research where industry and academia will work side by side"

GILKES DISCOVERS POWER OF SIMULATION

Hydro power and pump company transforms design process through the use of ANSYS simulation software

Gilbert Gilkes & Gordon is a leading manufacturing group serving both the power generation and engine industries. Gilkes Hydro is a global leader in hydro power systems, with more than 6,700 turbines installed in more than 80 countries. Gilkes Pumping Systems manufactures a range of sophisticated pumps for the cooling of high-horsepower diesel engines, supplying many of the world's top diesel engine manufacturers.

With a stable of proven product designs, Gilkes has led the global market in small hydropower systems and engine cooling pumps for many years. However, in 2013, executives recognised that, to maintain leadership, product innovation was needed.

Pump and hydro firm Gilkes has revamped its manufacturing via simulation

IN BRIEF

- Product innovation helps firm maintain lead
- Engine and engine components face tough emissions standards
- CFD simulation drive fast design at Gilkes
- Engineer champions new computer tools
- Teams now regularly use ANSYS software

REGULATION + COMPETITION = INNOVATION

Increasing environmental regulations, coupled with government incentives for green products and systems, have created dramatic changes for engineering teams. The rise of water and solar power created a fast-growing market and a new set of customer needs. Product development teams focusing on engines or engine components faced stricter emissions standards, as well as weight restrictions that support greater fuel efficiency.

Elsewhere, government subsidies for renewable energy became a catalyst for the global market for hydro-turbines. In addition, increasing environmental awareness meant new regulatory standards for diesel engines. Across both market segments, Gilkes had to move quickly to develop innovative designs that capitalised on these opportunities. This necessitated the use of computational fluid dynamics (CFD) engineering simulation tools to drive fast design and market launch of new products.

"We had dabbled in engineering simulation in the past, but not really committed to it as a central strategy to support our product innovation," explains Alan Robinson, research and development manager for Gilkes hydro-turbines. "The engineering team responded with a proposal to create an in-house simulation capability because we recognised that simulation could become a key competitive edge."

FINDING A CHAMPION

In 2013, Jo Scott was hired as an experienced CFD engineer for Gilkes' hydro-turbines business. Scott rapidly became the champion of simulation within both Gilkes business units.

"Our first lesson was to choose the software carefully," notes Scott. "We realised that CFD simulation was a requirement for both businesses, but that the pumps engineering team also needed to do finite element analysis (FEA) to ensure structural robustness. There were many levels of FEA analysis tools, so we had to match the solution to our day-to-day challenges."

Scott also quickly realised that the best strategy was to leverage the expert training provided by ANSYS. "It simply wasn't time and cost-efficient to have me manage the internal development," says Scott. "So we had a team of people attend formal software training, to get a core group of users up and running."

The adoption of engineering simulation was embraced by many employees, eager to learn leading-edge skills. "Our engineers had been doing a lot of complex calculations and design work using more traditional methods, so they were extremely enthusiastic about having new software do the work for them," says Robinson. "They wanted to get up to speed on the latest practices."

While the change was welcome, Robinson notes that it was challenging from a cultural standpoint. "We've installed a modular process in which people have different roles and different areas of expertise. We have specialists at every stage, including our CFD and FEA experts. We've changed our processes and re-aligned employees' roles to fully adopt simulation as a core competency.

"It was helpful that everyone recognized the need to change," added Robinson. "We realised that our efficiencies had to improve, and everyone recognised that we had to do things differently. I would advise other businesses to share the top-level vision with their engineers, because that certainly helped us overcome any cultural resistance."

LAUNCHING A NEW ERA

In just three short years, Gilkes has gone from having no internal simulation capability to having 10 engineers regularly using ANSYS software. The company is now looking into the creation of a high-performance computing (HPC) cluster to manage large simulations and make its analysis capabilities even more powerful.

"Engineering simulation now forms the basis of a strategy of analysis that is being used to promote intelligent, blue-sky design thinking, where we continually assess and develop our designs," says Robinson. "We are now seeing a return on that investment due to winning more contracts because we can produce innovative designs more quickly and cost-effectively. We believe that simulation has made a real difference already — and that it is positioning Gilkes for a new era of success." MR

EPSRC is strongly backing the emerging field of quantum technologies to develop new devices

TIME FOR QUANTUM TECHNOLOGY

EPSRC provides millions in support to the emerging field of quantum technologies as new previously unimaginable products and systems are developed

IN BRIEF

- Quantum technologies harness quantum physics for otherwise unattainable performance
- Many existing technologies rely on quantum effects including lasers and microprocessors
- Emerging technologies mean the manipulation of individual atoms, electrons and other particles
- EPSRC providing millions in support for quantum technologies
- Applications include quantum communications to provide very high security for transmitting sensitive data and quantum clocks and sensors

Quantum theory was one of the most significant scientific breakthroughs of the 20th century and has led to the development of some of today's most widely-used and lucrative technologies. Our understanding of the way light and matter behave at a fundamental level helped develop the flash memory on our mobile phones and computers, the superconductors in our MRI machines, the lasers in our barcode scanners – and the LEDs in our screens.

Now it is developing into new and exciting areas, with next generation quantum technologies moving beyond the exploitation of naturally-occurring quantum effects. This is leading to the creation of a plethora of new devices and systems that would previously have been considered impossible; they range from entirely new methods of computing that can solve the previously unsolvable, to powerful medical imaging devices.

UK PLACED TO BE QUANTUM TECH LEADER

The UK is ideally placed to emerge as a global leader in a new quantum revolution, and this could translate to major improvements within the manufacturing sector as use of the technology moves from specialist equipment used by scientists to mass-produced products.

EPSRC is supporting the continuation of this technological revolution by delivering the UK National Quantum Technologies Programme alongside the Department for Business, Energy and Industrial Strategy, Innovate MR, the National Physical Laboratory, Government Communications Headquarters, the Defence Science and Technology Laboratory and the Knowledge Transfer Network.

Supported by a £270 million Government investment, the national network of four Quantum Technology Hubs are accelerating the development of the technology and are closely linked to funding for industry-led projects, providing an easy entry point for companies interested in unlocking the potential of emerging quantum technology markets.

The UK National Quantum Technology Hub in Sensors and Metrology has incorporated the universities of Birmingham, Glasgow, Nottingham, Southampton, Strathclyde and Sussex and is developing quantum sensor and measurement technologies that could have wide implications across sectors and fields such as defence, construction, health and archaeology.

Led by the University of Glasgow and incorporating the universities of Bristol, Edinburgh, Heriot-Watt, Oxford and Strathclyde, the Quantum Technology Hub in Quantum Enhanced Imaging (QuantIC) is focusing in pioneering a range of multi-dimensional cameras based on quantum principles to create a new UK industrial landscape for imaging systems and their applications, which include the automotive and oil and gas industries; life sciences and pharmaceuticals; and general manufacturing through process control systems incorporating multispectral cameras.

NETWORKED QUANTUM INFORMATION TECHNOLOGIES

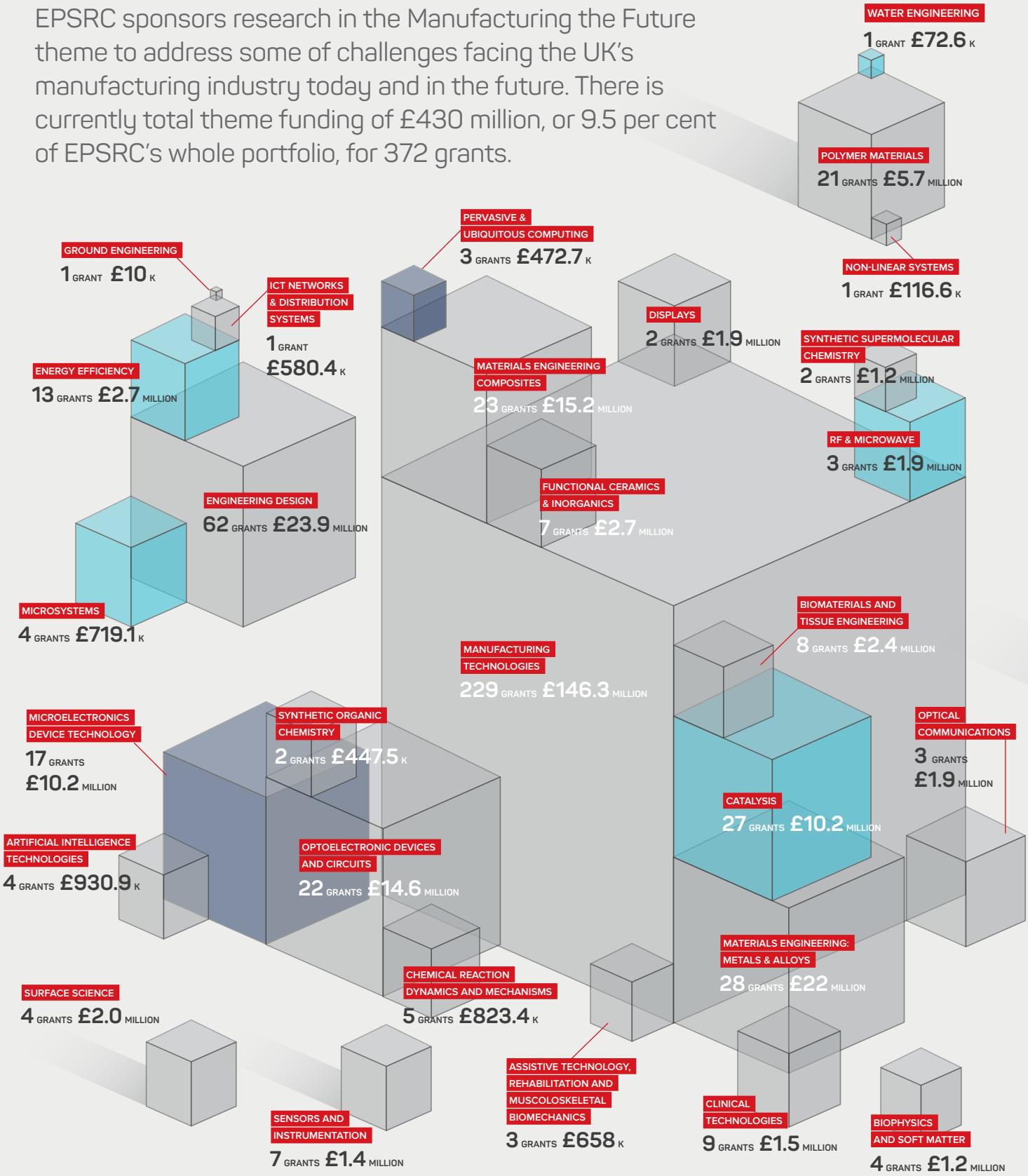
At the Networked Quantum Information Technologies hub (NQIT) led by the University of Oxford and incorporating the universities of Bath, Cambridge, Edinburgh, Leeds, Southampton, Strathclyde, Sussex and Warwick, researchers are working on networked quantum information technologies able to carry out complex tasks that are beyond even the most powerful of today's supercomputers. The flagship project is the Q20:20 quantum engine, which could put the UK at the forefront of quantum computing and simulation.

And the Quantum Communications Hub led by the University of York and including the universities of Bristol, Cambridge, Heriot-Watt, Leeds, Royal Holloway, Sheffield and Strathclyde, is exploiting the fundamental laws of quantum physics for the development of secure communications technologies and services.

Work taking place at the hubs and in the wider development of quantum technology presents a major opportunity for the manufacturing sector as our ability to harness quantum for practical applications increases, and the programme accelerates the development of equipment such as robust, reliable, small and low-power lasers, optical components and ion traps. MR

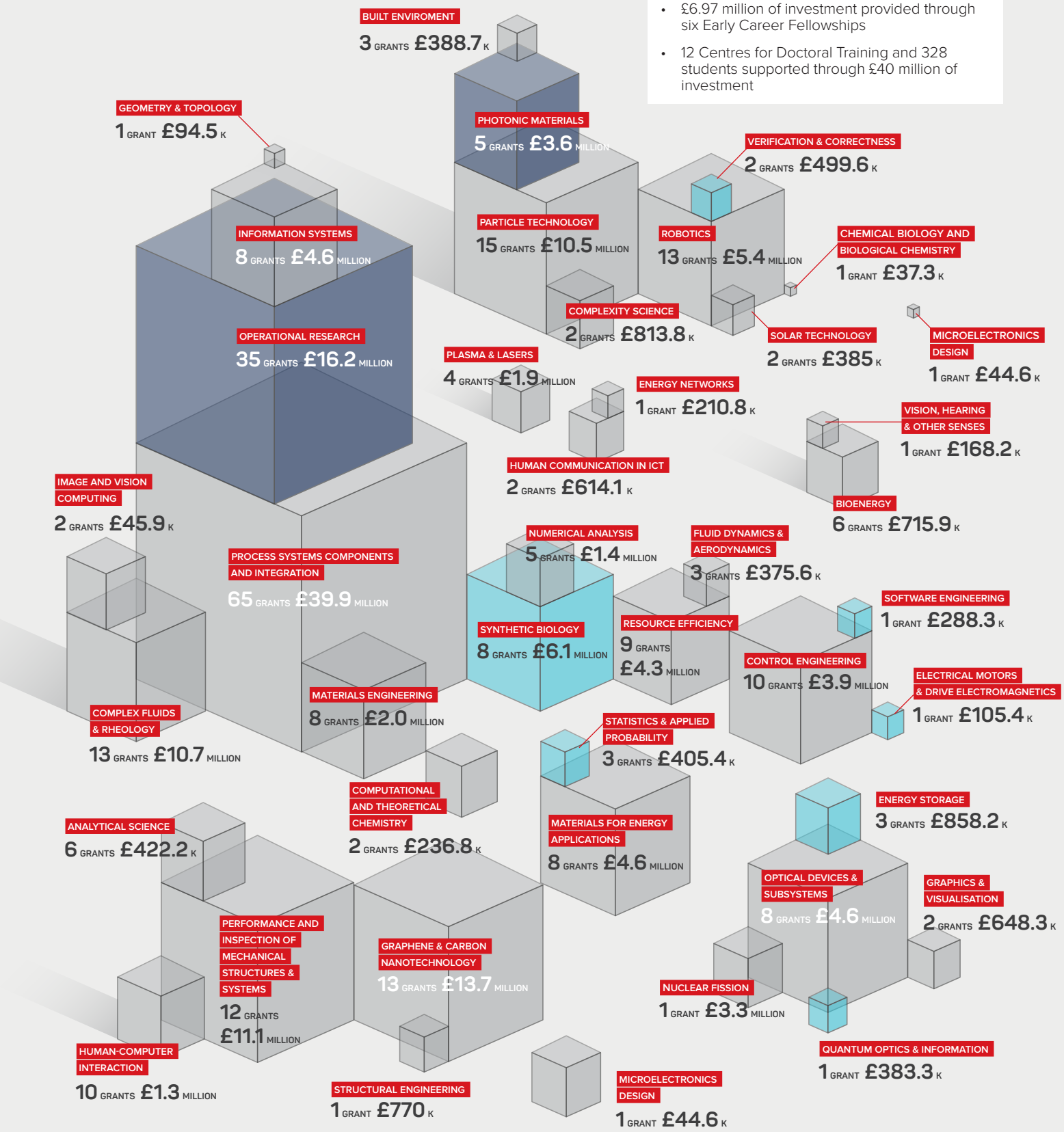
MANUFACTURING THE FUTURE WITH THE EPSRC

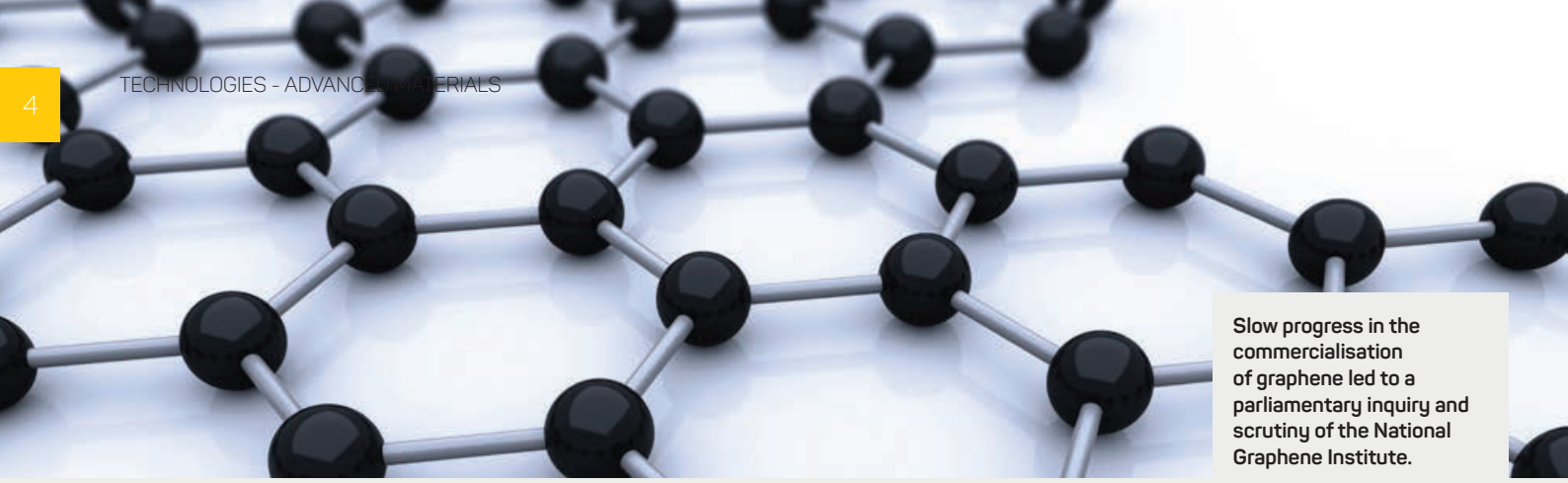
EPSRC sponsors research in the Manufacturing the Future theme to address some of challenges facing the UK's manufacturing industry today and in the future. There is currently total theme funding of £430 million, or 9.5 per cent of EPSRC's whole portfolio, for 372 grants.



EPSRC INVESTS:

- £20 million of investment provided through 18 Manufacturing Fellowships designed to provide a mechanism to bring senior figures working in industrial research into an academic research environment.
- £6.97 million of investment provided through six Early Career Fellowships
- 12 Centres for Doctoral Training and 328 students supported through £40 million of investment





Slow progress in the commercialisation of graphene led to a parliamentary inquiry and scrutiny of the National Graphene Institute.

COMPANIES MUST CATCH UP WITH RESEARCH TO MAXIMISE MATERIAL BENEFITS

THIS ARTICLE EXPLAINS:

- **UK has dynamic advanced materials research base**
- **A number of new centres of excellence have been set up**
- **2016 was 'prolific' for advanced materials research**
- **HEFCE seeks clear impact on training and upskilling of the workforce**

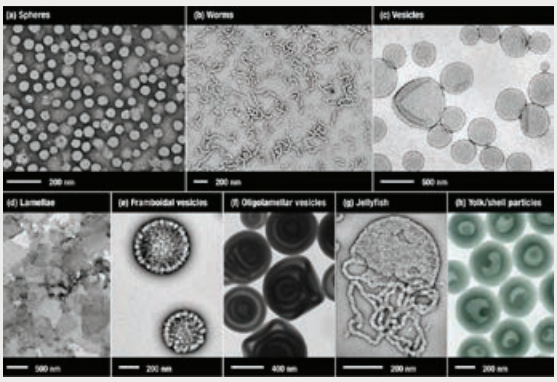
When it comes to advanced materials, the UK is dynamic, featuring leading research, numerous new centres of excellence, and the potential for a new advanced engineering workforce. Asa Barber reports

The advanced materials landscape in the UK is incredibly dynamic, benefiting from the breadth of world-leading research and national priorities driven by government. Significant growth in advanced materials discovery and the pull-through of economic impact of advanced materials are characteristic of the changing environment. Perhaps more noticeable is the surge in the underpinning skills associated with requirements of a workforce aligned to a higher value-added economy. The vehicles for these growth activities are capital investments, particularly in the building of new centres and institutes containing the facilities required to develop advanced materials for economic benefit.

Advanced materials were part of the government's 'eight great technologies' announced in 2013, and directed by UK materials-related industries providing reported annual turnovers of £197 billion. Such national policy has seen a growth in the number of UK centres from the Manufacturing Technology Centre in 2011, and has progressed to include areas of excellence such as the National Structural Integrity Centre, the National Graphene Institute and The Sir Henry Royce Institute for Advanced Materials. The latter provides a national presence from its hub in Manchester, but with spokes extended out to other geographic locations. Professor Richard Jones, former pro-Vice-Chancellor for Research and Innovation at the University of Sheffield, comments: "The Royce Institute isn't just a place where ideas are born, it is a place where things will get done. It will drive economic growth in the North of England by connecting our prestigious academic base in materials science with industry to design new materials, make new products and develop new processes. Through this we can drive down the cost of manufacturing products and make our industries more competitive on a global scale." This infrastructure therefore provides potential seeding points for economic growth and benefit through a number of approaches.

PROLIFIC MATERIALS RESEARCH

The UK has been prolific in materials research in the last year, and this growth is expected to continue into 2017. Journal article publications remain the best method to characterise this rise in fundamental research that the Government expects to deliver economic impact through its infrastructural investment. The



Forms of nanoparticulates, used in a number of forms for coatings, drug delivery, sterilisation gels and emulsifiers

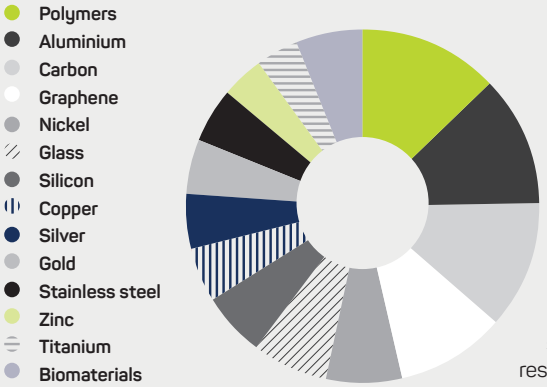


Fig. 1. Forms of nanoparticulates, reproduced from a Creative Commons CC-BY Usage Agreement: Canning et al. Macromolecules 2016, 49, 1685 (American Chemical Society). Fig 3: Analysis of significant materials research output for the UK in 2016 (Source: SCOPUS, Elsevier)

so-called 'soft' material types including polymers, carbon and graphene are clearly a significant part of the advanced materials scene. The rest of the materials of importance are dominated by metals typically used in high performance applications. Perhaps more interesting is the way in which materials are processed into a range of forms. Nanoparticles are utilised in a number of forms for coatings, drug delivery, sterilisation gels and emulsifiers. Graphene has been pioneered as a specific nanoparticulate material, with a number of unique physical properties due to its two-dimensional geometry. Upscaling into industrial usage and large volume manufacture is a major area of research, with the potential to consider other two-dimensional structures, most noticeably using graphene oxide for increased processability and new transition metal dichalcogenides. While coatings and thin films are a more established industrial form, electrodes and solar cells indicate the shift into more energy related technologies.

FUTURE RISKS

Strong advanced materials developments are perhaps offset by the UK's historic weakness in exploiting IP to commercialisation. The ideas are there, but the 'something' required to accelerate to market is a constant limitation and discussion on trying to pin down the cause is attracting the headlines. The University of Manchester's National Graphene Institute was one such initiative that was reported in the May 2016 issue of *Nature* magazine as stuttering. The lack of translating Nobel prizewinning academic success into a viable business opportunity was subject to a parliamentary inquiry, partly prompted by reporting in *The Sunday Times*, leading to a number of points being raised that are perhaps endemic within the UK's R&D scene. The basis for the weakness of commercialisation is commonly suggested as a corresponding weakness in the UK's business R&D spending, which has dropped from 1.5 per cent of GDP 30 years ago to its current 1.1 per cent level, while many competitor nations have reversed this trend. So the 'something' appears to be a lack of UK companies that are able to exploit the breadth of national research for industrial benefit, and the government is starting to agree.

BOOST TO BUSINESS-LINKED R&D

The Autumn Statement this year attracted considerable attention by announcing a raft of measures within a 'National Productivity Investment Fund' totalling £23 billion, and reaching a headline figure of an increased £4.7bn a year of public R&D funds. Critically, the funds are far more targeted towards development through measures to enhance collaboration with business and improve research capacity and research innovation. These approaches have been attempted previously, and Innovate UK calls are a more identifiable routine in the university system to link with companies, but the magnitude of the funding increases are a potential step-change. The outcome of government policy will push public R&D spend up from 0.48 per cent to 0.58 per cent of GDP and provide opportunity for significant change; a surprising positive in a post-Brexit UK.

TRAINING

An improved knowledge-based economy is seeing clear impacts on training and upskilling of the workforce. The Higher Education Funding Council for England (HEFCE) announced £200 million of teaching capital funding to grow the provision of science, technology, engineering and mathematics (STEM) subject areas, and completed the allocation of resources this year to 73 universities and colleges. An example of the potential of these new activities is highlighted by the Future Technology Centre at the University of Portsmouth that promotes new courses, training and R&D with multinational – as well as local – companies, particularly within the materials engineering remit.

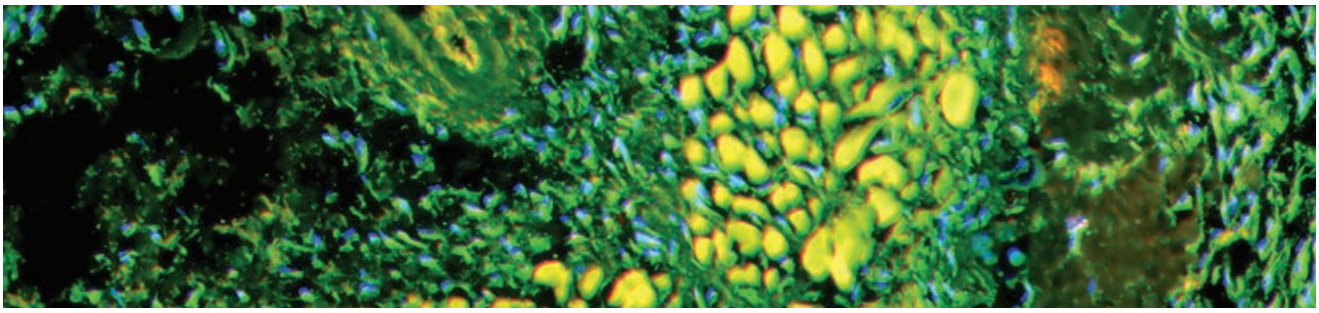
Evidence of the importance of training in materials engineering at a national level is highlighted by the apprenticeship levy. The high skill requirements in advanced materials engineering provide an opportunity to shape the expected three million additional apprenticeships expected by the Government by 2020. Under this legislation, employers can access a new digital apprenticeship service account to pay for training and assessment for apprenticeships. Such an initiative benefits synergies between employers paying the apprenticeship levy, the government supporting training of apprenticeships, and training providers including universities that have recently invested in modernising training facilities. MR

THE FUTURE TECHNOLOGY CENTRE

The Future Technology Centre (FTC) is a novel initiative developed at the University of Portsmouth with an expected late summer 2017 opening. The FTC delivers new training with a problem-based learning focus that are relevant to industry. The £12m centre is funded by the Higher Education Funding Council for England, Solent Local Enterprise Partnership and the University of Portsmouth. Over 2,000 m2 of space over four floors are dedicated to training activities using new facilities. The centre is focused on 3D engineering and provides significant facilities in imaging materials in 3D, modelling resultant material behaviour and manufacturing facilities. The centre integrates all of the physical facilities with a virtual teaching environment through novel digital solutions. The centre is prepared for student intakes in the new innovation engineering course and degree-level apprenticeships. Strategic links with Carl Zeiss Ltd. in materials imaging and 3D systems in additive manufacturing have already been put in place, with a number of further industrial links planned.

THE SIR HENRY ROYCE INSTITUTE FOR ADVANCED MATERIALS

The Sir Henry Royce Institute for Advanced Materials is a £235 million government investment aiming at enhanced commercialisation of fundamental research. The four major themes of energy, engineering, soft and function materials define a breadth of materials discovery, while nine specific areas of excellence are: 2D materials; advanced metals processing; atoms to devices; biomedical systems; chemical materials discovery; materials for energy efficient ICT; materials systems for demanding environments; nuclear materials, and energy storage. The central hub at the University of Manchester is supported by additional partner universities at Sheffield, Leeds, Liverpool, Cambridge, Oxford and Imperial College London, as well as the Culham Centre for Fusion Energy, and the National Nuclear Laboratory.



ADVANCED THERAPIES: 2016 HIGHLIGHTS AND A FORWARD LOOK

At least eight new cell and gene therapy companies have been created in the last three years. Dr Mike Sullivan and Dr Kath Mackay at Innovate UK explain what must happen next to grow the RegenMed industry

Medicines based on genes, cells and tissue engineering offer treatments and possibly cures for conditions that currently lie beyond the reach of traditional drug and biopharmaceutical approaches. Collectively known as Advanced therapy medicinal products (ATMPs) they represent an exciting but complex set of therapeutic products that will require specialist manufacture, storage and distribution to get the products to patients.

In the UK in the last two years there has been growth in the commercial sector of regenerative medicine and advanced therapeutics with a number of new UK based pioneering cell and gene therapy companies being formed (e.g. Achilles Therapeutics, Autolus, Catapult Therapy TCR, Freeline Therapeutics, Islexa, MeiraGTx, NightstaRx, and Orchard Therapeutics) to develop and commercialise advanced therapeutics. These new companies together with the more established UK companies previously supported by Innovate UK funding; Adaptimmune, Cell Medica, Oxford Biomedica, ReNeuron, and Tissue Regenix have secured publicly declared investments of over £400 million since 2014 from venture capital funds, institutional investors and equity placings.

Since 2009, Innovate UK's Regenerative Medicine Programme, the Biomedical Catalyst, and a number of other funding streams, have supported over 120 advanced therapy and regenerative medicine projects with over £54 million in grants. This level of support positions Innovate UK as a key supporter of UK regenerative medicine and advanced therapies businesses.

Innovate UK established the Cell and Gene Therapy Catapult in 2012 to support the growth of this emerging industry sector and establish the UK as a global centre. The Catapult works with companies and academic groups, such as the EPSRC Centre for Innovative Manufacturing in Regenerative Medicine, providing access to technical, regulatory, clinical and financial expertise and infrastructure, enhancing the UK's key strengths in this area, and enabling the UK to be a global leader in the development and rapid commercial exploitation of cell therapies.

In 2016 the European Commission approved GSK's Strimvelis™, the first corrective gene therapy for children to be awarded regulatory approval anywhere in the world.

2016 saw the formation of the Advanced Therapies Manufacturing Taskforce and publication of its report on what the UK needs to do anchor manufacturing of advanced therapies in the UK and capture investments to secure the UK position as a world class hub .

It calls for the maintenance of science and innovation funding to support industry developing cutting-edge technologies.

The European Commission also approved GSK's Strimvelis™ in 2016. This is the first corrective gene therapy for children to be awarded regulatory approval anywhere in the world.

NEW CELL MANUFACTURING CENTRE

As we head in to 2017, the industry is far from standing still. 2017 will see the opening of the Cell and Gene Therapy Manufacturing Centre at Stevenage, which will enable large-scale manufacture of cell and gene therapies for late-stage clinical trials and commercial supply. They have already attracted the first tenant, Autolus to manufacture their pipeline of T-cell products for the treatment of cancer patients.

The outstanding challenge remains the routine translation of the science of regenerative medicine and advanced therapies into safe clinical treatments and key to that will be manufacturing. Supporting companies to cross this gap between research and product or therapy is the core function of Innovate UK. We will continue to work with the UK's Advanced therapy medicinal products sector to ensure the UK is developing real strengths in the sector, and use our competitive advantages to maintain global leadership in this exciting and complicated sector. MR

MORE RESOURCES

http://ec.europa.eu/health/human-use/advanced-therapies/index_en.htm

http://www.abpi.org.uk/our-work/mmip/Documents/Advanced-Therapies-Manufacturing-Taskforce-report.pdf

MANUFACTURING FELLOWSHIPS SUPPORT GROUNDBREAKING RESEARCH

HIGHLIGHTS:

- £20 million EPSRC scheme brings senior industrial researchers into academia
- This research would not take place without EPSRC funding
- Knowledge from academia leveraged into industrial partnerships
- Eighteen Manufacturing Fellows recruited through five calls
- Early career Fellowships offer support for aspiring world-leading researchers

The EPSRC £20 million Manufacturing Fellowships scheme provides a mechanism to bring senior figures in industrial research into an academic research environment. Two EPSRC Fellows outline their areas of research

DR CHRIS PRICE

EPSRC Manufacturing Fellow

Chemical and process engineering, University of Strathclyde

My research focuses on improving the purification of active pharmaceutical ingredients by using ultrasound to remove impurities from crystal surfaces during the growth process. Crystallisation is the pharmaceutical industry's process of choice for separating molecules of the active drug substance from closely related impurities formed during chemical synthesis of the desired molecule. My research has the potential to increase product purity, process throughput and yield, as well as reducing the amount of product which is lost in the waste stream instead of being recovered. In order to demonstrate these benefits, a second strand of my research is focused on delivering enhanced filtration and washing to facilitate recovery of pure crystals from the solution containing dissolved impurities. The overall target is to deliver the necessary scientific understanding, experimental methodologies and technical proof of principle to allow the research to be industrialised to reduce the cost of medicines.

Without EPSRC funding me as a Manufacturing Fellow I would still be working in industry and the research would not be taking place. Prior to my fellowship I was a manager in particle generation control and engineering at GSK where key elements of my role included continuous drug substance particle formation and isolation, which was linked with continuous drug product formulation with the aim of accelerating development. The pharmaceutical industry focuses its research effort on discovering and commercialising new medicines. While there is a clear urgency to developing new medicines, the type of process technology I am researching has the potential to impact a whole industry sector and fund the development of many new medicines by providing savings.

Manufacturing Fellowships provide a mechanism to bring industrial research expertise into academia and embed industry best practice in academia. This serves to encourage industrial engagement amongst the wider academic community, fostering knowledge exchange and enhancing research impact. My own experience of this includes drawing an academic colleague into a Knowledge Transfer Partnership with a micro SME implementing some of the findings arising from my fellowship project.

DR LAURA TORRENTE MURCIANO

EPSRC early career Fellow Department of chemical engineering and biotechnology, University of Cambridge

Our research is focused on filling the gap between the discovery of nanomaterials at lab scale, and their implementation in products and services at large scale. Our understanding of the unique chemical and physical properties of nanomaterials has been vastly developed during the last few decades, thanks to a combination of new synthetic routes and characterisation capabilities. At the lab scale, the scientific community has revealed new reaction pathways, demonstrated sustainable energy production, and developed novel therapies to name just a few applications based on nanomaterials.

However, the implementation of these exceptional materials at large scale is currently limited by the lack of a reliable, reproducible and flexible manufacturing technology. In this context, my EPSRC Fellowship project, Compact, is developing a novel microdevice-based manufacturing technology for the continuous large-scale synthesis of metal nanoparticles and nanostructured materials with controllable morphologies and tuneable sizes.

By coupling experimental data, additive manufacturing tools and fluid dynamic simulations, we design bespoke nano-factories where we integrate the synthesis and stabilisation of tailored products for specific applications without the need of capping ligands, the ions or molecules that bind to central metal atoms to avoid agglomeration but potentially interfering in the final application.

Being awarded this Fellowship at this stage of my career was an important milestone. It is allowing me to develop my ideas, evolve as a scientist and build my research reputation at an accelerated pace. In addition, it is giving me the time and flexibility to create a strong network and explore a range of multi-disciplinary collaborations, outside my area of expertise in fields where the new technologies we are developing can make a notable impact.

One of the most important aspects of the Manufacturing Fellowships is the leverage of the research. In my specific case, the project is mainly focused on the fundamental understanding of the kinetics, mechanism and fluid dynamics during the synthesis of nanoparticles and nanomaterials. And it is this knowledge which is leveraged into several consortiums with strong industrial partnerships.

METROLOGY UNDERPINS MANUFACTURING CHAIN – FROM INNOVATION TO COSTS

NPL's Product Verification Programme offers manufacturers the opportunity to improve productivity and reduce waste through implementation of more accurate measurement processes and techniques, says Philip Cooper, leader of the programme

NPL Instruments provides confidence that products and processes perform as they shoulda

Ensuring that products coming off an assembly line precisely match their design brief can save companies thousands of pounds in waste every year.

But this verification process can itself account for up to 20 per cent of a product's overall cost, so streamlining procedures to ensure problems are spotted as early as possible can have a significant impact on a company's bottom line, as well as the quality of its finished products. To this end, we at the National Physical Laboratory (NPL), based in Teddington, have created the Product Verification Programme, which is intended to help manufacturing companies to improve their productivity and reduce waste through better measurement technologies and processes.

This is becoming increasingly important as customers expect components to conform to ever more stringent specifications – an aircraft engine manufacturer, for example, may potentially have thousands of components supplied to them from all over the world, which all need to be brought together to be assembled into a single product. So whether the parts are manufactured to the specified dimensions is absolutely critical, and we are talking about tolerances right down to a few microns.

By verifying that parts conform to their original design dimensions, metrology can improve the entire manufacturing chain, increasing productivity, research and development efficiency and lowering costs. Many manufacturers are equipped with co-ordinate measuring machines, devices that use a probe attached to a moving axis to inspect the size and shape of products coming off the assembly line. However, investing thousands of pounds installing such a machine at the end of the production line is pointless if your manufacturing process is not consistent in the first place.

By improving the application of measurement techniques, you will be able to manufacture with a higher degree of confidence and efficiency; enabling you to provide more for your customers for the same cost.

METROLOGY IN MANUFACTURING

- Research carried out for the European Commission suggests that an investment of €1 (73p) in metrology results in an increase of €3 in the EU's gross domestic product
- In the UK alone, around £342 billion worth of products are sold each year on the basis of a measurement of their performance, while goods worth a further £280bn are weighed or measured at the business-to-business level
- Research has shown that around three quarters of all errors have their routes in the early stages of production
- Of these, around 80 per cent are not picked up until much later – either during manufacturing or after the product's sale – making it far costly to put right the error

INTRODUCING NPL INSTRUMENTS

Recently launched, NPL Instruments provides confidence that products and processes perform as they should and to the highest quality, by maximising the reliability and efficiency of their systems. The commercial service brings its world-class measurement instruments and expertise closer to industry, improving quality, productivity and efficiency.

Organisations like NASA, the MoD, Defra and the European Space Agency (ESA) are already benefiting from this expertise. NASA, for example, uses the most accurate machines in the world to craft the mirrors in its space telescopes. NPL was uniquely placed to create the laser systems that control and operate these machines. For the European Space Agency, NPL has developed a unique vibration test facility that underpins the performance of satellite components for European space missions. Defra has made use of new environmental monitoring techniques from NPL that track greenhouse gas emissions in 3D over large areas, allowing it to manage sites such as landfills much more effectively.

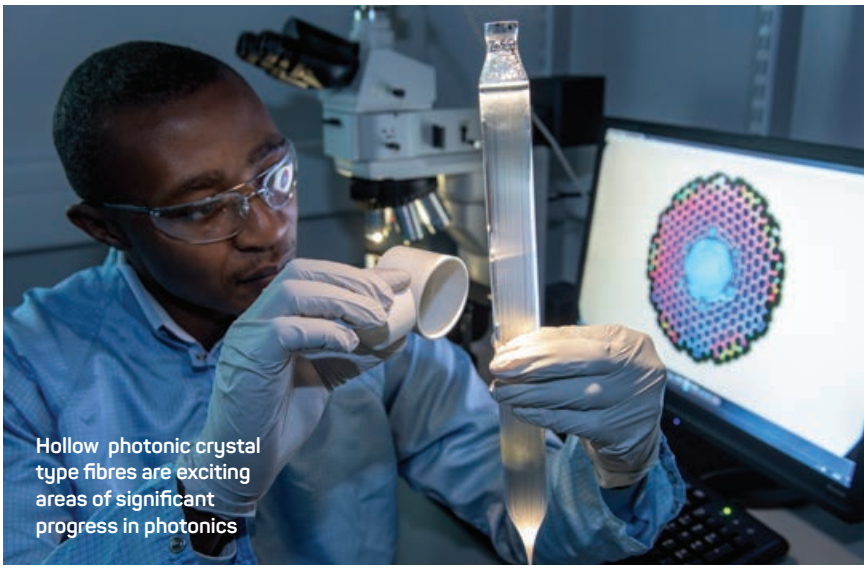
NPL Instruments will be putting £1.5 million towards new machining centres and state of the art laboratories, as well as the recruitment of new engineering specialists and advanced engineering apprentices. NPL supplies instruments to industry to give organisations confidence through traceability: from vibration facilities at the ESA which will help test and improve satellite performance, to environmental mobile labs which give confident measurements of greenhouse gases. The launch of NPL Instruments gives industry access to unrivalled measurement capabilities, underpinning prosperity and productivity.

PHOTONICS INDUSTRY POSITIONED FOR A STRONG 2017

With big investments taking place in the UK photonics industry and support from the research base, the future looks bright. By the EPSRC Photonics Hub

THIS ARTICLE EXPLAINS:

- UK photonics has a healthy future
- Southampton's Optoelectronics Research Centre supporting the industry
- Lasers play critical role in manufacturing
- Advanced imaging an 'emerging megatrend'
- ORC heavily involved in quantum technology



Hollow photonic crystal type fibres are exciting areas of significant progress in photonics

With recent acquisitions and expansion of manufacturing opportunities in domestic and overseas markets, the future is looking healthy for the photonics sector. Overall, UK photonics continues to show strong performance, in no small part due its increasingly valuable role enabling manufacturing efficiency, according to industry experts from the University of Southampton's Optoelectronics Research Centre (ORC).

In 2015-16 there has been strong inward investment in the UK. Recent acquisitions point to a resilient market: SPI Lasers' acquisition of UK-based JK Lasers for $31.5 million in cash; Coherent's global $942m acquisition of rival Rofin-Sinar, both of whom have significant UK operations.

EXPANSION OF LASERS IN MANUFACTURING

The continued expansion of lasers applications in manufacturing and the persistence of the Asian market offer further reasons to be optimistic. The role of lasers in manufacturing is critical, especially when working with more complicated advanced materials. For example, laser cutting is essential to the processing of strengthened glass used in smartphones. Indeed, photonics is seeing a triple growth driver in consumer electronics with more embedded photonics components, such as cameras, a greater range of lasers used in more manufacturing processes, and an expansion in total manufacturing volumes.

It's just one example typifying why there is escalating demand for core components and material, photonic products, and photonic-enabled services. From LEDS in lighting, to high power lasers in manufacturing and optical communications behind online services, and more, the photonics R&D sector in the UK is in a strong position.

Another area to watch is the advanced imaging market. The emerging megatrend concerns the use of simultaneous imaging in multiple wavelengths to gain more information from a process, object or area. Such data is increasingly used to enable precision decision-making and is therefore in strong demand from the industrial process control, defence and security, healthcare and automotive sectors.

The ORC and the Future Photonics Hub continue to be at the forefront of emerging photonics markets. Recently, they have achieved major advances in new types of optical fibre. Hollow photonic crystal type fibres for high-powered laser transport used in manufacturing and optical communications are exciting areas of significant progress. Other hot spots include significant improvements in infra-red glasses for imaging applications and advances in adaptive metamaterials that will impact multiple sectors into the future. Silicon photonics, integrated photonic circuits and healthcare diagnostics represent more growth opportunities where the ORC is developing new manufacturing processes that increase the practical impact of photonics even further.

The ORC is also heavily involved in quantum technology, playing a pivotal role in beginning to produce the integrated photonic devices needed to make quantum applications a reality. High power fibre lasers are being further developed, with the advent of next-generation lasers which enable the processing of more complicated materials.

The photonics sector is showing no signs of slowing and the ORC and Future Photonics Hub are strongly positioned to translate the latest breakthroughs into marketable technologies and applications. MR

FAST PHOTONICS FACTS 2015-16

1,500 photonics manufacturing companies in UK

70,000 people employed in UK photonics

Generating economic output of **£10.5 BILLION**

Similar in size to UK pharmaceutical industry but distributed among **THREE TIMES AS MANY** firms

Core photonics components global revenues **$182BN**

Photonic-enabled worldwide market of **$1.45TN**

Total global employment **3,533,000 JOBS**

Countries

The proliferation of wind turbines increasingly covering our landscape is like Marmite... love it or hate it. However, their manufacture and construction across the UK provides a valuable source of green energy for a modern manufacturing Britain.

CREDIT: Wind Turbine, taken by Simon Ovenden at Little Cheyne Court Wind Farm, Romney Marsh in Rye, East Sussex, shortlisted in the amateur category of the EEF Photography Competition 2016.

Manufacturing the 2017 Ford F-Series Super Duty at the company's Kentucky truck plant. Ford is filling its US assembly plants with high-demand pickups and utility vehicles and sending smaller cars to Mexico

Credit: Sam VanHagen/Ford

COUNTRIES - USA

US MANUFACTURING AT A CROSSROADS

President-elect Donald Trump talks a good game when it comes to manufacturing but tearing up trade deals could prove problematic when it comes to aerospace and automotive. Paul Eisenstein reports

THIS ARTICLE EXPLAINS:

- Many US manufacturers have sought low cost countries
- President-elect Donald Trump made rebuilding manufacturing a cornerstone of his campaign
- Renegotiation of key trade deals might adversely affect the Big Three carmakers and aerospace
- Increasing automation might see exports grow but manufacturing jobs decline
- US has its own concerns about skills

Hidden away in a tired old section of Raleigh, North Carolina, tucked into a once-abandoned warehouse, workers are busily stitching together a line of designer jeans. Marketed under the brand name Raleigh Denim, the company has become a hip, boutique brand, marketed at high-end outlets like New York-based Barney's, as well as through the clothing manufacturer's own stores.

Raleigh Denim is something of a fluke, launched by Victor Lytvinenko and now-wife Sarah Yarborough in 2007, almost by accident. Both seriously under-employed, they were supplementing meagre incomes by buying and repairing old sewing machines – many of which are still in use at the company's factory. They decided to try making some of their own goods, and a chance connection to a "friend of a friend" helped the couple connect with Barney's and then rapidly line up other retail outlets.

At one point, Raleigh Denim would have been just one of many garment companies dotting the landscape throughout the southern United States. Today, however, it's a rarity. Over the last few decades, the vast majority of clothing and white goods manufacturers have fled abroad, generally seeking cheaper wages. Even the clothing lines bearing the Trump label, for American president-elect Donald Trump, are imported.

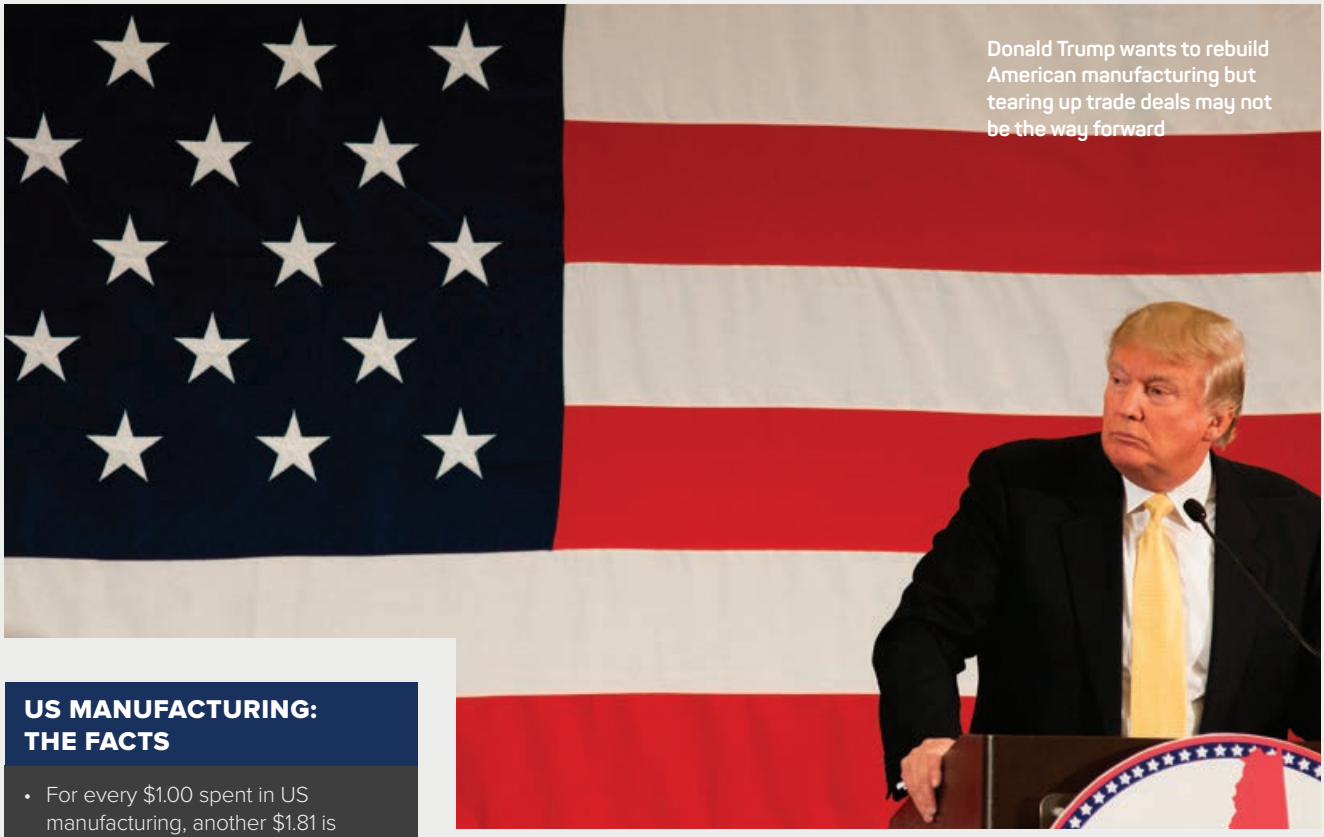
To many, that's a major irony considering the New York businessman-cum-politician made rebuilding American manufacturing a cornerstone of his contentious campaign. There is no question that for a country that was once one of the world's powerhouses, many manufacturing sectors have been hollowed out over the years, clothing among the most obvious. Perhaps the highest profile example, however, is the smartphone industry. Apple may be one of America's wealthiest companies, but its trademark iPhones, among other goods, are imported from China.

MEXICO REVS UP FOR AUTOMOTIVE

A centrepiece of the recent election, however, was Mexico, then-candidate Trump frequently criticising the North American Free Trade Agreement, or NAFTA, in general, and the Ford Motor Co., in particular, for its plans to shift small car production from factories in the Midwest to a new assembly line south of the border.

At first glance, there might be reason for such concerns. Once an automotive backwater, Mexico is now one of the five largest auto-producing nations in the world, despite the fact that it has a relatively small local market, taking into account the country's population. There's a Who's-Who list of manufacturers operating there; over the last 12 months alone, Kia, Audi and Nissan's high-line Infiniti brand have opened up new plants. But the story may not be nearly as dire as it seems.

Less than three hours drive from the Raleigh Denim plant, just outside



Donald Trump wants to rebuild American manufacturing but tearing up trade deals may not be the way forward

US MANUFACTURING: THE FACTS

- For every $1.00 spent in US manufacturing, another $1.81 is added to the economy
- The majority of US manufacturing firms are small. In 2014, there were 251,901 firms in the manufacturing sector. All but 3,749 firms were considered small – that is, having fewer than 500 employees
- There are 12.3 million manufacturing workers in the US – accounting for nine per cent of the workforce
- Ove the next decade, nearly 3.5 million manufacturing jobs will be needed in the US; two million are expected to go unfilled due to the US skills gap. Eighty per cent of US manufacturers report a moderate or serious shortage of applicants for skilled shopfloor positions
- Productivity in US manufacturing is roughly 1.7 times greater than all non-farm businesses

Credit: National Association of Manufacturers, US

Charlotte, South Carolina, Daimler AG broke ground in July for a new plant that will soon begin building its big Sprinter model. Until now, those Mercedes-Benz vans were built in Europe, broken down into a handful of components and shipped to Charlotte to be put back together – an odd strategy that helped the German company avoid a 25 per cent import tariff, the so-called chicken tax. The $500 million investment will create close to 2,000 jobs.

Only a few miles away, meanwhile, Swedish automaker Volvo is setting up its first US assembly plant. And BMW has been steadily expanding its own operations in South Carolina, its Spartanburg plant serving as the sole global source for several models, including the big X5 Sport-Activity Vehicle.

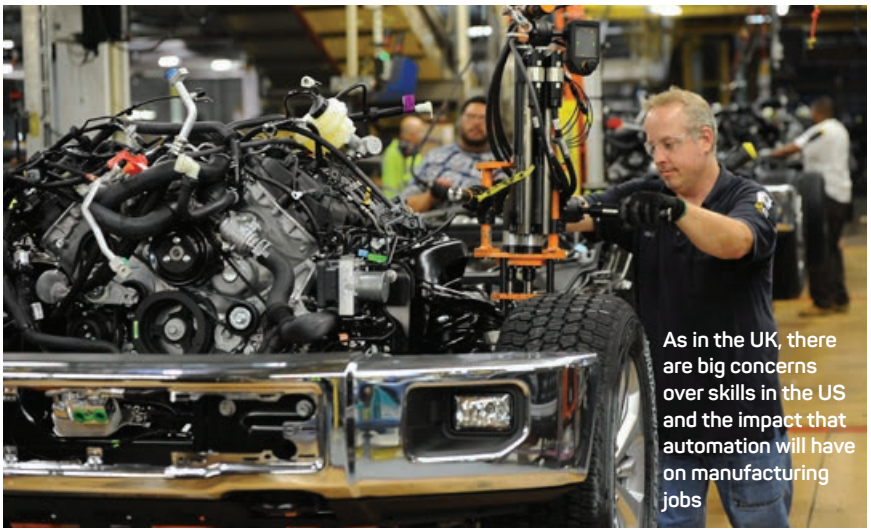
If anything, the auto industry has expanded rapidly since it hit rock bottom at the beginning of the decade, two of the Detroit Big Three automakers going through Chapter 11 bankruptcy. Ford, for one, says it has invested $12 billion in its US plants since the American market began to recover, creating 28,000 US jobs in the process. The maker pointedly notes that while it is sending some slow-selling small cars to Mexico, it is filling those US assembly plants with high-demand pickups and utility vehicles.

The incoming president has said he will abandon the recently negotiated Trans-Pacific Partnership as soon as he takes office. Trump has also promised to renegotiate NAFTA, though exactly what he might seek, never mind get, from partners Canada and Mexico is far from certain.

In part, that's due to the fact that the agreement isn't the disaster some have claimed, depending upon how it is measured. For all of 2015, the US exported $1.5 trillion worth of goods – the vast bulk of the $2.17 trillion manufacturing contributed to the American economy last year. That's nearly double the $804 billion – adjusted for inflation – in 1994, the year the agreement took effect, according to the Bureau of Economic Analysis. However, the number of American manufacturing jobs tumbled by more than a quarter, from 16.8 million in 1994 to 12.3 million as of July 2016, reports Michael Hicks, an economist at Ball State University, in Muncie, Indiana.

"We are seeing a good level of strength in the key US manufacturing sectors that we support, with growth in automotive, aerospace and space," says Chris Pockett, spokesperson for British research and consulting firm Renshaw. On the other hand, Pockett adds, "We are currently seeing very little of significance in terms of the 're-shoring' of US manufacturing".

Whether a new administration will be able to re-shore manufacturing is a matter of intense debate, two weeks after the election, as the newly elected president again took aim at the automaker, Ford chief executive Mark Fields warned that talk of tearing down trade pacts and erecting new barriers will have a "huge impact" on not just Ford, but the US economy as a whole.



Credit: Sam VanHagen/Ford

As in the UK, there are big concerns over skills in the US and the impact that automation will have on manufacturing jobs

AEROSPACE – AN AREA OF CONCERN

One area of serious concern is the aerospace industry. Boeing has traditionally led its largest competitor, Europe's Airbus, but the battle for supremacy has grown all the more fierce in recent years. And some analysts warn that Boeing could become one of the biggest victims if efforts to boost manufacturing by erecting trade barriers were to backfire.

Critics warn of the risks of kicking off another global recession, much like what happened when Congress passed trade barriers, known as the Smoot-Hawley Act, that kicked off the Great Depression. Supporters, however, insist that the US needs to play hardball with countries like China, Japan and Mexico, that have talked free trade but done little, they contend, to level the playing field.

"It is simply too early to say what the detailed policies will be, when they will be implemented and whether they will ultimately work for US manufacturers," says Renshaw's Pockett. "What is important is that governments in the U.S. and elsewhere recognise the importance of manufacturing for wealth creation, recognise the challenges that we face, including skills shortages and the need for capital investment to improve productivity, and then create policies that help us address those issues."

The auto industry is a good example of the challenges facing American manufacturing. Visit almost any Detroit assembly plant and you'll find cars and trucks rolling off the line, 60 or more an hour, 16 to 24 hours a day. But driving up I-75, the big freeway running from Miami to the Canadian border, you might notice the large, empty lot on the north side of Detroit where American Axle & Manufacturing employed more than 1,000 hourly workers at the beginning of the decade. Those jobs are now based abroad.

That's something that weighs heavily on Matt Simoncini, the chief executive of Lear Corporation, one of the world's largest suppliers of automotive seats and other components. "I want to bring more jobs back to America, but it just won't work when you're talking about making parts that have a high labour component," he says. Still, Simoncini suggests that he hopes to re-source some more high-tech products in the next few years.

> "I want to bring more jobs back to America, but it just won't work when you're talking about making parts that have a high labour component"
>
> **Matt Simoncini, chief executive, Lear Corporation**

Automakers insist they would be glad to get more American-made parts – at the right price. There are some advantages to building locally, insists Dave Cole, director-emeritus of the Center for Automotive Research in Ann Arbor, Michigan. It shortens supply lines, making just-in-time manufacturing, as well as even more advanced just-in-sequence systems, possible.

Surprisingly, Cole and other experts warn that there actually is a substantial number of manufacturing jobs that are open, mostly in skilled trades. "We're not producing enough of them," says the former University of Michigan professor who also has started a non-profit foundation aimed at encouraging the growth of German-style apprentice programmes and greater skilled trades education as an adjunct to traditional college programs.

TRAINING CRITICAL IN YEARS AHEAD

Such training programs are expected to become even more critical in the years ahead as manufacturers increase their dependence upon automation. Already, even line workers in the aerospace and automotive industry are expected to have some degree of skills with quality control and other advanced manufacturing concepts.

The push for further automation is expected to create a conundrum. Research by Ball State University's Center for Business and Economic Research found that only 13 per cent of the manufacturing jobs that have been lost since the beginning of the new millennium were accounted for by trade. The rest were taken by improved productivity, with robots and automation primary factors. Consider that as recently as 1990 a General Motors plant producing 200,000 vehicles a year needed as many as 5,000 hourly workers. Today, a third as many can produce anywhere from 250,000 to 400,000 vehicles annually. That shift can be seen throughout the manufacturing world.

And it raises the very real possibility that if the US takes the steps needed to become truly competitive with low labour cost countries like China and Mexico, America might wind up seeing the annual numbers grow in terms of manufacturing and trade dollars even as the figures continue to decline in the jobs category.

Considering that the average U.S. manufacturing job paid $81,289 in wages and benefits in 2015, almost a third more than other non-farm industries, the impact could be even more substantial than the hit the country has taken over the last two decades.

American manufacturing is clearly at a crossroads and it remains to seen what will happen as a mix of politics, trade, economics and automation all come into play. MR

Read more about manufacturing in the US on pages: 79 224

U.S. MANUFACTURING REVIEW AND OUTLOOK

As economic fundamentals continue to fluctuate, leading to soft demand and sluggish orders for some products, the U.S. manufacturing sector is continuing to see signs of resurgence.

Manufacturers are getting more optimistic about their growth prospects, with 61 percent responding positively on their company's outlook in the third quarter National Association of Manufacturers (NAM) Outlook Survey, up from 56.6 percent at the beginning of 2016. Expected growth rates for sales, production, capital investment and full-time employment are also trending up. Among the one-quarter who expect to increase capital spending, 46 percent pointed to new products and innovations in the manufacturing process as the primary reason.

As the industry embraces advanced technologies and drives full-speed ahead into the fourth industrial revolution, coined "Industry 4.0," they're seeing both new opportunities and new risks. The Internet of Things (IoT) has introduced new ways to gather and store data in factories and across the supply chain to enable smarter, faster and more efficient decision-making—if manufacturers can analyze and extract actionable insights from that data. And the potential benefits aren't going unnoticed: Nearly two-thirds of manufacturers believe applying IoT to their products will increase profitability over the next five years, according to the MPI Internet of Things Study, sponsored by BDO.

But as manufacturers embrace sophisticated technologies, they must also balance the cybersecurity risks that come with connectivity. Manufacturing was the second-most targeted industry for cyberattacks in 2015, according to IBM. Manufacturers' data and intellectual property—as well as products in the hands of end-users—have become prime targets for cyber criminals. And preparedness has been slower to keep pace: The MPI Internet of Things Study found that only eight percent of manufacturers were very confident in their ability to prevent an IT breach. To maintain a competitive edge, security can no longer be an afterthought in products and processes; the stakes are too high. Efforts are starting to surface to add greater rigor to the process. For example, in September, the Federal Aviation Administration adopted language to ensure that cybersecurity protections are part of all future industrywide standards, meaning everyone involved in aviation equipment and infrastructure (including manufacturers) will need to integrate cybersecurity standards in their routine activities.

General economic unsteadiness, coupled with a contentious lead-up to the landmark 2016 presidential election, has led to a climate of general uncertainty in the business environment. These challenges are magnified in the manufacturing industry as companies jostle to not only keep up with the Joneses, but be the Joneses. To do that, the industry will need to cultivate the next generation of manufacturers, many of whom need sophisticated technological and engineering skill sets. The *Wall Street Journal* reported that software engineering and developing jobs were the second-most in-demand positions in manufacturing over the past year after high-turnover sales positions. Manufacturers are fighting to win over the same pool of applicants as Silicon Valley and other tech-enabled industries. BDO USA's 2016 Manufacturing RiskFactor Report, an analysis of the latest 10-K filings of the 100 largest publicly traded U.S. manufacturers, found that 97 percent discuss labor concerns and 74 percent are worried about attracting and retaining key personnel.

In response to the industry's persistent shortage of engineering and tech talent, businesses, academia and federal partners are working together through programs like Manufacturing USA, which aims to address and make progress against some of the industry's challenges and increase U.S. competitiveness. In June, President Obama announced the launch of five new manufacturing hub competitions via Manufacturing USA, which will invest nearly $800 million in transformative manufacturing technologies, in addition to a new smart Manufacturing Innovation Institute headquartered in Los Angeles to focus on innovations like smart sensors that can improve the efficiency of U.S. advanced manufacturing.

While radically shifting technologies glimmer with the promises of increased speed and productivity, U.S. manufacturers are proceeding cautiously to ensure the right people are in place to support future growth and address emerging risks.

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GERMANY

GERMAN POWERHOUSE IMMERSED IN FOURTH INDUSTRIAL REVOLUTION

The assembly line at plastics manufacturer Igus in Cologne

German industry is performing very well – but that shouldn't be taken for granted. Some companies are using a period of growth to start huge transformation projects focusing on staffing and digitisation. But Brexit, China, and the new US presidency are all causes for concern. Manuel Heckel reports

In terms of numbers, finding a bad one is the hardest challenge when it comes to German industry: production levels, expectations on the future of business, operating grade – every statistic was at an outstanding level at the end of 2016. "The domestic economy, in particular, continues to run smoothly. Construction and several service providers are setting new records in their situation assessments." This is what the chamber of industry and commerce (DIHK) reported in September – and manufacturing industry companies have improved, again, as well, the DIHK adds.

Nevertheless, industry is not resting on its laurels. Many companies have started huge transformation projects to shift their business model or adjust to a changing environment, domestically and internationally. The approaches change: Siemens completed a realignment of sectors and divisions in the spring. Pharma heavyweight Bayer surprised many analysts by plans to merge with US-based GMO-specialist Monsanto. Volkswagen, still struggling with the aftermath of 'Dieselgate', is looking for a new, consistent strategy across its 12 very different brands, but has not got too far with it.

THIS ARTICLE EXPLAINS:

- German manufacturing is performing well
- Industry 4.0 is an operational reality for many German manufacturers
- Question marks over how Industry 4.0 will affect working life
- 'Smart services' on the rise
- Brexit and US presidential election causes for concern

INDUSTRIE 4.0 REACHES OPERATIONAL LEVEL

Among SMEs, the huge project of digitising industry, widely branded as "Industrie 4.0", has reached an operational level. The trade fair Hannover Messe in April was full of different use cases combining software and hardware along the assembly lines or the supply chain. The different technical parts for solutions are available, but the intelligent combination of them remains a challenge. "It is a difficult way, as you are not able to buy the perfect solutions, but you have to build most of them by yourself," says Frank Blase. Blase is chief executive officer of Igus, a Cologne-based plastic manufacturer with a €500 million revenue.

Finding the ideas which makes most sense for business model will take more than a couple of years. "It has to work not only within one company, but along a whole value-added chain," says Roman Dumitrescu, head of the Fraunhofer Institute for design methods and mechatronics (IEM).

Along with the technical and organisational side of 'Industrie 4.0', the topic of 'Arbeit 4.0' became increasingly relevant within the German economy in 2016. "We have to discuss the impact of Industry 4.0 in terms of the human side of the

Pharma giant Bayer surprised analysts with plans to merge with US-based Monsanto

"Some numbers provided by the VDA show how closely linked the UK and Germany are when it comes to the automotive industry. In 2015, about 1.3 million new cars were sold to the UK by German brands – roughly a market share of 50 per cent. And more than 800,000 cars were built in Germany but exported to the UK – more than to any other country"

working world," Brigitte Zypries says, state secretary with the Federal Ministry for Economic Affairs and Energy. "The development is already there; we have to see how we can shape it." From the industry perspective, two aspects are already relevant and will probably become even more relevant over the next years: the first is that requirements for jobs change much faster than they used to do. Companies are forced to invest heavily in training for workers across all levels. Kuka, for example, implemented a digital 'wiki' to share knowledge across the company more easily and broadly. The company was presented with a Digital Leader Award as a result in summer 2016.

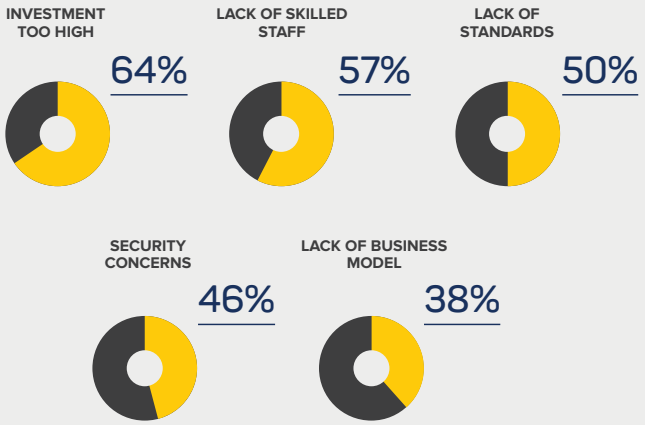
The impact of Industrie 4.0 in working life is under close supervision by the still-influential trade unions in Germany. So far, helped by the overall economic situation government, companies and unions are working in hand-in-hand – for example in the 'Zukunft der Industrie' initative – focusing on future developments of the economy. If some of the jobs along the assembly lines or in logistics are made redundant by technology, this might put some well-paid workers out of work in the future, and change the tone of the discourse.

AMBITIOUS CHANGE

But companies are under pressure to find the right staff for ambitious change projects. The competition for talent specialising in data science or programming is intense, and the industry is learning to attract interesting candidates. One common method is the opening of venture units or incubators

LACK OF MONEY AND PEOPLE

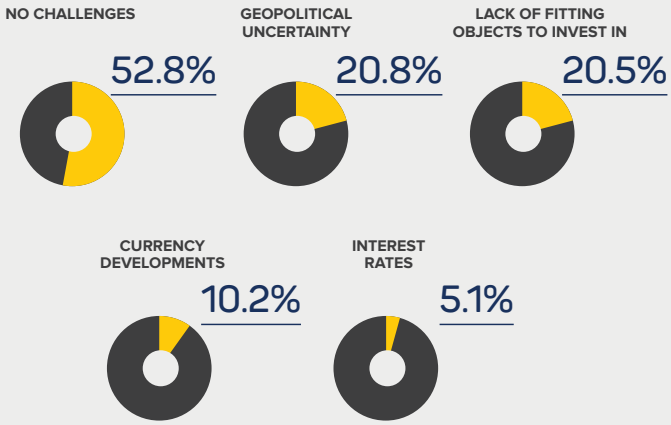
Biggest challenges for German industrial companies in terms of Industry 4.0



Source: EY 2016

HAPPY TO INVEST?

Reasons not to invest given by family-owned businesses from Germany



Source: BDI / Deutsche Bank, 2016

to add some start-up feeling to the still conservative hierarchies of some companies. One example is steel company Klöckner, which has opened 'Kloeckner.I' in the middle of Berlin to test new business models for the sector. Meanwhile struggling utility giant E.on has already managed to spin-off the first start-ups from its own innovation program. Warsteiner, one of the biggest family-owned breweries in Germany, has announced plans to open a second office in Düsseldorf. The new location within a big city might make it easier to attract young talent than from its headquarters in the remote area of Sauerland – a problem shared among many German 'hidden champions' in the eastern parts of Westphalia or in the Black Forest.

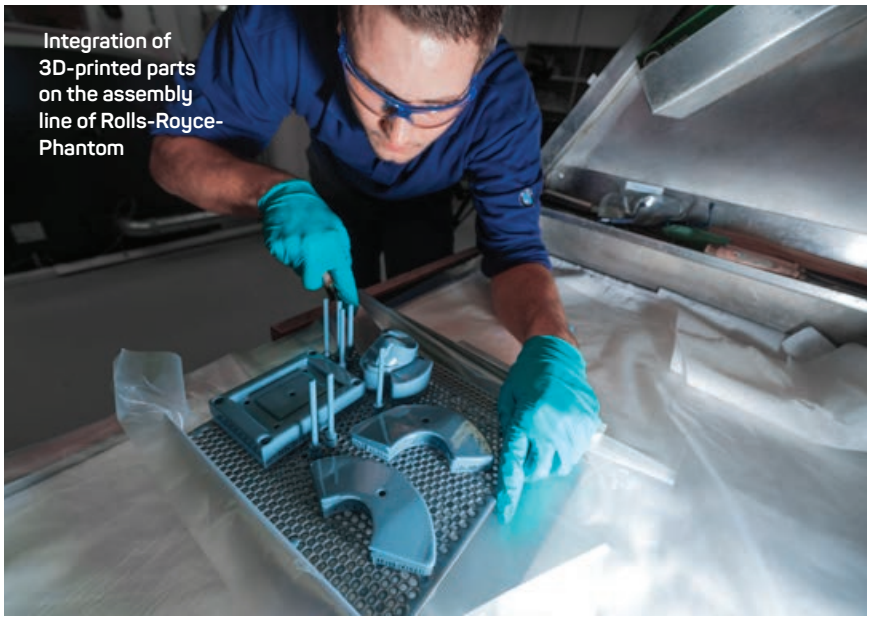

Integration of 3D-printed parts on the assembly line of Rolls-Royce-Phantom

Photo courtesy of BMW

SELLING DATA RATHER THAN HARDWARE

These efforts indicate an underlying fear shared by many companies used to working, growing and making profit in a quiet environment for decades. With digitisation, change is coming: the hardware itself, let it be screw, ball bearing or gear, might develop towards an interchangeable resource. On the rise are 'smart services', using and monetising machine data. Predictive maintenance or optimisation of the supply chain were buzzwords at any industry conference in 2016. Few companies, unlike Heidelberger Druck, commenced with initital, successful projects: most are still looking for the new digital pot of gold. This requires greater transparency and more communication between companies – and some SMEs fear that platforms will generate and distribute revenue in the future. "A lot of companies are afraid that their data will be taken away," Roman Dumitrescu of the Fraunhofer adds.

There is a risk that some companies might not take the time to invest and reshape – and fall back in the coming years if the economy declines. The automotive industry – which employs every tenth worker in manufacturing industry – is a difficult position. Right now, a lot of the OEMs and their suppliers profit from global markets. But if electromobility progesses, some parts of the automotive supply chain might not be needed anymore. The news that machinery manufacturer Grohman Engineering has been bought by Tesla in early November indicated an SME that is investing in the right technology.

In addition to all this change, some challenges for the heavily globally-oriented German industry came not from within the country, but from other markets. A huge amount of uncertainty was added by the election to the US presidency of Donald Trump: In 2015, German companies sold goods and services worth €114 billion to the US. A more protectionist approach might reduce that significantly.

Brexit is another challenge. "The UK is an important market for us", said Matthias Wissmann in July 2016. Wissmann is head of the Verband der deutschen Automobilindustrie (VDA), the most important automotive sector organisation in Germany. Some numbers provided by the VDA show how closely linked UK and Germany are when it comes to the automotive industry. In 2015, about 1.3 million new cars were sold there by German brands – roughly, a market share of 50 per cent. And more than 800,000 cars were built in Germany but exported to the UK – more than to any other country.

MIX-UP WITH CHINA

In addition to Brexit, relations with China have gone down a rough path. In the first six months of 2016, Chinese companies bought 37 German firms and invested about $10 billion in total. They increasingly focus on high-tech-companies and have identified some of the 'hidden champions' – like EEW Energy from Waste', a specialist in the waste industry. 2016 saw a resurrection of the German fear of selling out important or critical know-how to the Chinese. This was especially visible when it came to the acquisition of Kuka, a leading specialist for robotic and systems engineering. During a trip to Bejing and Shanghai in November, Federal Minister for Economic Affairs and Energy Sigmar Gabriel was attacked by government officials for interfering in this merger. He asked for the fair treatment of German companies in China in return.

Other challenges remain on the macro-level: industry has not yet found its place in the huge challenge of integrating huge numbers of refugees. In 2015, about one million refugees came into the country. In the first half year of 2016, the number went down to 220,000 people. At the peak of the wave some CEOs spoke very much in favor of an increasing workforce for the country. "In the very best case, this could be the base for a next 'Wirtschaftswunder'", Daimler-CEO Zetsche said in 2015. A year on, the actual number of refugees put in regular contracts is negligible. The gap between the education level most of the refugees have and the skill level the economy is looking for will remain a challenge for many years to come.

In short, although German industry is enjoying good times, there is little opportunity to relax. Looking at 2017, the DIHK is expecting the dynamic to slow. After expected 1.7 per cent GDP growth this year, the chamber expects 1.2 per cent for 2017. MR

Chinese manufacturers are embracing digital technology and sustainability as part of a government-backed Made in China 2025 strategy

CHINA

FROM WORKSHOP OF WORLD TO MANUFACTURING POWER

China has ambitions to be not just a prolific manufacturer but one that overtakes the West in terms of quality and technology. Miying Yang reports

China, as the world's factory, is on the path towards transforming into the world's manufacturing power, under ambitious government plans and global pressure. In the first three quarters of 2016, China's GDP kept an annual growth rate of 6.7 per cent, thereby achieving the government's target.

THIS ARTICLE EXPLAINS:

- China wants to becoming the world's leading manufacturing nation
- Made in China 2025 is its strategy to catch up with Western countries
- Companies already using digital technology as part of China's own Industry 4.0
- Cost of labour is rising and major companies are automating
- Sustainable development and environment now firmly on manufacturers' agenda

However, there are concerns about overheated real estate markets and inflated debt levels. There are strong differences in growth between different sectors. Technological sectors, such as shipbuilding and automotive industry, exhibited strong growth, while traditional heavy industries with overcapacities, such as steel, are still struggling.

The China Caixin manufacturing purchasing managers' index (PMI) rose to 51.2 in October, which is the highest reading since July 2014. This was mainly driven by the growth of larger firms. A sub index for smaller firms fell, a sign that the country's economic development is still highly dependent on big state-owned firms.

MADE IN CHINA 2025

In 2010, China had overtaken the US as the world's largest industrial producer. In total, China makes more than 20 per cent of the world's goods. Most of the goods are still at the lower end of the value chain compared to other industrial countries with more advanced technologies, such as the US, Germany and Japan. Meanwhile, China is under pressure from emerging economies with cheaper labour and lower costs, such as India and Vietnam.

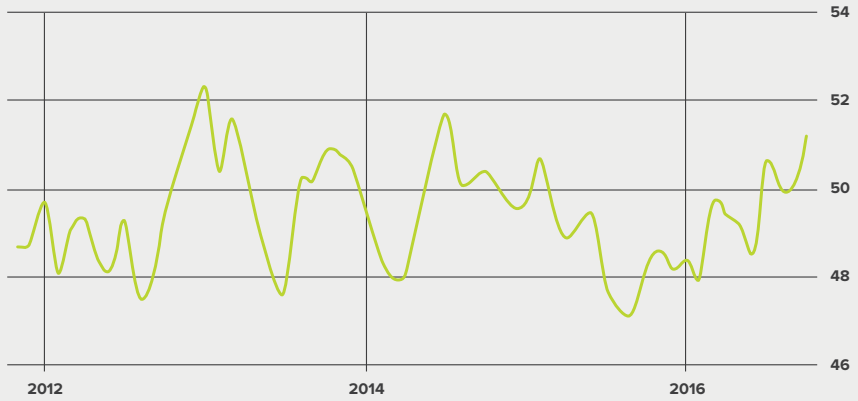
Facing competition from both advanced and emerging economies, in May 2015, China's State Council released Made in China 2025, a national initiative to upgrade China's manufacturing and transform China from the world's factory towards the world's manufacturing power by 2025. This is the first step of China's 30-year three-step strategic plan, which aims to become a medium-level manufacturing power by 2035, and the leader of the world's manufacturing power by 2049. To achieve the ambitious goal, Made in China 2025 identifies four principles and five guidelines, and focuses on five projects and 10 key sectors.

Following the Made in China 2025 strategy, the 13th Five-Year Plan, announced in March 2016, sets out to deepen the implementation of this strategy in the next five years.

As the first year of the 13th Five-Year Plan, 2016 was also a key year for imple-

menting Made in China 2025. The process of implementing Made in China 2025 has already begun. More than 50 pilot projects were launched across China, successfully promoting smart, green and service-oriented development of the manufacturing industry. The spirit of Made in China 2025 has rapidly spread all over the country, from the central government to regional governments, from state-owned companies, to private companies across various sectors. The implementation of Made in China 2025 has made good progress in large manufacturing companies, especially in the 10 key sectors. The government policy provides a great incentive for companies to study how to integrate information technologies into their business, how to improve quality, and how to develop value-added services. Commercial Aircraft Corporation of China (COMAC), the largest Chinese aircraft manufacturer, has started to use big data and cloud technology to reduce safety risks caused by anomalous human behavior.

CHINA CAIXIN MANUFACTURING PURCHASING MANAGERS' INDEX (PMI)



Credit: Source: www.tradingeconomics.com/china/manufacturing-pm

"As one of the 10 key sectors of Made in China 2025, we benefited a lot from government policies to develop technologies. The growth of our company will help the upgrade of a number of related industries and research institutions," says Lei Tao from COMAC. In June 2016, ARJ21, China's first regional jet manufactured by COMAC, made its maiden commercial flight from Chengdu to Shanghai.

The implementation of Made in China 2025 in large companies is rapid and effective. The smaller companies, however, are facing difficulties of upgrading their manufacturing due to the lack of financial support, talent and intelligent technologies. These companies are either purchased by larger companies or going bankrupt. This phenomenon happens in several sectors, such as electrical cars and heavy equipment. Only the companies who are able to produce high value through upgrading the quality, technology or business models could survive and develop. In this way, China is moving the entire manufacturing industry towards a higher end of the value chain.

INTELLIGENT MANUFACTURING TAKES OFF IN CHINA

Made in China 2025 takes learning from Industry 4.0, the core of which is intelligent manufacturing – that is, integrating information technology and production. A number of Chinese companies have started to learn the concepts of intelligent manufacturing: Internet Plus, automation, robotics, Internet of Things and Big Data, and are trying to adopt these technologies into their manufacturing. These technologies have become hot topics across different sectors, and related fields have become the direction for investment. "Manufacturing has to become 'smarter', relying on technologies such as the Internet, cloud computing and big data," as Premier Li Keqiang said at a meeting of the World Economic Forum in Tianjin in June.

Most leading companies are preparing for a future data-driven factory where all internal and external entities are connected through the same information platform. Shaangu Power Group, the largest Chinese turbo-machinery manufacturer, is building up a big data service centre for the entire turbo industry, in order to extend its service solutions and improve service capabilities. The COMAC America Corporation launched the Moore Cloud Civil Aviation Technology Solutions platform as a global internet-based R&D platform to connect resources in China and the US. Hangzhou Steam Turbine (HTC), the largest industrial steam turbine manufacturer in China, has launched several projects to improve quality and integrate information technology into production. The company has built advanced manufacturing systems including a high-tech production workshop, where data is collected and analysed through remote monitoring systems.

TRANSFORMATION VIA SERVITISATION

Transforming to service-oriented manufacturing, known as servitisation, is an important approach in upgrading China's manufacturing from low-end to high-end value. Several large manufacturers have made good progress on servitisation, such as Shaangu Power, HangYang and Hikvision. Shaangu Power is a leading service-oriented manufacturer, selling integrated solutions and services (for example, selling power) rather than turbo-machines alone. The release of Made in China 2025 has accelerated the transformation of Shaangu Power to a service-oriented manufacturer and has greatly improved the integration of intelligent technologies into production and services.

However, not all companies are able to servitize. "It is not easy to transform from a traditional manufacturer to a service-oriented manufacturer," says Sun Weiping, the deputy director of the strategy planning department at Shaangu Power. "Our successful experience in servitisation might not work for other companies due to the different timing and context. Companies need to identify their own pathway of servitisation which are suitable for their situations."

Sustainable development is one of the guidelines of Made in China 2025 strategy. In September, the G20 Hangzhou summit saw a series of agreements reached that would facilitate sustainable growth – economic, social and environmental development. China and the US, the world's two largest economies, have formally joined the Paris Global Climate Agreement. Together they are responsible for 40 per cent of the world's carbon emissions. This year, Chinese policy has put pressure on factories that feature excessive energy consumption and pollution, expediting the shutdown of companies that produce

COMAC ARJ21 passenger jet model on display at Singapore Airshow. The regional jet made its maiden flight in June 2016

Photo: © Commercial Aircraft Corporation of China Ltd

negative environmental impacts. "Cleaner production, energy efficiency and green manufacturing are becoming some of our main considerations," says Sun Jianqiang, the chief engineering manager of Hangzhou Steam Turbine Co.

A 5G REVOLUTION

In 2016, China has made an effort to increase the quality of consumer goods and promote the Made in China brand. The Chinese State Council officially launched a campaign to boost quality and branding in the consumer goods industry, and regards launching investment funds to promote high-end manufacturing as a main goal. Premier Li Keqiang has emphasised the craftsmanship concept in manufacturing for the first time, and stressed efforts to improve quality, build more brands, and diversify the varieties of products.

Lack of innovation and core technologies have been the major challenges for Chinese manufacturing. After hard work on improving technologies and achieving innovation, this year, the technological innovation breakthrough happened in the telecoms sector. With the world's largest number of 4G users, Chinese companies have staked their claim to building global standards for 5G. This new generation of the mobile internet will turn things into reality which are impossible in the 4G era, such as downloading an 8-gigabit movie in seconds. It will also provide the foundation for various data-intensive innovations, such as self-driving cars. The strategy is to make China the world leader in developing 5G services. For China, this is a breakthrough of technological innovation in 2016.

This year, the challenges of Chinese manufacturing remain the increasing cost of labour, the lack of innovation, and high pollution and energy consumption. Since the 1990s, the rapid growth of China's manufacturing has benefited low wages, low cost of resources, low taxes and duties on exported goods, a favorable foreign exchange rate and a highly functional business ecosystem. In recent years, the principal advantage of low cost of labor has come under pressure. Since 2001, average hourly manufacturing wages in China have risen by 12 per cent per year. More and more multinationals have decided to move factories from China to Southeast Asia. This has led to a huge loss of jobs in China.

In addition to that, the automation of manufacturing processes has cut down the number of jobs done by people. In 2016, Foxcoon, the supplier for Apple and Samsung, replaced 60,000 factory workers with robots. The application of robotics can replace repetitive tasks previously done by employees, but it means job losses. On the positive side, the loss of low-end manufacturing jobs pushes Chinese manufacturing to move towards the higher end of the value chain, and train the employees to focus on higher value-added tasks in the manufacturing process. This requires skilled workforces, so education is essential.

LOOKING AHEAD

The implementation of Made in China 2025 has entered a new stage of development. The next step is to set specific targets and tasks, and name responsible parties, based on the respective guidelines. The manufacturers who can transform into service-oriented companies and embed intelligent technologies will lead the market – and those who cannot will die out. Competitive capability will improve, on average. Different types of companies should choose different modes of development. For some time to come, China will be the "manufacturing power", featuring low production costs, a huge labour pool, vast talent base, and business ecosystem.

Recent political developments may also have an influence on the development of Chinese manufacturing. The newly-elected US administration has campaigned for US manufacturers to move their production from China back into the US, put high import taxes on Chinese goods, and force China to increase the value of its currency. All this could cause severe damage to the Chinese economy.

However, so far it is not clear which exact course the new government will take on this. Due to the EU referendum, meanwhile, the United Kingdom will look to improve relationships and economic collaborations with countries outside the EU – which may be beneficial to China. MR

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UK MANUFACTURING REVIEW 16|17

The UK Manufacturing Review is published once a year by Stirling Media. For this edition & back issues contact:
Stirling Media. Registered office: Cedar Studios, 49 Kings Road, Teddington, TW11 0QE.
Stirling Media Ltd
T: +44 208 9730920
M: +44 7920 179496

Brompton Bicycle moved into a new 84,000 sq.ft facility in West London in early 2016. The move gives the company the capability to expand production to meet growing demand. 80% of the 44,000 bikes hand-made each year are sold abroad to 44 countries

ACKNOWLEDGEMENTS

Stirling Media would like to thank everyone involved in the production of the UK Manufacturing Review 2016-2017. Special thanks are due to the sponsors: Henriette Lyttle and Dick Elsy at the High Value Manufacturing Catapult; Tom Lawton and Baljit Bhamra of BDO; Professor Raj Roy of Cranfield University; Nikki Stokes and Kim Olander of Sandvik Coromant; Kate Watcham at BAE Systems; Justin Leonard and Matthew Aldridge of igus; Laura Jones and Neil Lloyd at FBC Manby Bowdler; Bimal Dharsi and Crawford Warnock at ANSYS; Ruth Harknett and Jen Harley at Infor; Chris Pockett and Tarquin Adams at Renishaw; John Kavanagh at JCB; Lisa Barwick at Warwick Manufacturing Group; and Kathy Riley and Mark Swift at manufacturers organisation, EEF.

Thanks for the cooperation of Jo Enderby and Katie Daniels at EPSRC.

Thank you to all the other manufacturing and engineering companies and research organisations that contributed to the editorial, and to all those who participated in the UKMR roundtables this year.

Stirling Media would also like to thank the UKMR production team, especially deputy editor Ben Hargreaves, designers Ben Gibbs and Brendon Ward, and administrator Jennifer Farrell. Thanks also to the the journalists and writers who contributed to the book this year for their excellent work, as well as to Dick Searle of The Packaging Federation, Kate Hills of Make it British, Fareha Lasker, Rosie Hopley of the EPSRC Photonics Hub and Dr Mike Sullivan at Innovate UK.

Many thanks to Caroline for her support during this project.

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Professor Inoue, Director of the International Institute for Green Materials, Josai University, Japan

Dr. Bernard H. Foing, Executive director ILEWG, ESA ESTEC, The Netherlands

Professor Steve Evans, Institute for Manufacturing, Cambridge University

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For more information on this free event:

www.manufacturing-2075.org