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UK MANUFACTURING REVIEW 2015 - 2016 | INDUSTRY SECTORS | SUBJECTS | COUNTRY REPORTS | RESEARCH | stirlingmedia

UK MANUFACTURING REVIEW 2015 - 2016

INDUSTRY SECTORS | SUBJECTS | COUNTRY REPORTS | RESEARCH

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UK MANUFACTURING REVIEW 2015 - 2016

Cover images:

Top right: Airbus A400M, wings made in Broughton. In September the programme achieved in-service delivery targets to the RAF with the 7th aircraft delivered.

Top centre: Studying nucleation is crucial to microstructural control and recycling of metals. An EPSRC-funded research centre at Brunel University won a £10m bid in November for metal casting research, becoming the new EPSRC Future Liquid Metal Engineering Hub.

Top right: 2015 is the International Year of Light and light-based Technologies. The ORC Centre at the University of Southampton was the second EPSRC Centre for Innovative Manufacturing to win new Hub status in November.

Middle left: The 100th P1007 transmission being assembled by Xtrac's Nigel Thorne. The world's biggest manufacturer of motorsport transmissions was The Manufacturer MX Awards overall winner in 2014, when chairman Peter Digby was also the IoD's Director of the Year.

Middle centre: The future of electronics is thought to be in plastic printed designs. The EPSRC Centre in Large-Area Electronics works with an array of industrial partners, including many British SMEs, on plastic electronic manufacturing processes.

Middle right: Laser-induced nucleation for crystallisation of high value materials in continuous manufacturing processes at the Centre for Innovative Manufacturing In Continuous Manufacturing and Crystallisation (CMAC).

Bottom left: At the EPSRC CIM in Laser-based Production Processes includes work includes laser beam shaping, the welding of ultra-thin materials and even underwater welding processes – and much more in this growing discipline.

Bottom centre: Researchers at Cranfield University are working on wire + arc additive manufacturing processes, resulting in often large parts made more efficiently than cutting metal, such as this aerospace component for BAE Systems.

Bottom right: The BAC Mono car at the Goodwood Festival of Speed, where it collected new orders in double-figures. The single-seater, which unofficially broke a Goodwood record, now exports to 16 countries. © BAC Ltd / Andrew Lofthouse

Welcome to the UK Manufacturing Review 2015/2016.

The rationale for this publication was to review a whole year in manufacturing and engineering, in a single reference, to provide a sense of the achievements, progress, and in some cases the inertia or pain experienced, across the board. The book is divided into four main sections: **Industry Sectors, Subjects, Country Reports and Research.** Content from the sponsors is peppered through the book in relevant places. Several sectors and business subjects are unavoidably omitted. I wanted to make the book rich in data and images so that it is more attractive to read.

Why a review of *2015/2016*? You cannot review 2016 of course, but at the end of most main chapters the author offers a forecast of 2016 – what is coming up, what is likely to happen in that sector or subject.

I would like to thank all the supporters and sponsors of this project who made it possible. Many thanks for backing this idea, I hope that we have repaid your faith with a novel, high quality product, which has a clear place in the publishing calendar. Acknowledgements to (nearly) all those involved are at the back. I must also thank the talented writers and journalists who have contributed. Apologies and thank you to those I may have missed.

There is plenty to read about in the Review but I would urge avid readers of the manufacturing press to devote some time to the Manufacturing Research section. This is where UK manufacturing competitiveness really starts, in my opinion, and there is some simply amazing stuff happening in these research centres that is being harnessed by business for the good of the UK economy and society. These stories need telling.

In the sidebar are some fascinating facts about the images we've used on the front cover that help to illustrate how broad, deep and rich manufacturing in this country is.

Enjoy.

Will Stirling

Editor and Publisher,
UK Manufacturing
Review 2015/16

Contents

07 Forewords from our main sponsors
BDO, Barclays, Airbus, EPSRC, High Value Manufacturing Catapult, Cranfield University

18 2015 Timeline: The road to 2016

20 A unique opportunity to reindustrialise Britain
James Selka, The Manufacturing Technologies Association

23 INDUSTRY SECTORS

24 AEROSPACE
Companies must invest in new processes if it is to keep its 2nd position in the global civil aerospace league table, while pressure mounts to follow the big aerospace hubs. Chuck Grieve reports

30 AIRBUS GROUP UK – PHOTO GALLERY
A showcase of some of Airbus's products made in Britain

32 AUTOMOTIVE
GM securing 2,000 jobs for a new Astra model at Ellesmere Port, is just one highlight in a purple patch for UK automotive. Ian Adcock reports

38 CHEMICALS
Upstream and downstream, Sarah Houlton reviews the fortunes of the booming chemicals industry, which topped £50bn output in 2014.

43 PHARMACEUTICALS
After pharma manufacturing fell by c. 26% between 2009 and 2013, prospects are now bright thanks to a host of forward-thinking, multidisciplinary initiatives with collaboration at the heart, says Zoe Cormier

46 THE NATIONAL BIOLOGICS MANUFACTURING CENTRE
This new £38m centre for biopharmaceutical research, run by the Centre for Process Innovation, was opened in September

48 METALS INDUSTRY
Closures and redundancies in the steel sector dominated the business pages in October. This sadness belies some encouraging news in liquid metal research and the aluminium industry, says Andy Sandford.

52 MACHINERY SECTOR: ADVANCED ENGINEERING OVERVIEW
The MTA's statistician Geoff Noon reveals the advanced engineering sector in 2015 in numbers.

55 FOOD & DRINK
The price wars omnipresent in the supermarket sector, with the rise of discounters like Aldi and Lidl the takeaway story of 2015, affects food manufacturing. Paul Gander reports.

60 ELECTRONICS
Peter Marsh reports that the household, white goods makers of yesteryear in Britain have transformed into SMEs excelling in niche areas of electronics – in fields that in many cases are barely recognisable.

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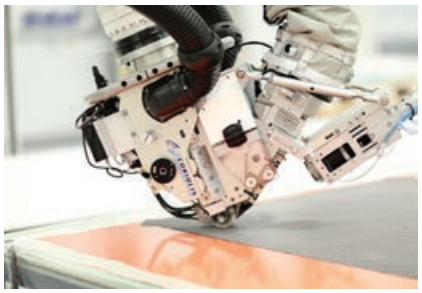
64 POWER GENERATION
The UK has a strong base in power generation equipment, from gas turbines to small and large wind turbines. Siemens' offshore wind turbine factory in Hull will soon become the jewel in the crown. Helen Knight reports.

67 RAIL
Rail industry expert Christian Wolmar explains that while the rail industry still has problems of efficiency and bureaucracy, few can criticize the recent and planned levels of investment

70 SPACE and OIL & GAS
The UK's biggest civil aerospace exporter, Airbus, has a huge influence on Britain's space and oil & gas sectors. It manufactures satellites and supports the North Sea O&G industry at Europe's biggest heliport.

72 COMPOSITES
Alison Starr of the National Composites Centre reviews some important progress in the UK's composites industry, exemplified by a doubling in size of the Centre, part of the High Value Manufacturing Catapult.



74 ACTION! THE UKMR 2015 TALKING WALL
Businessmen and women across the manufacturing sector opine what industry and government need to do in 2016 to keep the sector on track.

77 BUSINESS SUBJECTS

78 HVM CATAPULT: A REVIEW OF THE YEAR
Alan Tovey reveals some of the 2015 achievements of the HVM Catapult, with special focus on three centres: The Advanced Forming Research Centre, the Nuclear AMRC and Warwick Manufacturing Group.

80 MANUFACTURING TECNOLOGY – BIG DATA
Big data is meant to transform business efficiency by revealing inefficiencies and savings and improving visibility of company departments. Malcolm Wheatley shows the manufacturing sector's adoption of BD has been slow thus far.

86 THE DIGITAL FACTORY – INDUSTRY 4.0
What is the much-hyped "Industry 4.0" and are any UK factories actually using it? The Manufacturing Technology Centre shows increasing signs of companies applying this technology. Will Stirling reports.

92 PEOPLE, SKILLS AND RECRUITMENT
John Pullin shows that the engineering and technical skills agenda is still characterized by too many competing programmes and initiatives. Importantly, however, they are working – although not at the rate they must do to close the vast gap.

96 AN APPRENTICESHIP AND A DEGREE
Airbus reveals the first UK programme to combine a technical apprenticeship with a degree option

97 2016 MARKETING FOR ENGINEERING
A successful manufacturing business relies almost as much on sales and marketing as in core production & design abilities. TAG's Sylvia Laws explains what firms should look for in digital and other marketing channels.

98 ENGAGING WITH EDUCATION – SIR DAVID MCMURTRY
Renishaw chairman Sir David McMurtry FREng CBE explains why Renishaw has an entire division devoted to engaging with schools, and its efforts to increase the proportion of women in engineering

102 TRADE
Britain's trade gap widened in 2015 (based on current data), thwarting the Chancellor's ambitions for £1 trillion exports by 2020. SuperPort's Bernard Molloy says more trade requires big improvements in the North's logistics infrastructure. Charles Orton-Jones reports

107 ROUTE TO INTERNATIONAL MARKETS
The MTA supports UK-based advanced engineering companies in exporting by arranging support at several key international trade shows.

108 PRODUCTIVITY
Low labour productivity in the UK economy has been much-lamented, leading experts to ponder if manufacturing is a cause, a solution or both. Peter Marsh analyses productivity in different manufacturing sectors.

114 THE MADE IN SHEFFIELD PRODUCTITIVTY ROUNDTABLE
How can manufacturing increase productivity and is lower employment inevitable to do so? Twelve company directors, Made in Sheffield and the Sheffield Chamber meet to debate the cause and effect.

120 UNIPART'S PRODUCTIVITY PUZZLE
The logistics and manufacturing company tries to solve the puzzle with an innovative online tool

123 LEADERSHIP OPINION EEF'S TERRY SCUOLER
Terry Scuoler highlights modern manufacturing's strengths and vital importance for a regionally balanced economy

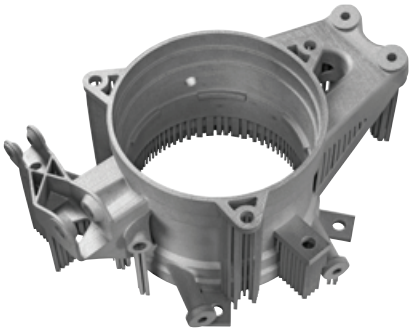
124 THE UK ENERGY MARKET
Jane Gray reviews a turbulent and busy year in the energy market as regulators, the Big 6 firms and industry battle to secure competitive energy prices for business.

128 ENERGY EFFICIENCY AND BOSCH
Robert Bosch has a multitude of innovations that improve energy efficiency, from power stations and automotive engines to sensors and autonomous lawn mowers

130 INDUSTRIAL SUSTAINABILITY
Britain is making solid but not radical progress in reducing CO2 emissions. The transformation of industry into a fully sustainable resource loop is still a long way off, but Isabella Kamynski reveals several important developments

136 INNOVATION AND GOVERNMENT SUPPORT
Business can be quick to chastise government fickleness in supporting industry long-term, but government's efforts to encourage innovation in 2015 should be lauded. Malcolm Wheatley reports

140 ADDITIVE MANUFACTURING
A new metal jetting process developed with Canon company OCÉ, the UK entry of the ARBURG Freeformer that uses standard granulate polymers, research from the EPSRC AM Centre - Rachel Park summarises the year for AM



143 GREENING AUTOMOTIVE - LORD BHATTACHARYYA
If UK automotive wants to rule the world it will need to green-up. Lord Bhattacharyya Kt, CBE, FREng, FRS reflects on some of Warwick Manufacturing Group's 2015 achievements

144 RENISHAW'S SOLUTIONS CENTRES, and AM's EFFECT ON BUSINESS
Renishaw's new AM Solutions Centres provides consultancy for businesses looking to develop an additive division, while IfM's Tim Minshall considers how AM can disrupt established business models

148 PRODUCT SERVICE SYSTEMS RESEARCH
The UK is a world-leader for product-service and through-life engineering services (TES) research = making services from products and maintaining assets. The EPSRC TES Centre launched a national strategy for TES in September.

156 MID-SIZED COMPANIES
Mid-sized manufacturing companies, broadly in the £15 to £500m turnover range, are vital for Britain's export prospects and regional employment. Prof Steve Roper of Warwick Business School assesses the performance of the Middle.

160 TAX AND INNOVATION
Elizabeth Anderson assesses how the UK tax system is affecting companies' approach to innovation, finding that the tax relief on offer has been both well-subscribed and effective.

162 FINANCE FOR MANUFACTURING
Kickstarter and the challenger banks are two forms of alternative finance getting a stronger foothold with manufacturers. James Hurley reports

165 EDUCATION ZONE
Articles from Primary Engineer's Susan Scurlock, George Edwards, Sir Richard Brook OBE and Cranfield University's Watch It Made scheme discuss how kids are introduced to engineering.

173 COUNTRY REPORTS

UKMR 2015 provides reports on seven countries that are either competitors to or comparators with the UK, or both.

174 THE UNITED STATES
By Monica Schnitger

178 GERMANY
By Manuel Heckel

182 FRANCE
By Marco Pisano

185 CHINA SPECIAL FOCUS – NEW ENERGY VEHICLES
By Dr Chao Lu

186 CHINA
By Yuan Tao

190 INDIA
By Huned Contractor

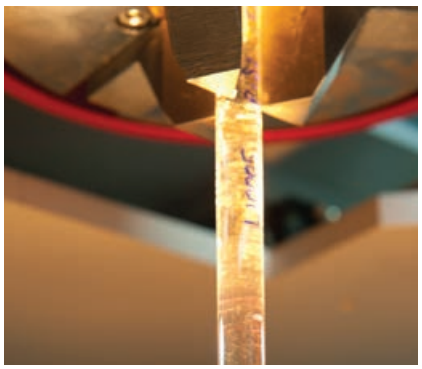
194 JAPAN
By Miho Okada

198 AFRICA
By Andres Ilves

203 MANUFACTURING RESEARCH

This 48-page section explores in detail some highlights of the Engeineering and Physical Science Research Council's year, including establishing the new Future Manufacturing Hubs, four Foresight Fellowships, and business success stories. The section also profiles the new Future Hub in Liquid Metal Engineering and 2015 achievements of 11 EPSRC Centres for Innovative Manufacturing, or CIMS.

204 EPSRC – NEW FUTURE MANUFACTURING HUBS
Liquid Metal Engineering at Brunel University London and Photonics at the University of Southampton



206 BUILDING SUCCESS
Three good examples of how EPSRC-funded manufacturing research has added value and created jobs in the UK in 2015

207 THE 2015 EPSRC FORESIGHT FELLOWS
EPSRC announced the first in a new series of fellowships, The Foresight Fellowships, in 2015

208 EPSRC FUTURE LIQUID METAL ENGINEERING HUB (LiME Hub)
The centre formerly known as the EPSRC CIM in LiME won a £10m grant, became a new Hub and will now expand research to help perfect new casting processes to enable, for example, a domestic automotive engine casting industry

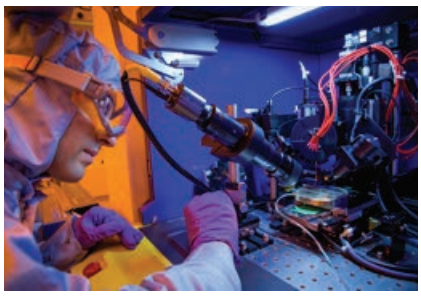
212 EPSRC CIM IN ADDITIVE MANUFACTURING

216 EPSRC CIM IN THROUGH-LIFE ENGINEERING SERVICES

220 EPSRC CIM IN CONTINUOUS MANUFACTURING & CRYSTALLISATION (CMAC)

224 EPSRC CIM IN INTELLIGENT AUTOMATION

228 EPSRC CIM IN LARGE-AREA ELECTRONICS



230 EPSRC CIM IN MEDICAL DEVICES (MeDe INNOVATION)

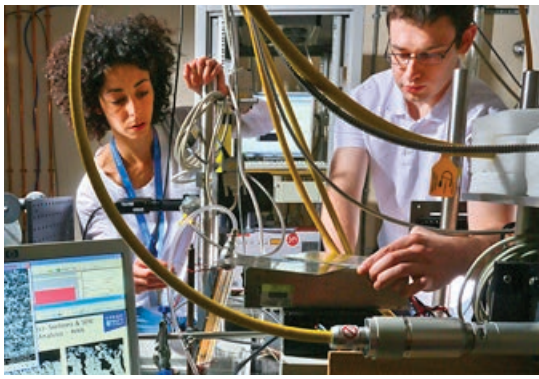
234 EPSRC CIM IN EMERGING MACROCELLULAR THERAPIES

236 EPSRC CIM IN FOOD

240 EPSRC CIM IN INDUSTRIAL SUSTAINABILITY

244 EPSRC CIM IN ADVANCED METROLOGY

248 EPSRC CIM IN LASER-BASED PRODUCTION PROCESSES



251 INNOVATION MAP
How Gripple navigates its way to innovative products

252 CONTRIBUTING WRITERS
Profiles of the journalists, writers and academics who contributed to UKMR 2015/2016

254 ACKNOWLEDGEMENTS

"We need an adviser that has a real understanding of our sector"

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Tom Lawton
National Head of Manufacturing
BDO LLP

We hope that this review provides an informative read showcasing the strengths, weaknesses, opportunities and threats of what is a vibrant and interesting sector; one which still has a critical role to play in the success of the UK economy.

A huge and growing global market that will have increased spending power

Manufacturing is a global industry and UK manufacturers are impacted by the short term changes in the global market, which in the recent past and short term future have not been and will not be helpful. However, from a global perspective the long term future for global and UK manufacturing could be extremely promising. The expected growth of China, India and other developing economies will continue to create new consumers demanding more manufactured goods. This trend of long term growth and more spending power in the developing economies should provide a massive market opportunity for UK manufacturing.

Significant changes are expected from digitisation and automation

The movement towards more automation, digitisation and new materials ("Industrie 4.0") is expected to have significant opportunities and challenges, particularly for manufacturers in the more developed economies. The UK's historic strengths of innovation, design, service and productivity position us well for continued success, but UK manufacturers will need to change and invest to keep pace with global competitors. The pace of change over the next 5 to 10 years will be rapid, requiring new thinking as to how best to use the different techniques that will be developed through Industrie 4.0. This is likely to have short term (pressures to automate, digitise through the supply chain, reduce costs) and long term (education, skills, training) implications.

Despite the issues of the past

The decline of UK manufacturing has been significant and this is highly likely to drop further in the short term, as a chasing pack of developing economies use manufacturing as their key driver of economic growth and well-being.

In developed countries such as the UK, it is expected that manufacturing's share of GDP and employment will decline over time, as the growing wealth of the country switches demand from goods towards services. Whilst other developed and developing countries identified the need for government to support manufacturing, the UK mostly adopted a "hands off" approach that provided very limited support for the sector. In order to help support a growing and dynamic UK manufacturing sector that is built on our core strengths, there is a need for a more interventionist approach from government - an industrial policy.

By creating a long term sustainable framework

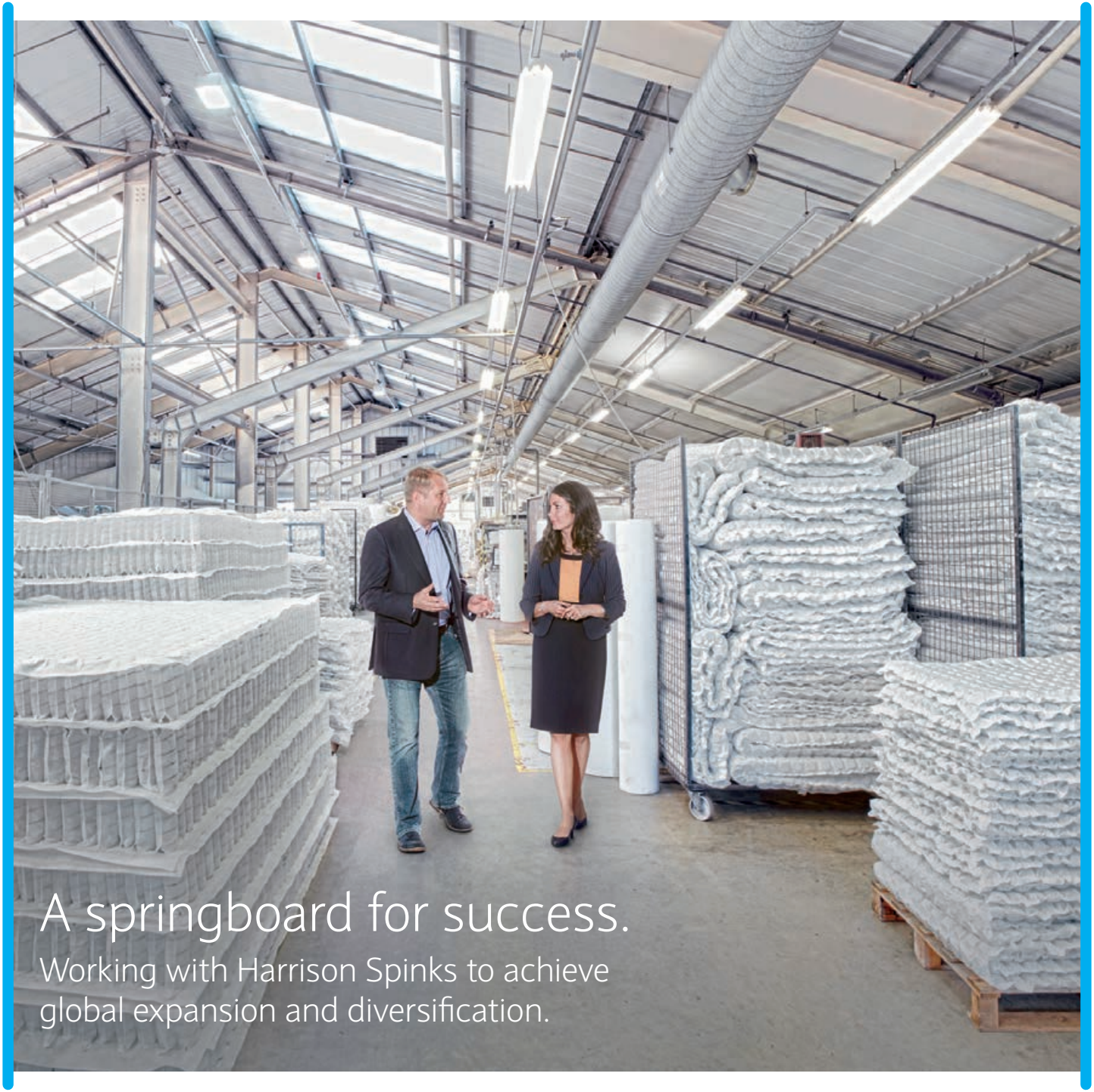
It is accepted that establishing an industrial policy in a developed economy with a rapidly changing global perspective is complex. But to stall the ongoing decline of the UK's industrial economy, more radical and robust long term ideas need to be implemented and quickly. The cornerstones for any policy or framework from government would include:

- Developing clear and sustainable objectives for UK manufacturing. These need to be aligned to the current strengths of the sector and also look towards the key opportunities for growth in the future. We are not a low cost manufacturing location and need to identify, grow and compete in the global market on our key strengths – innovation, design, service and productivity.
- Establish policies that will help support the factors above over the long term. For example: our investment in automation has been weak compared to most of our competitors and this damages the sector's productivity and innovation. Tax policies that really support significant capital investment would give a clear directional signal to the sector.
- Set targets that measure and help respond quickly to the factors in both of the above. In the absence of hard targets, there can be no accountability for developing and implementing the right initiatives that work over the long-term.

Many initiatives have been introduced in recent years to "help manufacturing" but too many of these initiatives have not delivered on their intention.

A bold first step

The UK needs to create a long term cross-party supported industrial policy with manufacturing at its core. To give this policy a real edge and the ability to cut across various inter-government departments, we recommend the appointment of a Minister for Manufacturing. This should be a powerful position within the Government, ideally a cabinet post, to send out a clear message that the future of manufacturing is important and will get the level of integrated support it needs to take advantage of the global opportunity. UKMR-15



Pocket spring manufacturing line, Leeds
Simon Spinks, MD, Harrison Spinks
Alex Pryce, Relationship Director, Barclays

Luxury bed and mattress manufacturer Harrison Spinks are expanding internationally, applying their innovative spring technology to new products such as baby mattresses, footwear and automotive seating. Barclays meets all their corporate banking needs, providing a dedicated relationship team with detailed knowledge of the manufacturing sector. As Simon Spinks, MD, says, "We're currently a mattress manufacturer that makes spring components. With Barclays' support we'll become a truly global components manufacturer."

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Mike Rigby
Head of Manufacturing Transport and Logistics, Barclays

Manufacturers appear to have had a progressive year in 2015, with some reasonable growth seen across the sector as a whole. This is generally confirmed at a client level with lots of talk of a "record year for sales" and "more visible order books".

AFTER THE UNCERTAINTY

Manufacturers would typically say that, to feel confident, they need political stability, a predictable economic outlook and a set of primary industries that are performing. We have had two of these but the political uncertainty arising from the General Election at the beginning of the year did create disruption and hence the sector's performance is more impressive.

However, as we approach 2016, we seem to have some more uncertainty for the sector, with the economic horizon looking more challenging and the effect of an appreciation in sterling likely to have further impact. This will, unsurprisingly, lead business to be more cautious about future investment.

INVESTING IN THE FUTURE

Looking backwards first, the sector did feel the impact of the General Election. But confidence rebounded towards the second half of the year. Although the PMI data still does not look especially strong, manufacturers have been increasing investment for their future – not only in fixed assets, but also in research and development. Our recent survey of UK manufacturers also revealed that 64% of respondents saw the potential of increased investment in automation and robotic equipment. This bodes well for the future and shows the sector trying to plan for the next evolution in manufacturing processes.

LOOKING BEYOND EUROPE

UK manufacturers are increasingly paying attention to international trade beyond Europe, especially given the lacklustre growth in the Eurozone and potential risks from Brexit. This is a big focus going into the new year and reflects the challenge faced around Europe – and the opportunity seen further afield.

The skills gap is, of course, a hot topic across the manufacturing sector and remains one of the most commonly talked about concerns. The combination of a shortage of labour and a return to wage inflation is unwelcome to a sector that is one of the UK's largest employers. Although levels of production remain in positive territory, for manufacturers to really ramp up, easy access to skilled labour is a key constituent.

From a funding perspective, the sector has benefited from a very plentiful supply of finance which has particularly resulted in an increase in demand for working capital. We have also seen an increased demand for more flexible financing solutions, on both working capital and asset purchases as they look to ensure cash flows are protected. With dynamic foreign exchange markets and the length of time between manufacturers receiving an order and receiving payment this remains an area of specific focus, and risk, for the finance teams.

POSITIVE OUTLOOK

We remain positive for 2016, given the overall UK economic forecasts of continued growth and an in-flow of capital to stimulate the industry. New technology, workforce upskilling and cost control will continue to be main areas of focus. In addition, to protect margins and drive growth, manufacturers will need to continue differentiating their products on quality and service as we move forward. The sector has had a good 2015 and hopefully 2016 will continue this trend. UKMR-15

Michael.rigby@barclayscorp.com

AIRBUS IN THE UK: THE FACTS

- 14,000 Employees
- Exports of more than £4 billion per year
- £500 million annual UK R&D spending
- Indirectly supports 135,000 UK jobs
- More than 4,000 companies in our UK supply chain
- The UK's largest civil aerospace company and civil aerospace exporter
- Airbus Defence and Space is the biggest supplier of large aircraft to the RAF
- Airbus Defence and Space is the UK's No.1 space company
- Airbus Helicopters is Britain's civil helicopter hub
- The world flies on Airbus wings made in Britain

Paul Kahn
President, Airbus Group UK

Think of a company which exports more than £4 billion every year from the UK and has a future UK order book of eight years. If Airbus Group's UK operations were an independent business, we would be a FTSE 100 company; we are not, we are bigger, more integrated and more global than that!

But Airbus's 14,000 employees in Britain, based in 20 sites from Aberdeen to Portsmouth, do much more for the UK than simply produce impressive economic numbers. Consider some of the ways that Airbus Group's three UK divisions – Airbus, Defence and Space, and Helicopters – boost growth and help build a stronger UK economy for the future.

In November 2014, we announced an investment of more than £100 million in our UK operations in conjunction with the government. Half of this money will be directly invested in Wales, for research and development in advanced technologies. Across the UK, around 100,000 jobs are generated by work on the wings for Airbus's aircraft at sites in Filton, near Bristol, and Broughton in north Wales – both directly, but also indirectly through an extended supply chain of over 4,000 companies. The bulk of these jobs are highly skilled. You might be surprised to learn that Airbus in the UK employs more engineers in high-value manufacturing work than Jaguar Land Rover.

"Airbus and its industry partners are committed to investing some £1 billion under AGP, with the government matching the figure, to help tackle barriers to growth, boost exports and increase the number of high-value jobs in the UK"

It is of course true, as Airbus Group's chief executive Tom Enders recently remarked, that we love to compete and we love to win. But in an industry as complex as ours, we also understand the importance of collaboration. In the UK, Airbus's success depends on a network of partnerships that connect employees, suppliers, technical experts and academia, across every area of the economy.

"The UK's Defence Growth Partnership, where Airbus is a key member, aims to increase the UK space industry's annual revenue from £7.9 billion in 2009 to a target of £40 billion by 2030, of which exports will account for more than 50%"

For example, Airbus is proud to be playing a leading role in the UK's Aerospace Growth Partnership. The AGP was established in 2010 as a sector-wide collaboration with government to develop Britain's world-class civil aerospace industry in the coming decades. Airbus and its industry partners are committed to investing some £1 billion under AGP, with the government matching the figure, to help tackle barriers to growth, boost exports and increase the number of high-value jobs in the UK.

In addition, Airbus is a key member of the UK's Defence Growth Partnership, which aims to build on the UK's strengths in air capabilities and advanced systems to deliver security, growth and prosperity in the years ahead. Meanwhile, Airbus is at the forefront of the UK's Space Innovation & Growth Strategy. The programme aims to increase the UK space industry's annual revenue from £7.9 billion in 2009 to a target of £40 billion by 2030, of which exports will account for more than 50 per cent.

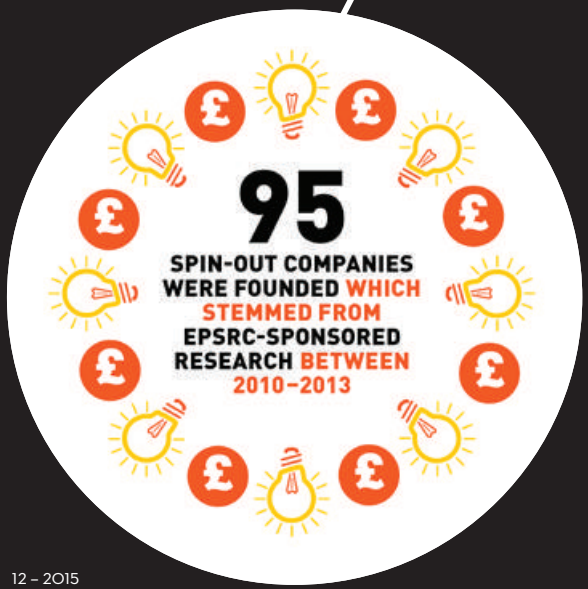
As it looks to the future, Airbus remains proud of its deep roots in Britain's engineering and industrial history, extending back more than a century through predecessor companies. Yet as part of a global group, we are also aware that the UK's economic strength now depends critically on the rest of the world. You can find Airbus technology from the depths of the ocean to the surface of Mars, much of it designed and built by our employees in the UK. In an interconnected universe Airbus make it fly, and whether making wings or landing on comets we will continue to help take the UK even higher. UKMR-15

115
Centres
for Doctoral Training

EPSRC
Engineering and Physical Sciences Research Council

14
Centres for Innovative Manufacturing

2
Future Manufacturing Hubs
created in November 2015



EPSRC
Engineering and Physical Sciences Research Council

Professor Philip Nelson, Chief Executive, the Engineering and Physical Sciences Research Council (EPSRC)

For 21 years, the EPSRC has been supporting UK manufacturing. It is part of the council's core mission to provide the knowledge, technology and trained experts to support the UK's economy.

It is a commitment that has meant two decades of close collaboration with British industry, with major established partners such as Rolls-Royce, GSK and BP, and with new start-ups such as SPI Lasers and Intelligent Energy, which have become significant earners in their own right. And in our 2015 Strategic Plan, we committed to strengthening these partnerships.

The EPSRC is the UK's primary funder of engineering and physical sciences research, supporting research and training at universities. Each year we fund research to the tune of £800 million, raising an additional £230 million through our partnerships with business, charities and public bodies.

As well as the knowledge generated by the 6,000 research projects we fund at any time, our funding supports typically 9,000 doctoral students, nearly 30,000 in total since 2005 – at least a third of whom go straight into industry and commerce, with many more moving on to further postdoctoral research.

The message we get from employers is that the skills these recruits bring are essential to their success: 74% say PhD recruits achieve high-impact results within two years of joining their companies. Sir James Dyson told us that "a ready supply of the best problem solvers in the world... will help ensure that we can continue to compete internationally".

An important initiative in keeping the supply healthy has been the establishment of 115 Centres for Doctoral Training (CDTs) that are led by 33 universities and involve a total of 40 institutions; these were formed following a call in 2013 and expanded this year.

With a critical mass of academic expertise and substantial industrial engagement, these centres are aimed at underpinning the UK's key strategic skills needs. Backed by 1,100 partnering companies, these centres will train a further 7,000 highly skilled researchers over the next eight years.

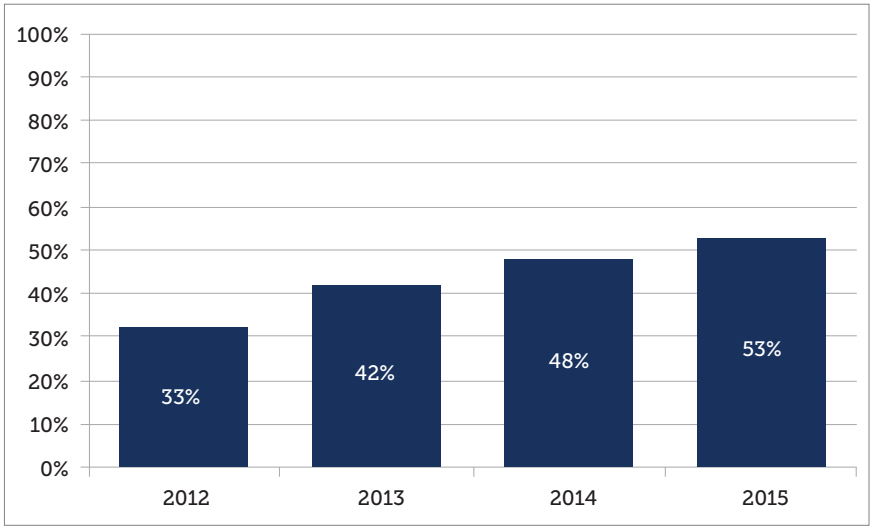
Such was the strength of the backing we received from our industrial partners, we have been able to establish many more centres than we originally planned. Since 2012, we have moved from a third of our portfolio involving collaboration with non-academic partners to over a half in 2015 (see graph below).

The same year saw a renewal of this commitment to collaboration, with the establishment of Manufacturing Hubs where leading academics work alongside experts from industry on innovative solutions to today's manufacturing challenges.

In the past, schemes such as these have shown a return of £9.60 for every £1 we invest, proof of how fertile the collaborations that we support can be. Four hundred new businesses were spun out between 2008 and 2013 from

projects we supported, employing 50,000 people and contributing £4 billion to the economy.

Our investments in research are investments in the future of the UK's science base, its economy, its industry – and its talented people. Year-on-year they pay real dividends, but science is a long-term game that requires a long-term view. UKMR-15



Proportion of EPSRC portfolio that is collaborative with non-academic partners

Infographics courtesy of eef The manufacturers' organisation

UK MANUFACTURING 2015, THE FACTS

2.6 MILLION EMPLOYEES

10% OF GVA

44% OF TOTAL EXPORTS

69% OF BUSINESS R&D

15% OF BUSINESS INVESTMENT

JOBS – MORE PRODUCTIVE AND BETTER PAID

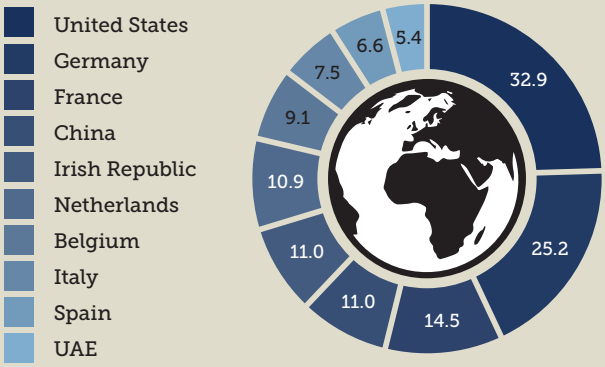
Average earnings
Mean annual gross pay (£)

MANUFACTURING	£30,900
SERVICES	£26,546
WHOLE ECONOMY	£27,271

Source: ASHE, ONS

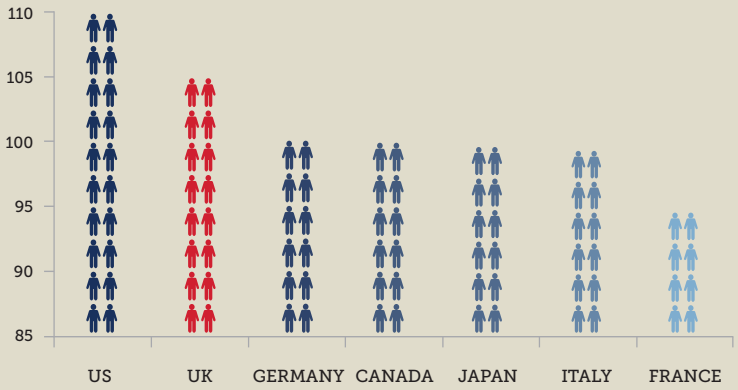
TOP 10 EXPORT DESTINATIONS, 2014

Value of exports (£bn)



UK MANUFACTURERS GOING FOR GROWTH

UK manufacturers have been creating jobs
Manufacturing employment 2014. 210=100



Source: OECD

STRATEGY, 2015

"Thanks to the Catapult network and the progress made by Innovate UK through its various programmes, we now have the innovation infrastructure capable of helping us scaling up our public and business investment."

HM Treasury and Department for Business Innovation and Skills - Our Plan for Growth: Science and Innovation

Source: Engineering Employers' Federation, 2015 Factcard

Dick Elsy
CEO, The HVM Catapult

HVM Catapult: Highlights

£15 net benefits
to the UK economy for every £1 of public core funding received

Economic impact of £1.6 billion
potential to generate a further £6.1 billion by 2020

1,259
Number of HVMC projects

1,514
Private sector clients

£183 million
Value of contracts

1,577
employees

"I have come to realise the crucial role organisations such as the Nuclear AMRC play in supporting both regional and national economies."

Bank of England Governor Mark Carney

Volatility persists on the global economic stage. Trouble on the Chinese markets, ongoing concerns in the Eurozone, a strong pound and weak crude oil prices are contributing to a period of uncertainty.

It is no surprise that this is reflected in the most recent data on the UK manufacturing industry, with the EEF Manufacturing Outlook showing that British manufacturers are less confident about their growth prospects in 2016.

The dip in confidence is based on recent output indicators, with the sector experiencing the weakest output growth since 2009, and exporters seeing the worst new sales figures in six years.

All this is against a backdrop of a surprise, sustained feelgood period, with commitment to UK high value manufacturing firmly on the government's agenda, a general recognition that we need to attract more new talent into the sector, industry confidence high – and manufacturers starting to bring off-shored production back to this country.

It might have been unrealistic to expect this journey to be without some bumps on the way. Yet long term commitment and investment in the future growth of UK manufacturing is now, more than ever, critically important.

I am therefore encouraged by the fact that UK manufacturers' investment plans remain resilient, with a commitment to investing in new technology to increase productivity and drive ongoing growth.

Industry understands that the competitive edge will fall to those companies who stay ahead of the curve and who maximise business opportunities by developing and implementing new technology solutions. Investment in technology innovation improves productivity, resilience and business growth. It is no coincidence that the two industries that spend the most on innovation – aerospace and automotive – have seen the greatest productivity gains and continue to do well.

Technologies that were developed for

these industries now find their way into rail, oil and gas and even medical applications, and their success serves as an important inspiration and example for other sectors.

At times of uncertainty, however, high-risk investment in innovation can seem less attractive. This is where the High Value Manufacturing Catapult plays an important role.

Working with the HVM Catapult enables companies to gain access to world-class expertise and the latest industrial scale equipment, allowing them to scale up their innovation, while deferring their own investment decisions until it has been established that the innovation can be exploited on a commercial scale.

Anyone with an interest in and passion for UK manufacturing has a responsibility to make government and other decision-makers understand the importance of long-term commitment to, and investment in, manufacturing technology innovation.

Because only by nurturing a healthy manufacturing sector – making and selling things – will Britain create a balanced economy which addresses its trade deficit and achieves ongoing sustainable growth. UKMR-15




National Manufacturing Debate (NMD) – A productive conversation

The National Manufacturing Debate, which is hosted each year at Cranfield University, started in 2010 in the depths of the recession as a means to stimulate discussion around manufacturing issues. It has run annually since then, bringing together professionals from a range of manufacturing sectors and countries to debate current challenges in the industry.

"We wanted a content-rich, fact-based debate," said Professor Rajkumar Roy, the founder of these debates and Cranfield's Director of Manufacturing. "It had to be absolutely neutral, talking about the most relevant topics of the year."

Since the start, more than 100 representatives from 451 companies and universities have considered topics as diverse as 2012's 'Enhancing the supply chain for growth', to 2015's subject "UK Reshoring Capability". Subjects are chosen by their currency, what is being discussed in the media, politics and in companies and also suggested by stakeholders, including attendees from previous events.

The debates are intentionally British in focus. "We have to regenerate British manufacturing," Professor Roy said. "While a long term goal is to have a global focus to these events, we have to start here first of all."

He continued: "Our main achievement is that this is a nationally recognised forum to debate fact-based issues, with less emotion. We have worked hard to maintain the debate's neutrality and make sure that contradictory views are heard in these discussions. This is an achievement."

The Debate is chaired by Sir Alec Broers, former vice chancellor of Cambridge University and president of the Royal Academy of Engineering and has included speakers from industry, academia as well as industry bodies such as the Confederation of British Industry.

The next debate will be in May 2016 when the subject of Accelerating UK Manufacturing Growth will be under discussion. Questions around how UK manufacturing has fared since the 2008 recession, what can be done to improve manufacturing growth in the UK and whether British manufacturing companies can influence UK manufacturing growth – or whether this has to be government led – are already slated.

National Manufacturing Debates topics since 2010:

2010 Manufacturing for Recovery

2011 Investment, Incentives and Innovation

2012 Enhancing the Supply Chain for Growth

2013 National Strategy for UK Manufacturing

2014 Manufacturing Productivity in the UK

2015 UK Reshoring Capability

2016 Accelerating UK Manufacturing Growth

Registration for the 2016 National Manufacturing Debate is now open.

www.national-manufacturing-debate.org.uk

Cranfield UNIVERSITY

Professor Rajkumar Roy
Director of Manufacturing
Cranfield University

Cranfield Manufacturing is:

challenging the limits of additive layer manufacturing to produce large aerospace parts

designing and building ultra-precision and desktop-sized machining centres for small but precise components

prototyping new thermal barrier coatings for the turbine blades

digitising manual manufacturing operations for automation

experimenting with how human and robot can work together in the future

simulating and visualizing manufacturing systems for operations excellence

developing technologies and solutions for through-life engineering services

finally offering solutions for sustainable manufacturing

"With the science base in manufacturing research, Cranfield is defining future manufacturing technologies, systems and management practices. We are looking to future business models and social evolution and how that leverages on cutting-edge technologies to create wealth in a sustainable manner"

Cranfield is a driving force in the advancement of manufacturing innovation. We innovate and offer complete solutions (Technology Readiness Levels/ TRL 1-6) to high value manufacturers, government organisations and the supply chain, to improve their competitiveness and long-term sustainability.

Manufacturing at Cranfield University is unique in its multidisciplinary approach that brings together expertise in the areas of design, technology and management. We integrate fundamental materials science research with manufacturing to develop novel technologies and improve the science base of the manufacturing research. Our world-class research facilities are near industry scale and are available for exploring novel technologies and processes.

Cranfield Manufacturing is proud of its collaboration and long-term partnership with the manufacturing industry across multiple sectors: from aerospace, automotive and defence through to process manufacturing.

We have developed a unique and comprehensive approach to industry collaboration. Our Executive Masters programmes, such as those in Operations Excellence, are designed mostly for the employees of our industrial partners, and they are well-recognised within companies for their leadership development. Our postgraduate courses have also been designed and developed in collaboration with industry to ensure that they provide the skills and knowledge that organisations require.

Our excellence in manufacturing education and training is recognised by a number of professional institutions within the manufacturing sector. These include the Institution of Mechanical Engineers (IMechE), the Institution of Engineering & Technology (IET), the Institution of Engineering Designers, the Institute of Materials, Minerals and Mining (IOM3) and the Royal Aeronautical Society (RAeS).

With the science base in manufacturing research, Cranfield is defining the future manufacturing technologies, systems and management practices. We are looking to future business models and social evolution and how that leverages on cutting-edge technologies to create wealth in a sustainable manner.

Cranfield's thought leadership in manufacturing technology and management is influencing the global manufacturing leadership. Cranfield is also the home for the National Manufacturing Debate that challenges the status quo and analyses the future for the UK Manufacturing. Facts about manufacturing productivity to reshoring are debated among large and small companies, government, academia and international experts.

Our future vision of 'manufacturing on the Moon' has become the central challenge for the National Apprenticeship Competition. Our thought leadership when it comes to postgraduate education in manufacturing is leading the debate on the future of an 'industry, academia and student' knowledge partnership, in a more connected world. UKMR-15

The Road to 2016

13 January

Royal Society president and geneticist Sir Paul Nurse tells BBC's Newsnight that politicians are "cowardly" in their ignorance of scientific evidence that may be unpopular with the public, adding the importance of big science initiatives should also be highlighted by the government, describing them as "extremely powerful and good for us"

15 January

Defence Growth Partnership appoints electronics engineer Steve Brittan, former Qinetiq boss, as chief executive of new Defence Solutions Centre. Centre opened by Philip Dunne and Matthew Hancock two months later

23 February

£165 million upgrade to Eurofighter capability announced, helping sustain more than 200 engineering jobs in Lancashire, where upgrade work will take place at BAE Systems

26 February

EEF National Conference takes place in Westminster, London. Includes panel discussion featuring Tony Walker, deputy Toyota UK, Nicola Salter, HR director, Williams F1, and Richard Kirk, chief executive, PolyPhotonix

July

Aerospace and defence business group ADS's aircraft delivery data shows a record first six months for 2015

15 June

Airbus Defence and Space selected to design and built 900 satellites for the OneWeb Satellite Constellation

11-14 June

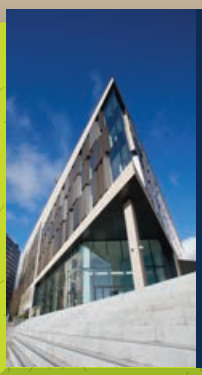
George Edwards the 19-year old inventor of Gas-Sense, an innovative sensor that measures the gas left in a bottle, is invited by Sir Richard Branson to Detroit to discuss investment opportunities

10 june

Warwick Manufacturing Group, the University of Warwick celebrates the completion of a scheme targeting SMEs, announcing it has reached 1,400 West Midlands companies, with 207 projects completed – and 200 jobs safeguarded or created in the region

8 July

The Summer Budget was announced. In the Budget, Chancellor George Osborne announced the UK would meet 2% GDP spend on NATO budget. It confirmed the Annual Investment Allowance would be set at £200,000, a relief to many manufacturing companies.



25 August

£11.2 million of government funding for the REMEDIES – RE-configuring MEDIcines End-to-end Supply – pharma supply chain project is approved, meaning work can accelerate into its next phase. The CMAC centre benefits, as does IfM, GSK and the UK pharma industry

September

Unipart Aftermarket Logistics awarded Investors in People, Champion Status

10 July

Airbus' fully electric E-Fan technology demonstrator aircraft successfully completes Channel Crossing

13 August

BAE Systems launches *HMS Artful* to continue sea trials of its Astute-class submarines

15 September

Airbus A400M in service date achieved with RAF following delivery of 7th aircraft

14 July

First Masters student graduates from the University of Warwick Technical Accreditation Scheme, which trains staff from Jaguar Land Rover

August

Brompton Bicycle announces big expansion with move to 86,182sqft Greenford site by January 2016. Aim is to produce 100,000 bikes by 2021, currently making 48,000 per annum.

6 August

Professor Jan Godsell is appointed to advise the UK Government on manufacturing policy as a member of the Department for Business, Innovation and Skills' Manufacturing Advisory Group

23 September

The BLOODHOUND Project reveals the world's fastest, most advanced "car": BLOODHOUND SSC. The product of eight years of research, design and manufacturing, it involves more than 350 companies and universitiesbusiness

3 March

Airbus Helicopters unveils the H160, it's next-generation medium helicopter

18 March

Mr Ratan N. Tata and Professor Lord Kumar Bhattacharyya unveil foundation stone of the new £150 million National Automotive Innovation Centre on the campus of the University of Warwick

April 10:

21 April
Renishaw wins its 18th Queen's Award, an Innovation Award for the Resolute absolute encoder. The device can determine position to a resolution of one nanometre – one billionth of a metre – with motion speeds of up to 100 metres/ second

9 March

Renishaw features in Guinness World Records for manufacturing the world's first 3D-printed titanium alloy bicycle frame

15 March

15 March
More than 70,000 visitors attend The Big Bang Fair, a science, engineering and technology fair at the NEC

4 June

Tunneling work for London's £14.8 billion Crossrail scheme, Eurpe's biggest construction project, is completed, and hailed as an "engineering triumph" by Prime Minister David Cameron

11 May

Sajid Javid, whose constituency is Bromsgrove in the West Midlands, becomes Business Secretary, replacing Dr Vince Cable. Amber Rudd, Conservative MP for Hastings and Rye, becomes Secretary of State for Energy and Climate Change

7 May

The Conservatives win the General Election by a working majority, with the Scottish National Party all but wiping out Labour in Scotland. The Lib-Dems lose almost 50 seats, their worst result since 1970

24 April

The forward island of new QE-class aircraft carrier HMS Prince of Wales departs from the River Clyde for her delivery voyage and around the UK. The cruise to Rosyth Dockyard, north of Edinburgh, takes five days

23 September

Professor Lord Kumar Bhattacharyya, chairman of WMG, is awarded Honorary Freedom of the City, the highest award possible by the city of Coventry, West Midlands

1 October

7 October 2015: Finnair becomes the first European operator of Airbus' new A350 XWB aircraft

2 November

Opening of The Institute for Advanced Manufacturing and Engineering (AME) in Coventry, supported by Unipart

2 November

BAE Systems invests in Reaction Engines to further develop a new aerospace engine. The engine class combines both jet and rocket technologies with the potential to transform hypersonic flight, and the economics of space access

12 October

The Insolvency Service announces that the coke ovens and blast furnace at Redcar steelworks are to close after no offers to buy them are received. In total 1,700 jobs were lost. The BBC reported that SSI lost >£500m by closing the plant

4 November

Cadbury upsets some fans of its Fruit and Nut bar by adding sultanas to the recipe as well as raisins, after 90 years in production. The firm says (cheaper) sultanas "add more variation"

1 October

Professor Andy Neely takes over from Professor Sir Mike Gregory as head of the IfM Cambridge. Prof Sir Mike joined the university in 1994 department and remains Acting Director of the Institute of Continuing Education at the UoC.

21 October

China's President Xi Jinping announces investment in nuclear new build in the UK against a backdrop of further job losses in the steel industry at Tata, with cheap imports of Chinese steel blamed

10 December

Winners of EEF's manufacturing photography competition are announced

Courtesy of the Photonics Centre, University of Southampton

The time is right to reverse Britain's industrial decline

BY JAMES SELKA

Talk of a post-industrial society proved premature but if manufacturing is to flourish again in an Internet-enabled global renaissance, there are challenges to overcome

For decades the story of British manufacturing has been one of managed, or mis-managed, decline.

It became a cliché in the 1990s that we were a post-industrial economy, and that we didn't make anything any more.

Well, that story is changing: the plot is becoming more complex.

I could take up most of this tome discussing the intricacies of Industry 4.0, digitisation, automation or smart manufacturing. These are but a few of the buzzwords used to explain processes being implemented and developed in manufacturing.

Technological change is a given in manufacturing, and has been since the Industrial Revolution saw steam looms replace hand. What is new now is the potential to connect up all those machines digitally. This trend goes by a number of names, including some of those buzzwords above.

But what matters is less what we call it than that it is set to be a driver of major change in manufacturing for years to come.

The message that we need to give is that as a result of this firmament of change, the UK can and should reindustrialise. That message has to be coherent. The 'can' is every bit as essential as – in fact it is the pre-requisite of – the 'should'.

We have to be clear about what reindustrialisation means. It is not a reversion to the days of yore when giant factories employed tens of thousands of semi-skilled workers – although that is the historic lens that much of the media still sees the sector through.

If that is the expectation, that at a stroke of the investment pen, we can move back to a simpler era of mass workforces in single, vertically-integrated companies, then it will be unfulfilled.

But that does not mean that this will be a jobless revival. On the contrary, jobs are at the very heart of the rationale for reindustrialisation, but the patterns of their creation will owe more to the 21st century than the 19th, or 20th.

James Selka is CEO of The Manufacturing Technologies Association

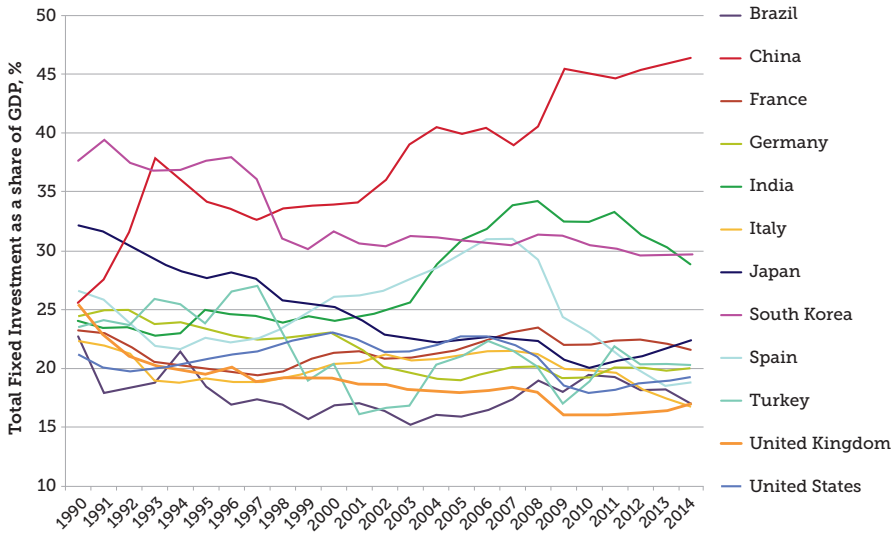
Reindustrialising does not mean the loss of jobs to machines. It means creating new jobs and developing a highly skilled workforce to operate in a new and more complex era. A rejuvenated workforce can jump on the opportunities to improve productivity, working practices and quality, through the aid of technology: machines, software, sensors.

The World Economic Forum reports that just a 10% increase in a country's digitisation rate provides a 0.75% GDP growth boost, and 1.02% lower unemployment. Digitisation is set to increase still further.

DRIVEN BY DEVICES

The number of devices connected to the Internet is predicted to double by 2020, to around 30 billion. Nearly all of that growth will be accounted for not by laptops, tablets or smartphones, but by machines that primarily do something else.

COMPARISON OF INVESTMENT RATIOS 1990-2014



Oxford Economics

"The modest uptick in manufacturing equipment investment is due to a more buoyant economic position since early 2013, and the effect of government initiatives – some of which are now being unwound."

Their connection to each other and to processing hubs, through the application of sensor technology, will enable the creation and utilisation of an unprecedented amount of data, providing for optimisation in a mind-boggling range of processes.

We are living through an explosion in the potential of technology, and it provides a most wonderful opportunity to reinvigorate the manufacturing sector in the UK for the 21st century.

Wealth creation and growing employment opportunities are key to paying for and maintaining the public services the country needs. Manufacturing is remarkable because of the multiplier effect that the sector has. It is so complex, and touches so many other sectors, that activity in it acts as a stimulus to the economy as a whole.

For a given output level in manufacturing the economy reaps a greater benefit than in other sectors. That is why the prospect of reindustrialisation is so attractive, and holds out the prospect of such great rewards.

BREATHING LIFE INTO SUPPLY CHAIN

Standing in the way of reindustrialisation is the issue of the UK's supply chain which, while still world-class in many areas, has been hollowed out over the last five decades to a dangerous degree. If we can reinvigorate the supply chain, we can get closer to a connected world. New technology provides the opportunity to do just that as manufacturing's models and cost bases change.

As technology becomes more central to the process of manufacturing, the cost of labour – the rationale for much of the offshoring that took place – is a smaller and smaller proportion of the cost of manufacturing activity. Labour cost becomes less a driver of location and other considerations such as the availability of skills, the convenience of logistics, and IP protection; these become more important.

Encouraging investment in the manufacturing supply chain is a must but at the moment we're still swimming hard against a historic tide. The UK has frequently lagged comparable economies in terms of its investment ratio.

The graph above shows the position of the UK relative to its industrial peers. An uptick in investment – albeit from a very low base – is discernible over the last two years. This is due to a more buoyant economic position since early 2013, and the effect of government initiatives – some of which are now being unwound.

Imaginative thinking is needed if we are not to lose ground. Government involvement in underwriting part of the finance for the most sophisticated projects would be a real step forwards to address a market failure.

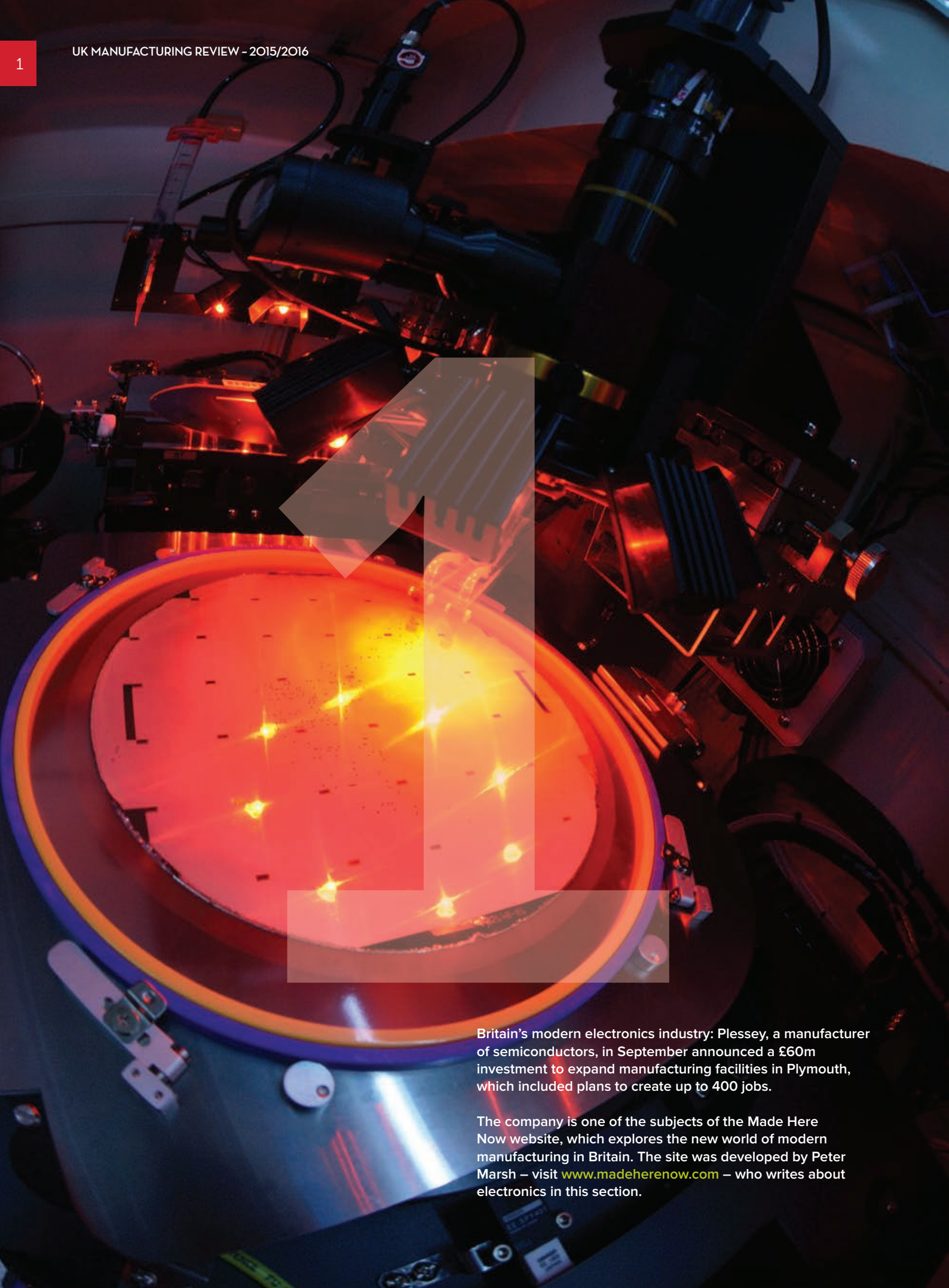
Automation packages – so necessary to take advantage of the opportunities outlined above – may, not untypically, have 70% of their costs accounted for in bespoke solutions, and software and only 30% in hardware, making them hard to finance through conventional, often asset-backed, means.

Even the most progressive of finance companies, who are putting together packages that help this sort of investment, are obviously pricier than a straightforward asset finance deal, because there is, from their point of view, more risk there. If the government could underwrite some of that risk, we could reinvigorate investment in the supply chain.

This is not just about what others can do for us, but what we – UK manufacturing – can do to help ourselves. Companies large and small need to understand the value they hold on their factory floors and in their design studios. They need to realise the importance of intellectual property rights in relation to manufacturing. The so-called 'creative industries', entertainment, music, film, sport, and so on, need to act to protect their IP and secure help from government for it. But where is the voice of the original creative industry, manufacturing, in this debate?

There is no one solution we can give when proposing to reindustrialise this country. But the forces that could drive it are taking hold rapidly all around us.

We need to be ready for this change, not in fear and with trepidation, but optimistically. We have a lot of the factors needed in place already in this country, we just need to realise reindustrialisation as a reality. UKMR-15



Britain's modern electronics industry: Plessey, a manufacturer of semiconductors, in September announced a £60m investment to expand manufacturing facilities in Plymouth, which included plans to create up to 400 jobs.

The company is one of the subjects of the Made Here Now website, which explores the new world of modern manufacturing in Britain. The site was developed by Peter Marsh – visit www.madeherenow.com – who writes about electronics in this section.

Sectors

Wing-tips. Developed by Airbus, winglets lower noise and reduce emissions by improving take-off performance. Sharklets are now used on the A320 family

Image: Airbus

SECTORS - AEROSPACE

Flight risks

By Chuck Grieve

The British aerospace industry is second only to the US but must become leaner, fitter and more productive to take advantage of a booming order book

A year of records in the global civil aerospace market is good news for UK aerospace. As Europe's largest aerospace industry, and second globally only to the US, Britain remains at the forefront of major civil and military programmes.

Aerospace was identified as 'one of the jewels in the crown' of the UK's advanced manufacturing sector in the 2013 report *Lifting Off: Implementing the Strategic Vision for UK Aerospace*. The report pegged the number of companies in the aerospace supply chain at 3,000, with a skilled workforce of 230,000. Their skill sets are broad, encompassing technologies and services from engineering to IT.

The British aerospace industry has an annual turnover approaching £20 billion. Export sales make up about £3 billion of that total, making the sector one of the UK's largest exporters.

The UK is a major manufacturer of aircraft components and enjoys competitive advantages in the key areas of wings, engines, aerostructures and advanced systems.

However, competition from both established and emerging markets is tough – and getting tougher. If the UK aerospace industry hopes to maintain its position globally, it will need to find better, faster, cheaper, and smarter ways of manufacturing the parts and systems in which it excels, without compromising quality and safety.

PLANE TRUTHS

In the first three quarters of 2015, the world's dominant prime contractors, Airbus and Boeing, had delivered a total of 1,026 aircraft, well on their way to delivering their combined projected total of almost 1,400 aircraft, a record.

In the same period, they added 1,262 orders to their backlogs, which stretch eight to 10 years.

All of which bodes well for the aerospace industry. Although the UK is not home to any final assembly facilities for fixed wing civil aircraft, its share of this market could be as much as £15 billion, the trade association ADS says.

"We're in a global marketplace full of demand," said ADS chief executive Paul Everitt. "Forecasts from the major players remain bullish – it's very encouraging."

"Looking at 2015 in terms of orders, delivery and backlog, the industry is very buoyant."

Aeroengines is one area where the UK, led by Rolls-Royce, holds a strong position. At the end of August 2015, the global engine backlog stood at 21,700 units, up 4% from the same period in 2014. Of these, about a quarter are to power widebody aircraft, a market in which Rolls-Royce enjoys considerable success with its Trent family of engines. About 4,500 engines have yet to be specified for aircraft in the backlog.

In April, Rolls-Royce announced an order worth £9.2 billion from Emirates for Trent 900 engines to power 50 of the Dubai airline's Airbus A380 aircraft. The order, a record for Rolls-Royce, made the company the top engine supplier for the A380. With the Emirates deal, Rolls-Royce will have supplied 600 engines for 150 A380s.

While the new engines will be assembled at Rolls-Royce's Seletar Campus in Singapore, not its home in Derby, the economic impact of the order was expected to be felt across its UK supply chain.

The increased business that this represents for the small and medium enterprises (SMEs) that make up a large proportion of the UK aerospace sector reflects one of its main challenges: ramping up their operations to keep pace as Airbus and Boeing increase the rate at which they're producing both single-aisle and widebodied aircraft.

"It puts significant stress on the supply chain," said Everitt. "As volume goes up, margins come under pressure – so the challenge throughout the supply chain is how to increase production sustainably." [see box on Sharing in Growth]

The aerospace report produced in July 2015 by BDO in association with the Institution of Mechanical Engineers found that more than 71% of companies surveyed had an issue with productivity. Tom Lawton, head of manufacturing at BDO, says

the "bald numbers belie some serious concerns" about the UK's ability to step up production and maintain its market position.

"Issues with long-term agreements, productivity levels, availability of correctly skilled people, and the rise of Asia as an aerospace powerhouse, conspire to negate any complacency," he says.

MILITARY UNDER PRESSURE

Figures from ADS show growth of more than 30% in civil aerospace since 2010. Military aviation, by contrast, has had a challenging time, as defence budgets come under increased pressure and air forces are forced to rationalise their expenditure.

That said, the government's commitment to an above-inflation increase to the defence budget, coupled with agreement to meet the 2% NATO target on defence spending, is likely to generate greater certainty and stability across the sector, albeit against the backdrop of the UK's 2015 Spending Review.

Products "in the air domain" make up 87% of export orders in the defence sector, reports ADS in its Outlook Report.

BAE Systems is part of the Eurofighter Typhoon consortium, with Airbus Group and Alenia Aermacchi. The multi-role fighter has not done well recently in export markets, with the sale of 27 Typhoons to Kuwait in September by the Italian partner the first order in three years.

BAE Systems had managed so far to cut manufacturing costs by about 20%, to offer potential Typhoon customers a better price. Without more sales, the assembly line at Warton, Lancashire, might shut – at least temporarily – before the end of 2018. At midyear, 440 of the 571 aircraft ordered had been delivered.

One of the Typhoon's competitors is the Lockheed Martin F-35 Lightning II. About 500 UK companies are involved in this programme, among them BAE Systems, which reached "a milestone" in August with the manufacture and delivery of the first Short Take-Off and Vertical Landing (STOVL) variant aft fuselage, for the Italian air force. About 3,200 aircraft are expected to be built over the next 20 years.

Aerospace achieved something of a breakthrough with the creation of the Aerospace Growth Partnership (AGP), a joint government-industry initiative to address concerns about UK civil aerospace. Set up in 2012 with cross-party support and designed to outlive a single parliament, AGP has overseen the creation of specific programmes to maintain the industry's competitiveness and propel it forward.

AGP also gave UK aerospace a boost in the global marketplace. A former managing director of ADS says AGP has forced international competitors to "revise their view of the determination of the UK to stay pre-eminent" in aerospace. One senior foreign national had commented to him, he said, that with the AGP, the UK was "five to seven years ahead" of other aerospace nations.

Foremost among AGP programmes is the Aerospace Technology Institute (ATI). Based at Cranfield University, Bedford, ATI has a budget of £2 billion, half of it from government, to be deployed over seven years in support of research and post-graduate education.

Image: Airbus

Test case. The highest-thrust production engine ever made by Rolls-Royce, a Trent XWB-97, is delivered for certification trials on the Airbus A350-1000 in 2016

Among its activities in 2015, ATI helped establish the Aerospace Research Centre (ARC). Designed as a national facility for aerospace research, ARC opened in August in Coventry where it forms part of the Manufacturing Technology Centre (MTC) research and development campus.

MTC chief executive Dr Clive Hickman says ARC will provide "a world-class environment" where MTC engineers will work with experts from the world's major aerospace companies on projects which will define future aerospace technology.

Another new part of the MTC campus is the National Centre for Additive Manufacturing (NCAM). Additive manufacturing is radically changing manufacturing as research institutions such as NCAM expand its applications. The most significant aerospace work carried out so far at NCAM – and the largest aerospace component produced by additive technology – is the turbine housing for a Rolls-Royce Trent engine.

ATI was also the headline sponsor in October of Aerodays 2015, the seventh

COMMENTARY: Paul Everitt, chief executive, ADS

Throughout 2015, the sectors represented by ADS – aerospace, defence, security and space, saw continued productivity growth. This against the backdrop of major political change, with the election of a new Government in May; and continuing economic challenge within the international market place.

Certainly ADS has worked hard to build a strong relationship with the new Government, with a focus on ensuring the growth partnerships sustained momentum. Through the growth partnerships, significant milestones have been celebrated, with the opening of the UK Defence Solutions Centre in March, and the launch of the Aerospace Technology Institute's strategy in July; and we look forward on reporting on their achievements throughout 2016.

The value of investment in R&D has been a consistent theme throughout the year. Not only is it fundamental to driving productivity, but it is this which enables the UK to compete effectively internationally. Remaining globally competitive is crucial if our sectors are to continue making their vital economic contribution.

Looking towards 2016, planning is already underway for the 2016 Farnborough International Airshow. This landmark occasion in the national calendar is an important opportunity to promote UK expertise, manufacturing excellence and innovation to key decision makers from the international aerospace and defence industries.

Inkerman creative.com

The aerospace and defence sector has a broader impact on the British economy than just manufacturing. According to a report by Oxford Economics in 2015, BAE Systems contributes almost £8 billion to the economy when direct, supply chain, and consumer spend related to the defence giant is taken into account. In the North West, it holds open days to match local suppliers of office consumables with the wider aerospace supply chain. Expansion of the UK's aviation capacity is viewed as critical to future manufacturing employment

European Aeronautics Days. The event, billed as the European Commission's flagship event in aviation research and innovation, brought together experts in aeronautical research, industry leaders and policy-makers from around the world for three days of plenary and technical sessions designed to present strategic perspectives for aviation, including research and innovation. This was the first time Aerodays had been held in London.

SERVICE INDUSTRIES

The drive for improvements in manufacturing aircraft and their engines, for reasons of sustainability, environmental protection and ultimately the total cost of ownership, has brought Through-life Engineering Services (TES) to the fore. In August, the TES centre at Cranfield University, which comes under the Engineering and Physical Sciences Research Council (EPSRC), launched a study to help develop a national TES strategy. It is supported by BAE Systems, Rolls-Royce and the Ministry of Defence among other leading engineering companies.

Centre director Professor Rajkumar Roy says TES, also known as 'servitisation', is already used by BAE Systems and Rolls-Royce to help spread the cost of expensive, complex products over time by guaranteeing their performance. With a potential global market running to trillions of pounds, it is important that industry and government change their thinking "to capture more value" from TES.

It's a "new way of approaching manufacturing", says Professor Roy. "It is a natural progression from what we currently do. We're actually looking at new ways of generating revenue, new ways of reducing resource consumption by manufacturing products so they have longer life and less whole-life cost."

UK aerospace continues to spread its wings with investments in production facilities in overseas markets, and not just Asia. AgustaWestland is setting up a new maintenance plant in Brazil with room for a final assembly line, while Rolls-Royce is spending £390 million over five years to modernise its manufacturing and assembly facilities in the US city of Indianapolis – its largest investment in the US for 20 years.

While companies of all size continue to establish bases in lower-priced economies, in part to move production work closer to their markets, the traffic is not all one-way. Recent geopolitical and economic events have forced senior executives to carefully consider their options.

"The impression I have is that companies ended up offshoring things they could move quickly rather than those things that made strategic business sense," says ADS's Everitt. "At board level, aerospace leaders are reconsidering their exposure to risk; some find they have a significant proportion of their activities in regions that are not as secure as they might like."

In such an environment, remaining – in or returning to – the UK becomes more attractive.

"There's no torrent of reshoring, but the lessons learned over the last five years are shaping people's strategy. Calculating total cost of ownership shows that the UK industry has inherent strengths and can be competitive.

"One thing is very clear," says Everitt. "Our ultimate customers, the airlines, want their aircraft sooner, and cheaper. That's a market dynamic that's not going to go away.

"We can compete, with the right investment in equipment, technology and training. It will take a combination of industry itself stepping up to the mark and government creating the right incentives and infrastructure. UKMR-15

Airbus

Carbon fibre composite wings are produced for the A350 XWB, Airbus's latest family of aircraft, at Broughton's North Factory site

FAST FACTS

Global backlog, large commercial aircraft: more than **13,000**
Worth up to:
£175 billion
to UK industry

SUPPORT FOR SMART THINKING

The National Aerospace Technology Exploitation Programme (NATEP) was set up as part of the Aerospace Growth Partnership to support the inventiveness of British SMEs with government funding and administrators who could guide applicants through the paperwork.

Demand for NATEP has exceeded the initial funding, helping build a strong business case for future initiatives. In total, the programme is on course to deliver 120 projects.

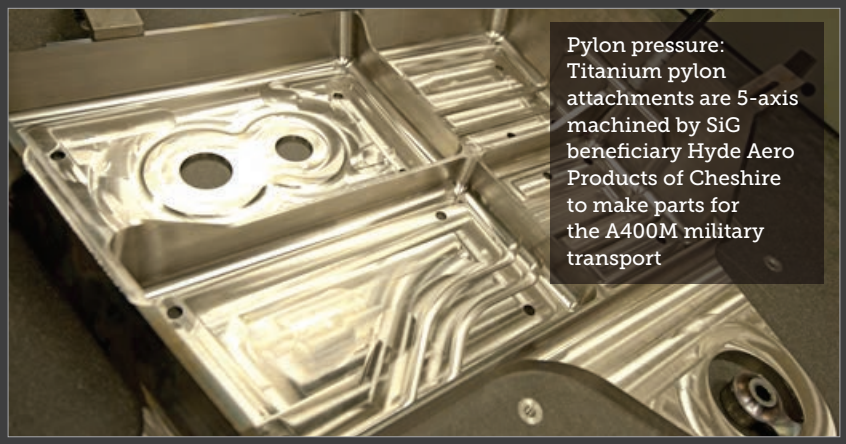
One of the reasons for the programme's popularity is the requirement for collaboration. Deputy director Bridget Day says this approach brings SMEs together with universities and Catapult centres and, crucially, involves the customer from the start.

"That's helping many companies progress their projects faster, safe in the knowledge that they're doing the right thing at the right time for the right reasons."

The programme is sponsored by leading primes and Tier One companies including Airbus, Bombardier, Controls and Data Services, GKN Aerospace, Rolls-Royce and Spirit.

This year, NATEP completed its fifth and final call for proposals. It differs from other funding programmes by encouraging collaboration among SMEs and requiring the participation of an end-user for the technology to be developed. It also takes a hands-on approach to written proposals.

NATEP has shown itself to be "the right approach", says Paul Everitt of defence and aerospace trade body ADS. After the conclusion of the current spending review, he is "confident we will find a route" to fund the programme for the long-term.



Pylon pressure: Titanium pylon attachments are 5-axis machined by SiG beneficiary Hyde Aero Products of Cheshire to make parts for the A400M military transport

Jason Aldridge, managing director of Arrowsmith Engineering, agrees. Arrowsmith and partner ANT Industries worked with Coventry's MTC, with NATEP support, to develop new aerospace standard manufacturing techniques, including threadrolling.

The project has given Arrowsmith the opportunity to become a "centre of excellence... manufacturing components that previously could not be made", he says.

Another NATEP project saw Kyocera Unimerco Tooling, Teer Coatings and the University of Manchester develop better tools for in-situ drilling on aircraft structures.

Teer's Dr Kevin Cooke, R&D technology centre manager, says the partners believe the process could be commercialised quickly. "This new process will be an important step forward for the aerospace sector, but there's potential for it in other industries too," he adds.

Another successful programme is Sharing in Growth (SiG), which focuses on developing suppliers in the UK into world-class companies, able to meet the exacting standards of Airbus and Boeing.

This autumn, it reported that the first group of 22 companies engaged in SiG had already won contracts worth more than £900 million.

SiG is backed by Rolls-Royce and run by one of its executives, former engineer Andy Page. Funded by the Regional Growth Fund, it aims to imbue ambitious suppliers with some of the qualities they might otherwise lack, such as awareness of lean techniques or meeting the latest aerospace quality standards.

Airbus UK's wing production combines eco-efficiency with the demands of a booming industry

With the number of passengers and civilian aircraft set to double in the next 20-years, Airbus is combining ultra-efficient wing designs with new, rapid manufacturing techniques to deliver wings for far more fuel-efficient aircraft – and lots of them.

The view from an Airbus A380, the world's largest commercial aircraft, flying over the 700-acre Airbus plant in Broughton, which employs over 6,000 people and produces over 1,000 wings per year

'The world flies on our wings'. That's the opinion of members of the 10,000-strong workforce at the company's facilities at Filton near Bristol and Broughton in North Wales – and no wonder. It's at these two sites that the wing design and manufacture takes place that makes Airbus the UK's number one civil aerospace company and exporter.

Every wing of every Airbus plane sold worldwide was conceived in the UK, at Filton, where the new Barnwell House facility brings together the largest concentration of aerospace engineers under one roof in the country. In total, about 4,000 people work at Filton, including more than 2,000 engineers. They design, test and provide support services not just for wings but also for fuel systems and landing gear on all Airbus aircraft. Meanwhile, a recently opened 12-acre aerospace business park has enhanced Filton's reputation as a world-class centre of wing design and engineering.

Airbus's Broughton manufacturing plant in Flintshire is steeped in aviation history. It was here, for instance, that the Wellington bombers were produced during World War Two. Today, Broughton's 6,000 employees make more than 1,000 wings each year for Airbus aircraft.

Broughton's West Factory site - the size of 12 football pitches, and the biggest factory to be opened in the UK in the last 25 years - is where the workforce manufactures wings for Airbus's A380 plane. After assembly at Broughton, the A380 wings, the largest ever produced for a civil aircraft, are transported by road and then by river to nearby Mostyn harbour. Here, they are loaded onto a roll-on, roll-off ferry for the voyage to France. At the North Factory site, opened by UK Prime Minister David Cameron in October 2011, carbon fibre composite wings are produced for the A350 XWB, Airbus's latest family of aircraft, which entered service in January 2015.

Broughton's West Factory site is the size of 12 football pitches and the biggest factory to be opened in the UK in the last 25 years

Airbus' commitment to eco-efficiency begins at the earliest stages of its aircraft development and underpins the entire design and manufacturing process at both Filton and Broughton. The A350XWB's wings contribute to the plane's 25 per cent fuel saving compared with competitors. More than 3,700 sets of wings for the A320, the fastest selling aircraft in history with a radically more fuel-efficient engine, were designed and built in the UK. The A320neo's 'Sharklets' – 2.4 metre-high wingtip devices that improve aerodynamics – deliver a 700-tonne reduction in carbon-dioxide emissions per aircraft, per year.

The A320neo's 'Sharklets' – 2.4 metre-high wingtip devices that improve aerodynamics – deliver a 700-tonne reduction in carbon-dioxide emissions per aircraft, per year

According to Airbus Group CEO Tom Enders, the global civil aviation market will see a doubling of both the number of passengers and aircraft in the next 20 years. Among other initiatives, Airbus aims to maintain and enhance the UK's competitiveness in the aviation market through its involvement in the Aerospace Technology Institute (ATI), an initiative between government and industry set up to further aerospace research and development in the UK. As part of the initiative, Airbus has invested around £100 million at Broughton and Filton to develop the next generation of wing technologies. The future of these facilities promises to be as distinguished as their legendary past. **UKMR-15**

THE AEROSPACE SECTOR

The UK has the world's second largest aerospace sector, owning 17% of the global market share.

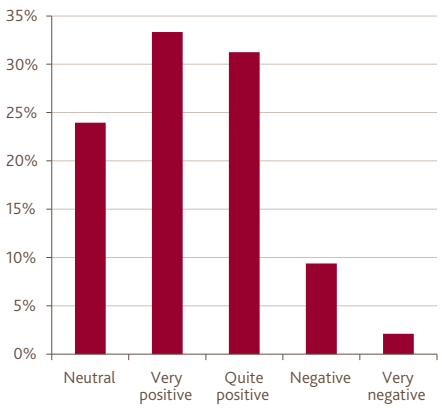
With airline traffic growth of almost 5% predicted over the next 20 years, will the UK be in a strong position to respond to increased productivity demands? BDO recently partnered with The Institution of Mechanical Engineers (IMechE) to analyse the sentiment, challenges and changing macro landscape for UK aerospace companies.

Our findings revealed strong positive sentiment in the aerospace sector, but the bald numbers belie some serious concerns about the UK's position. Issues with long term agreements, productivity levels, availability of correctly skilled people and the rise of Asia as an aerospace powerhouse, conspire to negate any complacency. Below are some of the findings from our survey, you can download the full report at www.bdo.co.uk/news/the-aerospace-report.

THE PROFILE OF UK AEROSPACE

How positive do you feel about the future order book of your organisation for civil aerospace products over the next five years?

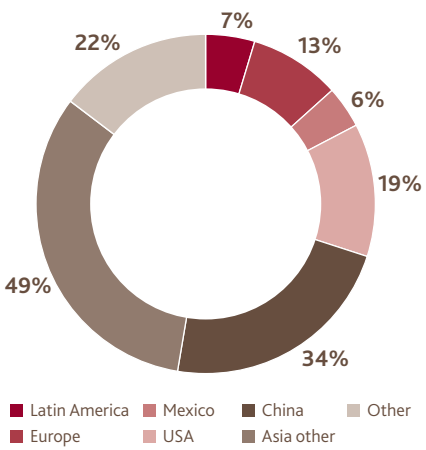
In spite of the challenges from new global markets and a range of more prosaic reasons, business sentiment in the UK aerospace sector is positive. 64% of those surveyed were either positive or very positive about the prospects for their civil aerospace order book in the next five years.



THE INTERNATIONAL LANDSCAPE

Where will you set up overseas facilities?

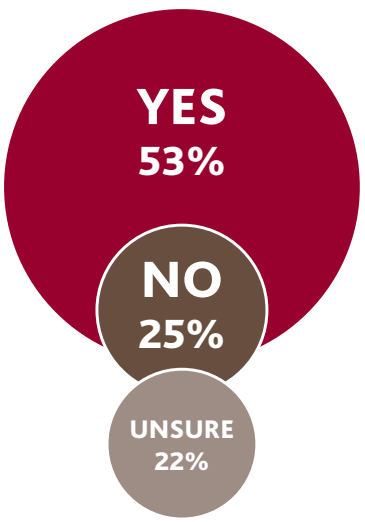
Around two thirds of the companies surveyed are in the process of creating an overseas facility. On a macro-level there is a lot of activity in Asia. Of the companies who are establishing overseas facilities, 49% are going to Asia (excluding China) and 34% are building a base in China.



STAFFING AND SKILLS

Is your organisation experiencing difficulties in recruiting the skills and people it requires?

The survey showed that 53% of companies experience difficulty with recruiting people trained in the disciplines they need.



>62%
OF COMPANIES HAVE AN ISSUE WITH PRODUCTIVITY, WHETHER LABOUR, CAPITAL EQUIPMENT OR PROCESSES

62%
OF COMPANIES ARE SETTING UP FACILITIES OVERSEAS

15%
SAY THAT LOCAL INCENTIVES THAT DE-RISK AN OVERSEAS INVESTMENT MAKE IT MUCH EASIER TO CREATE A FOREIGN BASE

63%
BELIEVE THE UK NEEDS MORE HOME GROWN, MID-SIZED COMPANIES TO STRENGTHEN THE UK'S AEROSPACE SECTOR

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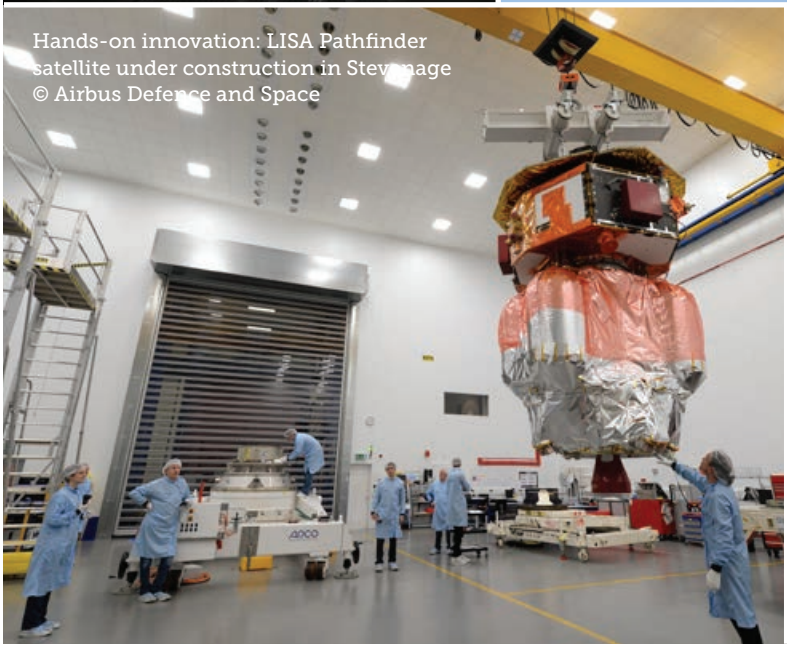
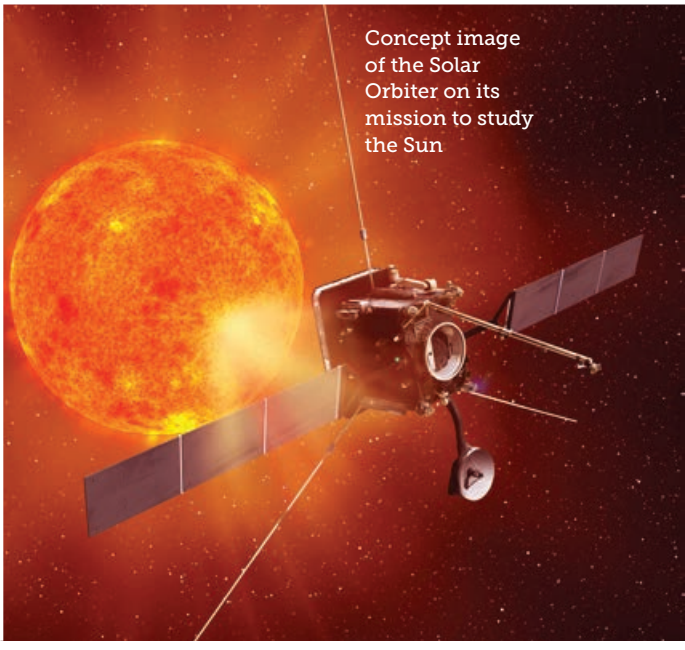
Airbus in the UK

PLANES, SATELLITES, HELICOPTERS AND MARS AUTOMOBILES

Airbus Defence & Space: Zephyr HAPS



Hands-on innovation: LISA Pathfinder satellite under construction in Stevenage © Airbus Defence and Space



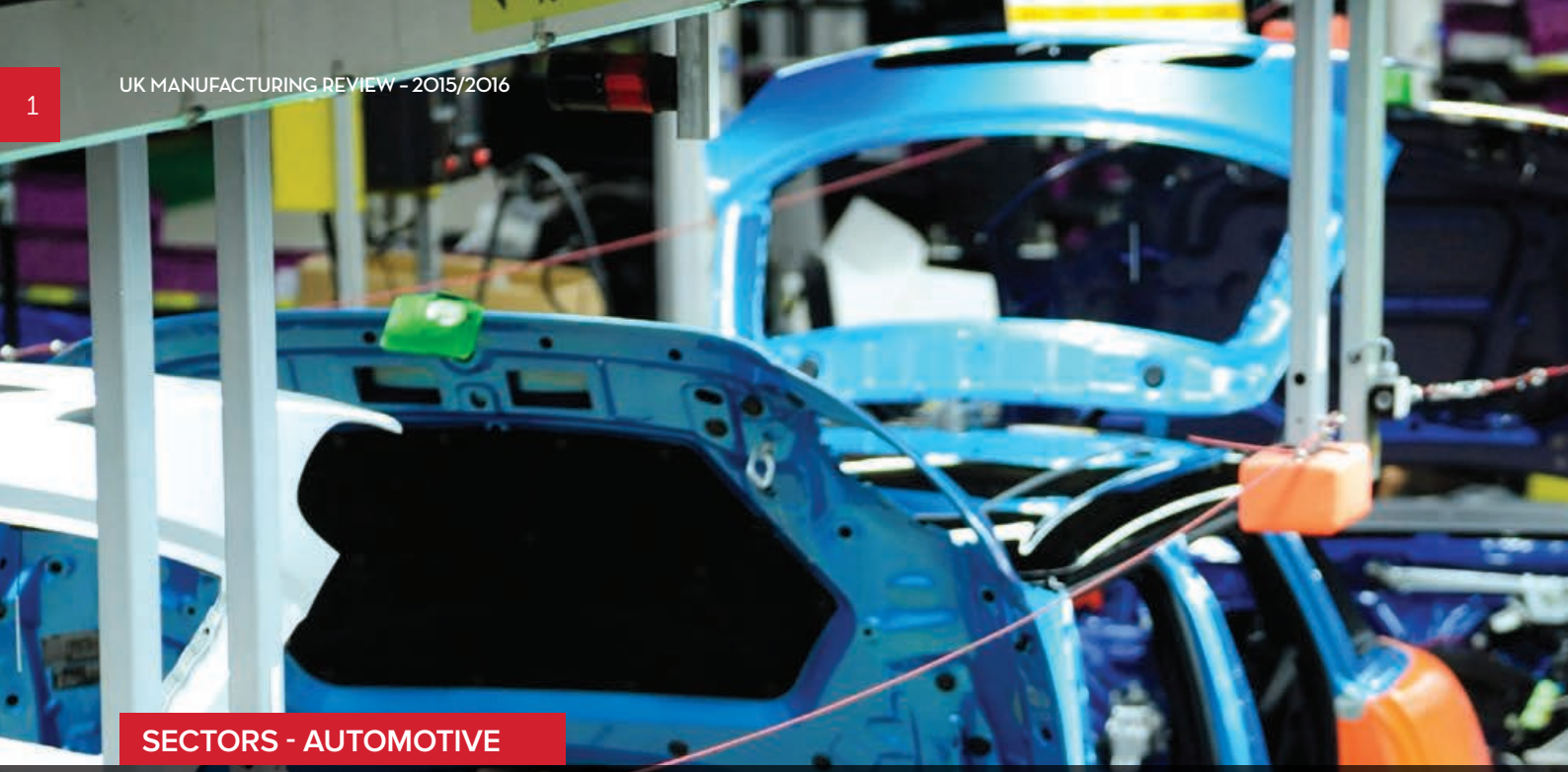
Concept image of the Solar Orbiter on its mission to study the Sun

All photos © Airbus Defence & Space and Airbus Group UK

A wing for the world's largest commercial aircraft, the Airbus A380, being assembled in Broughton, North Wales

Airbus Defence & Space's ExoMars Rover, part of ESA's planned mission to search for life on Mars

Winglets used on the Airbus A350 and A320 are a proprietary Airbus innovation, providing faster lift and allowing higher cursing altitudes, saving airlines millions of dollars fuel costs



SECTORS - AUTOMOTIVE

TOP GEAR for UK Motor Sector

BY IAN ADCOCK

The British car industry took a battering in the financial crisis but is in rude health today. Can the supply chain further fuel the phoenix of UK engineering?

Photo courtesy of: MINI UK

Thirty years have passed since the news broke that an airfield on the outskirts of Swindon, owned by Vickers and where Spitfires were once assembled and tested, had been sold to Honda. At the time, the UK motor industry still boasted brands such as Daimler, Austin, Morris and Rover – with total production running at 1,047,973.

In the intervening years, the fortunes of the industry have waxed and waned from the humiliating – think of BMW's retreat from Rover – to the triumphant, such as BMW's success with Mini.

The year just gone, 2015, must be marked down as one of the most successful in the British motor industry's renaissance: OEM investment broke the £2 billion barrier, with 4,500 new jobs created in the UK automotive sector, which accounts for almost 12% of Britain's total exports.

A PART OF ENGLAND, FOREVER GERMAN

If there is a downside to those headline figures, it is that marques once cherished as being "British" to the core have slipped into the custody of foreign owners: Bentley (VAG), Mini and Rolls-Royce (BMW), Jaguar Land Rover (Tata), Lotus (Proton) and Vauxhall (owned by General Motors since 1925), while some, such as Aston Martin, rely on overseas investment.

Others like Honda, Nissan and Toyota are contemporary versions of Henry Ford's concept of establishing a European manufacturing bridgehead in the UK that dates back to 1911.

Tom Lawton, head of manufacturing, BDO

"The UK automotive workforce is excellent both at the assembly level as well as innovation and design."

"Ninety-nine times out of a hundred, when engineers are faced with a problem they solve it. And that's why the assemblers are here to help them achieve things they couldn't in lower cost countries."

"What is disappointing is that the assemblers want more suppliers to give us the products we need, so there's several billion pounds worth of product coming from outside the UK."

"It would be a massive boost to the whole sector if we had more ability to supply what the OEMs needed."

Jaguar Land Rover's decision to opt for Slovakia to build its next factory rather than the UK is, says Lawton, "disappointing, but understandable... but they do have to reduce costs to sell their cars into a global market and cost is a major factor in that".

He thinks that autonomous driving will add "a completely different dynamic to transport in all forms across the world", but fears that the cutting-edge technology is being developed elsewhere than the UK.

"What manufacturers will want in the future – as the internet of things and industry 4.0 happens – are more IT specialists as much as engineers."

At the time of writing, there were scores of major new OEM investments in the works in the UK [see box]. Earlier programmes were delivering world firsts, too. For example, thanks to significant investment at its Burnaston, Derbyshire assembly facility, Japanese carmaker Toyota delivered the simultaneous start of production of new Auris and Avensis models in the summer, with two body styles and a choice of three power-trains each.

Internal competition, combined with regional incentives and lower costs and wages, can make it tempting for a continental OEM to decide on a European location for manufacturing. Even so, Vauxhall's Ellesmere Port and Luton

Photo courtesy of: Vauxhall

Production value: Vauxhall's investment in Ellesmere Port has resulted in 800 jobs

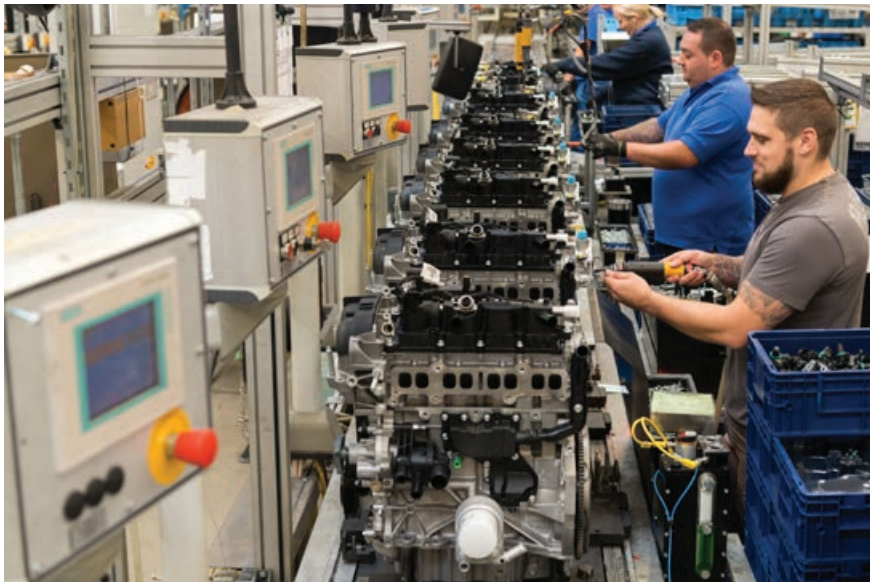


Photo courtesy of: Ford

Bridgend has benefited from £180 million investment as part of Ford's global strategy to manufacture low-emission engines

Dick Elsy, chief executive, High Value Manufacturing Catapult

"The important message for me is that the car industry has definitely embraced the productivity agenda in respect of bringing new technology through. Its appetite to develop new technology to keep its competitive advantage has been outstanding and 2015 has seen an even greater acceleration of that... and an incredible increase in R&D investment."

"I see a lot of stimulation in the supply chain, a desire to have a leading edge supply chain in the UK. It's a very active market for innovation, that's dynamic and willing to cooperate with one another."

Although Elsy concedes that much of the R&D is being done on the supply chain's home turf, what he terms as early stage development "the likes of which I have never seen before" is emerging thanks to the Catapult programme he heads up.

"There's every chance of embedding that in the UK and making it a more attractive place to come and put an R&D footprint down because we have some really interesting research coming through."

For Elsy, the "absolute" remit of the Catapult programme is to avoid the UK's bad habit of developing new technology and then letting it slip away to be developed by a third party. MAGLEV anyone?

"We are here to fix that market failure. There's a progressive push to lightweight vehicles spearheaded by Jaguar Land Rover's aluminium intensive strategy. The next step beyond that are composites, but it's frighteningly expensive so we're bringing companies together on a national scale to make it cost-effective."

"That's a great example of how we can bring businesses together to achieve a common goal."

plants were both favoured ahead of continental rivals by parent company General Motors for producing the new Astra hatch and Vivaro van, respectively.

An all-new car, the Astra, pitched into one of Europe's most competitive model sectors, secured 2,000 jobs – until 2020 at least – at Ellesmere Port, thanks to a £140 million investment from GM. Colleagues in Luton won a similar long-term contract after a £125 million investment secured 1,500 jobs for the next decade.

According to the Centre for Economics and Business Research, UK firms, including those in manufacturing, utilities, construction, transportation and storage, benefit from almost £70 million gross value added and 800 jobs that result directly from Vauxhall's investment in Ellesmere Port; at full production, the plant will build around 680 cars a day, or 120,000 a year, of which more than half will be exported to Europe.

Which is good news on the surface and testament to the commitment made to win the contract ahead of the Bochum plant in Germany. Yet underlying that is the fact that local content, although having doubled, only accounts for 25% of content, with various high-value items, such as powertrain, still being imported.

Along with other OEMs like Jaguar

Photo courtesy of: Jaguar Land Rover

260 Robots have been installed at Halewood by Jaguar Land Rover to support production of the latest Land Rover Discovery Sport

"It has been quite a good year for UK manufacturing," reflects head of manufacturing at BDO, Tom Lawton. "A lot of my clients have benefited from the JLR effect, and it just feels that the traditional strengths of the UK automotive industry are growing: we're highly regarded in terms of production, innovation, quality."

He adds: "The ongoing investment and commitment to the UK by JLR is a massive boost to the automotive sector and proves that a 'Made in Britain' brand still carries weight around the world."

FULL THROTTLE FOR AUTOMOTIVE INVESTMENT

Jaguar Land Rover: 1,300 new jobs and £600 million investment in its West Midlands manufacturing facilities.

London Taxi Company: 1,000 jobs and £200 million investment in low-emission taxis.

Honda: £200 million for the new Civic 5-door production at Swindon.

Infiniti: 300 jobs and £250 million for Q30 and QX30 production at Sunderland. The Q30 and QX30 will not only be the first premium models manufactured in Sunderland, but also the first to be manufactured there and exported to the North American and Chinese markets.

Nissan: £37 million for a new extra large press line, plus a further £100 million for the new Juke, again, at Sunderland.

Ford: £181 million for new low-emission engines at Bridgend.

Aston Martin: a "multi-million pound" investment in a new 250,000 sq ft warehouse and logistics hub as part of its £200 million "Second Century Plan", that will see its DBX luxury crossover launched and its current range replaced by 2020. The Gaydon-based luxury manufacturer also confirmed a limited production run of 200 Lagonda Taraf saloons.

Bentley and Rolls-Royce: making significant investments in their UK operations. Bentley is spending £40 million to build a new 484,000 sq ft research and development centre at its Crewe headquarters, as part of a wider £840 million investment plan, which will generate a further 300 new positions.

As well as launching its Bentayga cross-over, Bentley also revealed it is now VAG's centre of excellence for the W12 6.0-litre engine that it will build and supply to fellow brands, Audi and Volkswagen.

Rolls-Royce's Bentayga rival, dubbed Project Cullinan, announced a new 323,000 sq ft technology and logistics centre at Bognor Regis just down the coast from its Goodwood factory. It will consolidate three current operations: a warehouse for incoming production parts, a distribution centre – including an inbound body store and finished car store – and a workshop.

Assisted by UK Trade and Investment and local government, supplier BorgWarner has launched a five-year R&D collaboration and testing programme with the University of Huddersfield. This includes establishing an MSc in Turbocharger Engineering, which aims to train tomorrow's engineers. BorgWarner also successfully applied for UK Government funding. This led to the setting up of a Turbocharger Centre of Excellence in the UK. It has now signed a contract to provide its leading turbocharging technologies for JLR's new Ingenium family of four-cylinder petrol and diesel engines, launched in 2015.

Land Rover (JLR) and Toyota, Vauxhall is working on shortening the supply chain, but it's proving an uphill struggle. Toyota Motor Europe (TME) is spending around £900 million a year with UK suppliers; 30% of all TME suppliers are UK-based.

According to the Automotive Council, the amount of value sourced by UK car manufacturers for indigenous suppliers has risen by just 5% between 2011 and 2015, to 41%, despite passenger car production increasing 16% over the same period.

Although it is difficult to quantify, anecdotal evidence suggests that for French and German OEMs, the figure is closer to 60%. In terms of value, the Automotive Council puts this at £9.5 billion annually, a 50% increase over 2011's £6.3 billion, the majority of which going to UK-based OEMs, rather than being exported, so there is significant room for improvement.

It's a point not lost on Joe Greenwell, chief executive officer of the Automotive Investment Organisation. He compares the UK's record of sourcing from the local supply chain unfavourably with that of Germany, where content sourced locally is at the +60% level.

"I am very focused on supply chain revitalisation," Greenwell says. "In the last year, there is strong evidence that we've had some success in the supply chain. This is a long-term process, but what is particularly encouraging is that we're attracting a lot of interest not just through the low carbon propulsion centre, but also the Catapult network."

That UK companies are increasingly attracting the attention of overseas investors was underlined by the purchase of Stadco by Magna. Stadco is a major international supplier of aluminium and steel body-in-white (BIW) products and services to a number of automotive OEMs including Jaguar Land Rover, Ford and General Motors. It has four facilities in the UK and one in Germany, employing around 1,400 people and is the UK's largest independent Tier 1 BIW supplier.

By purchasing MIRA – the Motor Industry Research Association – Japanese precision instrument maker Horiba underlined the UK's excellence in vehicle testing and development. The acquisition enables Horiba to address the emerging areas of next-generation mobility including electrified powertrain, intelligent vehicles and vehicle attributes technologies. The deal should allow MIRA to invest in its current facilities and enhance its capabilities on a global scale.

SPORTING LIFE

Beyond the global OEMs and suppliers, there is a wealth of expertise and knowledge that, it could be argued, is unparalleled. In the 2015 season all bar two Formula One teams were based in the UK and, even then, Ferrari's technical director is English.

In 2012, the UK motorsport engineering and services industry had a turnover of £9 billion, nearly doubling sales from £4.6 billion in 2000, with some 4,300 businesses employing 41,000 people, compared with 38,500 in 2000. And with new businesses such as Williams Advanced Engineering entering the sector, there is every opportunity for OEMs to take advantage of the speed and technical ingenuity that wins Grands Prix.

When it comes to vehicle design, meanwhile, there can be no greater accolade for a graduate than to have the initials of the Royal College of Art on his or her business card. There can hardly be a design department in the world that hasn't benefited from its influence.

Three decades on from Honda's pioneering move to a former WW2 airfield, the British motor industry has never been stronger – or more ambitious. **UKMR-15**

THE AUTOMOTIVE SECTOR

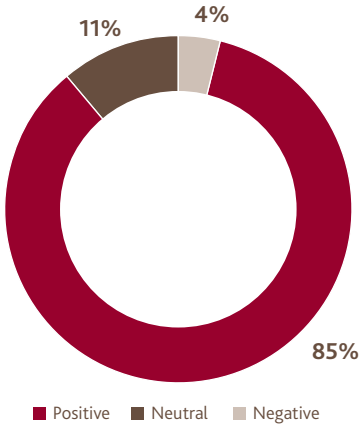
The UK automotive industry is one of the nation's success stories.

Car production is rising and is set to pass the 1972 high of 1.92 million cars in 2017. UK automotive manufacturers export around 80% of production; equal to 10% of total UK exports.

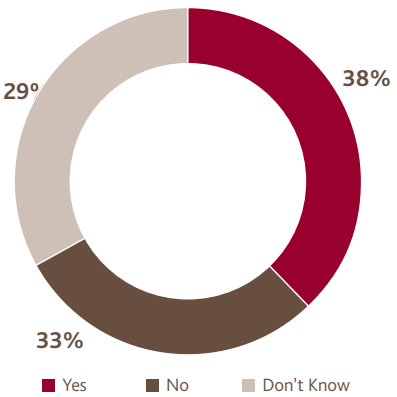
Engineering and technology are central to the UK's automotive future and BDO recently enlisted the aid of the Institution of Mechanical Engineers (IMechE), the principal UK professional body for technical people engaged in the automotive sector, to get the inside story on the issues that are shaping the industry as seen by those at the heart of the action. Below are the findings from our survey, you can download the full report at www.bdo.co.uk/news/manufacturing-foundations-automotive-report-2015.

GROWTH AND PROSPECTS

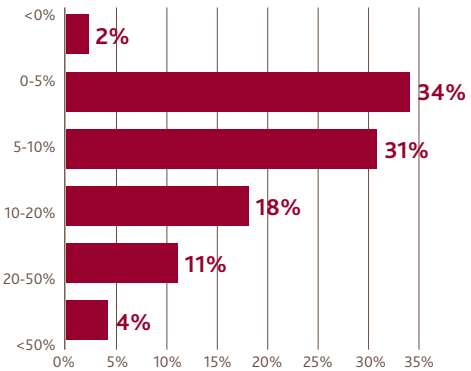
How positive do you feel about the future of automotive manufacturing in Britain?



Do you think UK-based automotive companies are likely to source more components domestically in the next few years?

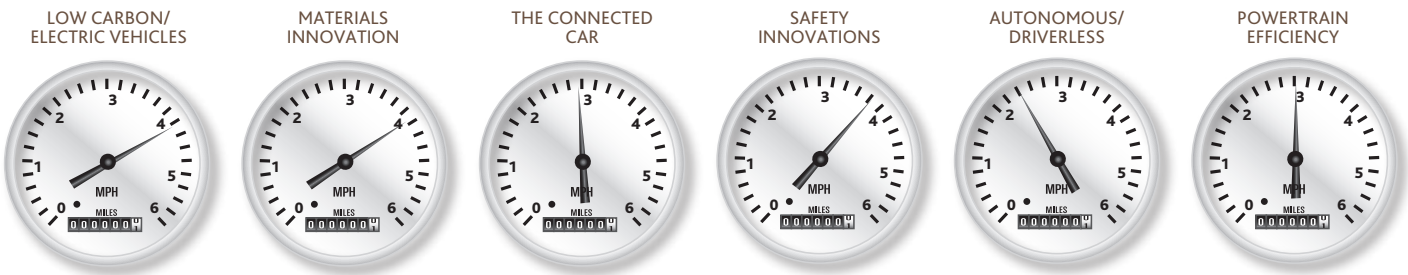


How much do you anticipate sales growing within the organisation you work for over the next year?



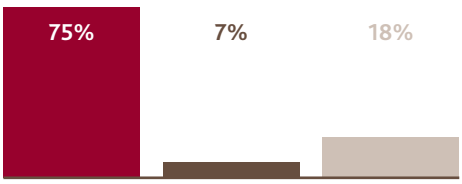
THE BUSINES OF INNOVATION

How important are the following automotive innovations to your company's R&D strategy over the next year (1 = very important and 6 = not all important). Below are the weighted results showing the average importance for each technology.

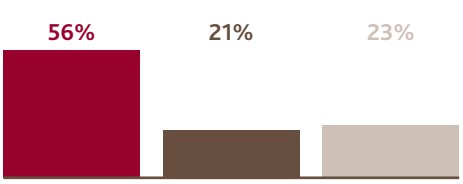


THE ROLE OF GOVERNMENT - SKILLS

Is your organisation experiencing any difficulty fulfilling skilled engineer places?



Is your organisation experiencing any difficulty fulfilling skilled technician places?



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Low cost, light weight

One of Cranfield's novel composite/metallic joining technologies

The beneficial properties of composite materials are well-known, offering high stiffness and strength alongside low weight. As such composite materials have grown increasingly commonplace in industries such as aerospace where these properties are highly sought. Composite materials are comparatively more expensive to manufacture than their metallic alternatives, hence using composite structures becomes a trade-off between cost and performance.

The Enhanced Composites and Structures Centre at Cranfield University specialises in research for next generation polymer composite manufacturing. This spans process modelling and simulation for optimised manufacture, novel joining technologies, and enhancements such as functional and smart structures. The centre has been working alongside industry partners to develop new techniques to increase the efficiency and cost effectiveness of composite manufacturers to open up new markets.

The automotive industry has used composites in motorsport and high performance applications for many years; however the application to mainstream automotive applications has been slow due to the high-cost and low volume nature, often of the manufacturing techniques.

"Composite materials will be centre stage in the future of manufacturing across a range of sectors not just in aerospace. For centres like ours there is a rich seam of research challenges to tackle with our industry and other partners to underpin step changes in manufacturing processes and composite performance," Professor Peter Foote – head, Enhanced Composites and Structures Centre, Cranfield University

EMERGING COMPOSITES

The most recent automotive focus for the centre was the design of an ultra-light carbon fibre body for the Nissan UK Infiniti Emerg-E range extending hybrid supercar which was demonstrated at the Geneva motor show and Goodwood Festival of Speed.

The Infiniti Emerg-E sports concept car is a unique, electric-propelled vehicle which was the first Infiniti (the luxury vehicle division of Japanese car-makers Nissan) car designed, engineered and built in the UK. The sleek and powerful vehicle symbolises the best of British engineering, capable of speeds up to 130mph.

Originally a Lotus Evora 414E, it became the first electric supercar with a range-extending battery hybrid featuring high performance and low emission. Cranfield's contribution to the Emerg-E project included producing the manufacturing instructions and designing the carbon fibre structure to be 'superlight'.

The original Lotus Evora 414E bronzed body structure of the car weighed 115lbs (glass fibre); however, the Cranfield team managed to reduce the weight by 61% to just 45lbs by the use of carbon fibre materials, and carried out vigorous impact and stiffness tests before the project completion in 2012. **UKMR-15**

Better living through chemistry

SECTORS - CHEMICALS

BY SARAH HOULTON

The chemicals industry in Britain is big business, booming on the back of a falling oil price, but its long-term energy security may depend on imports of shale gas from the US

The UK's chemicals sector is booming. Including pharmaceuticals, chemicals output topped £50 billion in 2014, making it the country's biggest manufacturing exporter. The falling oil price provided a boost for industry, especially on the petrochemicals side, which has been struggling in recent years.

Upstream, the big story has been the move away from cracking naphtha to cracking ethane. The UK has three crackers. ExxonMobil's cracker in Mossmoran, north of Edinburgh, was always an ethane cracker, but the Ineos cracker in Grangemouth now uses ethane as a feedstock, and Sabic's naphtha cracker on Teesside is also to be converted.

Ineos has signed 15-year deals to import shale gas from the US, via eight specially commissioned ethane-powered ships, and is building a huge storage tank at Grangemouth.

"We're going to move more than 40,000 barrels of gas a day, every day of the year, for 15 years, from the US to Europe," says Ineos chairman Jim Ratcliffe. "This gas will keep our businesses competitive for years to come, and guarantee jobs and investment."

Ineos has acquired UK shale exploration rights, but even if it does start producing gas, it will be some time away before they can utilise it. "With dwindling North Sea supplies, and no real onshore shale development in the UK, it has been necessary for these companies to look elsewhere," says Stephen le Roux, head of economics at the Chemical Industries Association (CIA).

BASF SE

Catalyst R&D plays a crucial role in innovation in the chemical industry. BASF uses catalysts in more than 80% of its production facilities

CPI's National Biologics manufacturing centre in Darlington opened in September, offering open-access facilities for the development of better biologics processes

CPI

A knock-on effect of the move from cracking naphtha towards cracking ethane is that there will no longer be a ready domestic source of feedstocks more complex than the ethylene produced from ethane. Sabic has already announced it will stop production of cyclohexane and benzene in the UK, and Zeon Chemicals is to close its nitrile butadiene rubber plant in South Wales, citing raw material availability as a major reason for the decision.

It's not the only site slated for closure. Others include AMRI's active pharmaceutical ingredients plant in North Wales, and Eastman's acetate tow plant in Workington. But other companies are opening new facilities and expanding capacity. Johnson Matthey, for example, has a new high containment capability for manufacturing highly potent actives in Edinburgh, while Eastman and BOC have opened a hydrogen plant in Newport. AkzoNobel is building a coating resins pilot plant in Gateshead, and Lubrizol has expanded its Manchester formulations and applications centre.

GROW AND PROSPER

Chemoxy is expanding capacity for low toxicity solvents at both Middlesbrough and Billingham, while Victrex has added capacity for the high performance thermoplastic polyaryletherketone near Blackpool. And BASF has doubled the capacity of its precious metals recycling facility in Gloucestershire, where the metals are recovered from automotive catalytic converters.

Other companies have become part of larger businesses via acquisition. One deal saw ThermoFisher Scientific taking over Alfa Aesar, the Heysham-based research chemicals division of Johnson Matthey (JM). JM, meanwhile, acquired solid form specialist Pharmorphix from Sigma-Aldrich. Lubrizol took over Warwick Chemicals, which produces tetraacetyl ethylene diamine, used as a bleach activator in laundry detergents. Other significant deals included Sensient's acquisition of specialty inks manufacturer Xennia Technology, and Sun Chemical purchasing cosmetics specialist Kingfisher Colours.

BRITAIN'S GOT TALENT

Technology and innovation play a key role in the success of the UK chemical industry. As Harry Swan, managing director of Consett-based Thomas Swan & Co and a governing board member of Innovate UK, explains, investment in future wealth-creating businesses is vital. "We're really good at this in Britain," he says.

"We've got fantastic universities, brilliant brains who are capable of thinking up solutions to complex problems, and we are getting better at capturing those ideas and then keeping them here in the UK."

The Centre for Process Innovation, one of the technology innovation centres under the auspices of the government's High Value Manufacturing Catapult, focuses on helping companies develop, prove, prototype and scale up the next generation of products and processes. It offers business support, incubator space, market intelligence and assistance in identifying funding sources. As part of this, a £38 million government-funded National Biologics Centre was opened in Darlington in September 2015. This is designed to help companies create new and improved processes and technologies for the manufacture of biologics.

A similar centre for formulation is now being set up. "We are working towards another two centres," CPI's chief executive Nigel Perry says. "We are always looking to the future, and we are now beginning to deliver. Some of the most exciting things we've been doing in the process industry involve putting in place, and sustaining, an innovation infrastructure that allows UK companies to generate new products and new processes."

Graphene is a great example of UK chemicals innovation. The wonder material was pioneered via Nobel Prize-winning research at the University of Manchester and CPI already has a graphene applications innovation centre. Graphene has potential in areas as

Johnson Matthey

Manufacturing highly potent active pharmaceutical ingredients at Johnson Matthey's Macfarlan Smith plant in Edinburgh

Ineos

The naming ceremony for JS Ineos Ingenuity near Shanghai in China, which will transport US shale gas to its Grangemouth ethane cracker

Ineos

A bird's eye view of the Ineos Grangemouth complex

> "When the weather is good and domestic electricity and gas prices are lower, people do not see how critical shale gas could be. We need to push the argument for shale – import first, domestic exploitation next."
>
> *Chemical Industries Association Chief Executive, Steve Elliott*

diverse as coatings, lubricants, materials and energy storage and several UK companies are looking to develop applications and commercialise products.

Haydale Graphene Industries, for instance, signed an agreement with resin producer Scott Bader to functionalise graphene nanoplatelets for use in resins. Advanced Graphene Materials announced positive results from independent trials in both polyurethane coatings and lubricating oils containing its graphene nanoplatelets. And Bristol-based Versarien's graphene subsidiary 2-DTech has developed a novel method for producing graphene, using a process licensed from the University of Ulster.

Research at the University of Southampton, funded by EPSRC, has led to the development of a way to make 2D molybdenum disulfide materials. They share graphene's electronic conduction and mechanical strength, but are metal-based. In contrast to graphene, they are able to emit light, giving them potential in applications such as LEDs and photodetectors. Using a chemical vapour deposition process, they are now able to build up sheets of MoS2, rather than just microscopic flakes, which is important if industrial applications are to be realised.

Thomas Swan is also looking to extend the 2D idea to other materials, in collaboration with scientists at Trinity College Dublin, by stripping layers off crystals.

"If you have a 3D crystalline structure, you can slough off 2D versions that can have interesting properties for downstream applications," says Harry Swan. This direct liquid exfoliation process allows them to make 2D materials from substances such as boron nitride, molybdenum disulfide and molybdenum trioxide. These have potential in printed electronics, energy applications and mechanics.

Graphene is far from the only hot innovation area in chemicals. For example, much effort is currently being put into transforming waste into useful substances. Biome Bioplastics – another CPI-supported company – started a development project designed to transform lignin waste from the pulp and paper industry into useful plastics. Three companies won government grants to help fund the development of biofuels from waste – Celtic Renewables, which is using waste from the Scotch whisky industry; Novo Pangaea, whose process is based on waste from forestry; and Advanced Plasma Power, which will transform household waste into fuel for heavy goods vehicles.

Such biofuels projects will be increasingly important in future in the light of the EU's plans to limit the use of crop-derived biofuels, in favour of those generated from waste products.

CHINA CONCERNS

Looking to 2016, overall optimism remains. Most CIA members anticipate sales will continue to increase in the next 12 months, and more than a third plan to increase capital expenditure.

The shift to ethane as a feedstock is likely to encourage the expansion of ethylene-based downstream activities. The CIA's le Roux says: "We hope that, ethylene will become cheaper, and this will encourage those intermediate and speciality chemicals firms that use ethylene derivatives to increase their production in the UK."

In such a global marketplace, events elsewhere in the world can have a knock-on effect on the UK industry. As the impact on the motor industry of the Volkswagen emissions scandal shakes down, what affects Germany is likely to have some effect in the UK, for example.

The Chinese economy is another source of uncertainty. "The speed the Chinese market is growing has an impact not just on direct imports and exports of chemicals to China, but on advanced manufacturing goods bought from western economies," le Roux says. "At the moment, this is still generally positive, but the downside risks have increased."

Currency effects are also a concern. "The value of the pound is a worry for UK companies, because Europe is our biggest market, and the pound–euro exchange rate can be volatile," he adds.

Monolith catalysts are used for exhaust gas purification in the automotive industry

BASF SE

The future of domestic shale gas production will also have an effect. If UK chemicals companies could rely on domestic ethane supply, rather than having to import from the US, that would likely save costs and contribute towards long-term stability. Nonetheless, widespread public perceptions of shale gas are decidedly negative.

"When the weather is good and domestic electricity and gas prices are lower, people do not see how critical it could be," says CIA chief executive Steve Elliott. "We need to push the argument for shale – import first, domestic exploitation next. We could then start to think about refilling supply chains, perhaps starting to make ethylene oxide in the UK once more."

But industry cannot do it alone. "What we need for the future is government action on energy policy and especially shale gas, plus a continued framework for innovation to drive productivity and growth," Elliott says.

"I am confident this will convince global companies to continue to invest in the UK and ensure we continue to deliver a positive environmental, social and economic performance." UKMR-15

FRAGRANCE AND DETERGENTS: A SUCCESS STORY FOR AQDOT

Aqdot, a spin-out from Cambridge University's chemistry department, has had a particularly busy year.

It completed a Series A funding round which will finance its operations until early 2018, and moved out of the university labs into a facility on one of Cambridge's science parks, which allowed it to nearly double the number of employees. It has also completed a couple of proof-of-concept studies.

Its encapsulation technology is based on self-assembling molecules and has many potential applications, from household products to foodstuffs to fertilisers. The initial focus is on the encapsulation of enzymes for liquid laundry detergents, where it has a collaboration with Novozymes.

"Our second proof-of-concept area is in fragrances, where we are working with one of the major international fragrance houses," says director of operations Jing Zhang, one of the founders of the company. "We have just delivered a sample for them to test in personal care applications. The aim was to encapsulate an ingredient that couldn't be formulated into this product."

Also this year, they have developed a scale-up process for one of the key raw materials for the capsules, cucurbituril, which is not commercially available. They now have a recipe that can be given to a toll manufacturer for production. In tandem, they completed the REACH regulation process with the European Chemicals Agency (ECHA) that will allow it to be produced at up to 10-tonne scale.

"The next step will be registering for up to 100 tonnes," Zhang says. "This will be important if it is to be used in commercial laundry and personal care products."

In pursuit of 200°C

Ultra High Performance TBCs – in pursuit of a 200°C temperature drop across a 200µm thick thermal barrier coating

Coatings are used in many different engineering applications to protect materials from wear and corrosion whilst also being capable of providing lubrication and thermal insulation. The thermal barrier coatings (TBCs) found on the blades of aircraft gas turbine engines have to work in a highly demanding high temperature environment and are now an essential feature allowing modern gas turbines to operate at the high temperatures required to maximise fuel efficiency.

Figure 1. A low K thermal barrier coating, doped with Erbia.

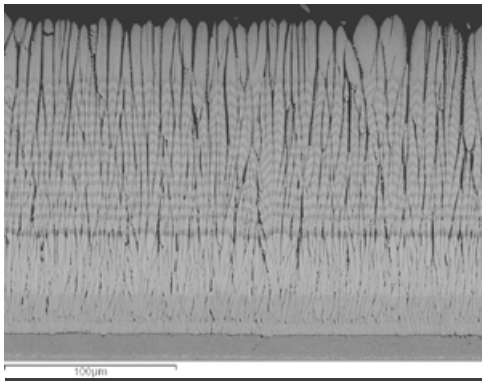


Figure 2. A micrograph of a multi-layered, high performance thermal barrier coating, tuned for thermal reflection in the near infra-red.

The Surface Engineering and Nanotechnology Institute (SENTI) at Cranfield University conducts world leading research into smart coating systems and advanced, functional surface engineering. Professor John Nicholls has led the Cranfield team in a joint Rolls Royce research programme to develop Ultra High Performance TBCs. This research started in the late 1980s, with Rolls Royce's interest in using zirconia-8 wt.% yttria, electron beam physical vapour deposited (EB-PVD) TBC on turbine aerofoils for engines powering the 747 and 777 aircraft at that time. At the commencement of this long-term collaboration, the projected engine operation benefits from adopting the EB-PVD technology was an annual saving of £6 million for an airline operating a fleet of 747 or 777 aircraft. As is evident below, this expectation was greatly exceeded with the development of new low-K (low thermal conductivity) TBC systems. On-going research has led to further incremental improvement of coating manufacturing technology with the SENTI team now in pursuit of the 200°C temperature drop across the 200µm ceramic topcoat thickness; a thermal barrier layer less than the breadth of three hairs.

LOW-K

New low-K thermal barrier coatings have been developed at Cranfield, as part of the research collaboration with Rolls Royce. Such coatings allow higher engine operating temperatures and the reduced use of cooling air, resulting in a reduced specific fuel consumption of over 1%. Figure 1 illustrates a blade coated with low thermal conductivity ceramic, with the pink colouration due to Erbia doping of the zirconia-8wt.%yttria ceramic top coat.

Advanced thermal barrier coating systems such as this have improved the thermal efficiency of large civil aero-gas turbines. Commercial variants of these coatings are now implemented on the Trent, the most powerful of the Rolls-Royce engines including the Trent 1000, used to power the Airbus 380, and the Trent XWB, the new engine to power the Boeing Dreamliner aircraft.

"The use of low-K thermal barrier coatings, is projected to save 14MtCO2e over the 20 year life of the modern gas turbine; while adjustment for the effect of emissions at high altitude, will increase the calculated benefits 26.6MtCO2e. In fuel costs alone, this amounts to a saving of £3.4 billion to the aircraft operators over the engine lifetime." (Prof John Nicholls)

ACHIEVING 200 - TACKLING RADIATIVE TRANSPORT

Is it possible to achieve to achieve 200°C across a 200µm thermal barrier coating? The SENTI team believe so, with the solution lying with tackling radiative transport through the TBC. Recent research has focused on building multi-layered structured TBCs. By layering TBC ceramics of differing optical densities it is proposed to reduce radiative transport by selective reflection of infra-red radiation in the 1-6µm range. Figure 2 illustrates a cross-section micrograph of such a coating produced using a multiple source, jumping beam, electron beam evaporation methods. Using this approach, it has been possible to deposit TBCs with periodic layers (Figure 2). The anticipated temperature drop across such a structured TBC should approach 200°C across 200µm, but this still has to be measured, however the team calculations would suggest it can be achieved.

Professor Nicholls would like to credit his research staff of Dr Christine Chalk and Tony Gray in the article as it would not have been able to produce these coatings without them.

UKMR-15

COLLABORATION IS THE BEST MEDICINE

Image courtesy of the Centre for Process Innovation

BY ZOE CORMIER

The prospects for UK pharma manufacturing are looking good thanks to a host of forward-thinking, multidisciplinary initiatives

Before the economic downturn of 2008, pharmaceutical manufacturing was one of the strongest areas of British manufacturing. Indeed, according to the National Office of Statistics, it was the best performing sub-industry within manufacturing.

Then things took a nose dive: pharma manufacturing fell by 25.9% between 2009 and 2013. The sector started to haemorrhage jobs, with production being moved to cheaper locations in China, India and elsewhere.

"After Pfizer left in 2008, there was a serious worry in the entire sector that pharmaceutical companies would leave the UK," says Fergal O'Brien, head of operations at the National Biologics Manufacturing Centre, a collaborative facility that opened this year. "Traditionally, pharmaceuticals have been strong, and we need to maintain that. The government needs to fund pharmaceuticals as a whole to prevent manufacturing from moving to cheaper countries."

But now there are signs of re-shoring. One of the big catalysts for the shift back to the UK is the recent creation of a string of multidisciplinary collaborative research and development centres, where commercial pharmaceutical firms can collaborate with universities – or even each other – to explore new technologies, processes, drugs and ideas more effectively, quickly and cheaply.

At the Centre for Innovative Manufacturing In Continuous Manufacturing and Crystallisation (CMAC) in Strathclyde, Scotland, for example, giants GSK, Astra

MEDICINE GETS PERSONAL

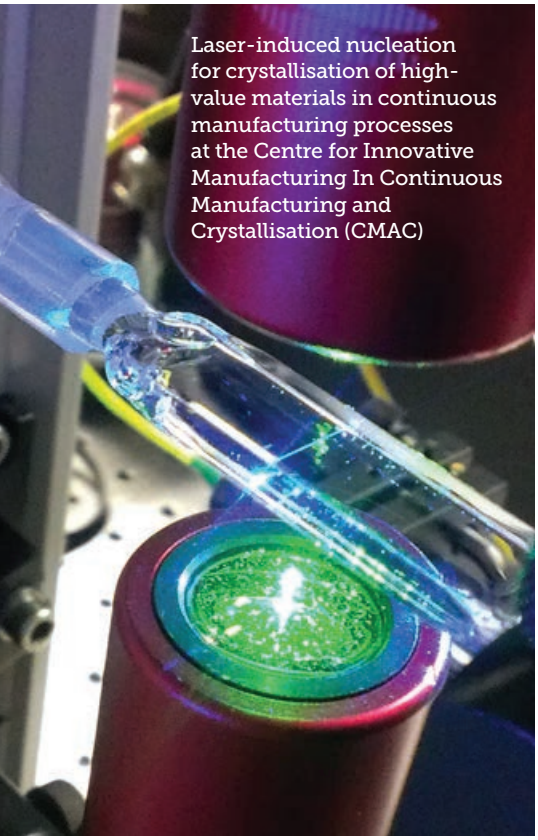
Creating drugs with the knowledge generated by the Human Genome Project is driving the push towards 'personalized medicine': drugs that are geared to work for people with specific genetic variants, rather than marketed to the entire population. Hence their other nickname: 'stratified medicines'.

Though more sophisticated and less prone to averse reactions, these drugs will be harder to scale up because they can only be sold to a smaller portion of the population: the benefits may be greater, but so are the challenges and the costs.

Enter the Centre for Innovative Manufacturing in Emergent Macromolecular Therapies, based at University College London and funded by the Engineering and Physical Sciences Research Council.

"We already have very encouraging results from the research on tools to aid decision making with regard to process," says Andrew Davidson, National Outreach Manager for the EPSRC Centre.

One such project, he says, has seen the centre work with GE Healthcare on a technology that combines standard chromatography resins with a modular cartridge design that is intended to make downstream purification and processing more efficient.



Laser-induced nucleation for crystallisation of high-value materials in continuous manufacturing processes at the Centre for Innovative Manufacturing In Continuous Manufacturing and Crystallisation (CMAC)

The Centre for Innovative Manufacturing In Continuous Manufacturing and Crystallisation: where the commercial and the academic collaborate

Zeneza, Novartis and now Bayer can access research facilities – and expertise – at seven universities across the UK. Here, big firms will be able to explore and hopefully adopt "continuous crystallisation" processes that can create drugs and chemicals more efficiently by keeping reagents in continuous flow, rather than churning out products one batch at a time. This year CMAC moved into a new facility equipped with £11.4 million from the Higher Education Funding Council for England (HEFCE)'s research Partnership Investment Fund (UKRPIF).

The German firm Bayer's move to become a Tier One member was a big win for the UK, says operations director for CMAC Craig Johnston. "They decided to join thanks to the research infrastructure we have in the UK: on the research side, the UK punches above its weight on the global playing field," he says. "Our goal is to help transfer that research power into manufacturing through new technologies and collaborations. Really, we're just replicating what the aerospace and auto industries have done for years in the UK."

Getting pharmaceutical firms to work together on any problem is an enormous change in an industry that has traditionally held its cards close to its chest. New drug discovery and the enormous profits from blockbuster drugs depend on IP, patents and processes.

"In pharmaceuticals, we have been a little insular and secretive, but things are changing now," says Clive Badman, head of Pre-Competitive Collaboration at GSK and industrial chairman of CMAC. "Over 2002 to 2012, the industry spent over £1 billion trying to implement continuous manufacturing without a huge return on its investment. What we needed was a way of bringing together industry with academics to address fundamental problems."

Simply put, with a national demonstration centre, companies can use the equipment to test their own processes without having to buy expensive machinery from scratch.

Moreover, says Badman, working with academics "can bring in fresh ways of thinking".

Also seeing its ribbon cut this year is the National Biologics Manufacturing Centre in Durham, a £38 million facility (part of the Centre for Process Innovation CPI) funded by the government's Department for Business Innovation and Skills through Innovate UK.

"By their very nature, big companies are too risk averse – new technologies need to be more developed before a larger

LOOKING FORWARD

Given that the government has tried to position the UK as a leader in scaling up risky and expensive, but promising, new technologies in pharmaceuticals, what can we expect from 2016?

"The predictions are slightly more difficult to make in pharmaceuticals – the time frame for biologics doesn't move as quickly as in sectors such as electronics or the computer industry. Things take much longer because the field is so heavily regulated," says Fergal O'Brien (pictured), head of operations at the National Biologics Manufacturing Centre.

It is certain however that we will see an increased move towards continuous manufacturing, "personalized medicine", biopharmaceuticals and stratified drug development.

"We're seeing a big shift into 'precision medicines': this is where the Human Genome Project has allowed us to understand the root mechanisms of disease more closely, and to create drugs that are targeted to specific populations of people with specific genetic variants," he explains. "This means you can only give the medicine to the people you need to, rather than waste 80% on the patient population for whom it won't work." The well-known anti-cancer drug Herceptin - on the World Health Organization's List of Essential Medicines - for example only works for certain genetic variants.

The old model of producing "blockbuster drugs" that are geared to treat everybody is being phased out as new kinds of drugs being produced in dramatically new ways is being phased in. Whatever the future holds, it's dramatically different from the bleak outlook for the sector half a decade ago.

"The ecosystem for innovation has been totally transformed over the last couple of years," says Johnston. "We're seeing so many things that just didn't exist a couple of years ago."

company can take them on," says Fergal O'Brien, head of operations at the National Biologics Manufacturing Centre, which aims to help bridge the gap between innovative centres in academia and big companies with the commercial clout to scale up. The site has already attracted four biologics developers. Manufacturing technology at the NBMC was provided by Pall Corporation, Advanced Scientifics, GE Healthcare, GEA, Millipore and Waters.

Like the CMAC, the NBMC aims to help major firms develop, prototype and scale up experimental manufacturing techniques – in this case, for the production of biopharmaceuticals. Also known as 'biologics', biopharmaceuticals are drugs that are derived from biological tissue or are synthetic mimics of naturally occurring proteins or molecules.

Vaccines, antibodies, hormones and other biologics account for 16% of all pharmaceuticals and are one of the fastest growing areas of drug manufacturing and research: "In the last 35 years, there has been a change to manufacture drugs using natural, biochemical processes, which can produce more complex molecules far more cheaply," explains O'Brien.

And the UK has always been at the forefront: In 1982, the UK became the first country to approve a biopharmaceutical when regulators gave the green light to Genentech and Eli Lilly's insulin replacement product Humulin, a month ahead of their US counterparts. "Prior to this, insulin was always extracted from cultured tissues, and it was slow and far more expensive," says O'Brien.

Since then, biopharmaceuticals have become a huge focus for pharmaceutical firms – in 2014, five out of the top 10 best-selling drugs were biotech products – and the UK continues to play a key role in developing the technologies and processes needed to produce them. This will give the UK a strategic advantage for the future, says O'Brien.

BREAKING NEW GROUND

In line with government-funded catalysts, firms themselves are starting to build new facilities.

In February AstraZeneca was granted planning permission for a new headquarters and R&D centre in Cambridge. The facility will replace the firm's base in Alderley Park, Cheshire, which is being redeveloped as a drug discovery hub by new owner, Manchester Science Park. AstraZeneca said the decision to move 1,600 jobs was prompted by the Cambridge site's proximity to a research 'ecosystem' that includes the University of Cambridge, Addenbrooke's Hospital and the Wellcome Trust.

This year also saw AstraZeneca's newly constructed £120 million manufacturing facility in Macclesfield produce its first batch of the cancer treatment Zoladex. The firm said its decision to build the plant in the UK was driven in part by support it received from the Medicines and Healthcare products Regulatory Agency (MHRA) relating to the design of the aseptic production areas.

On a negative note for UK manufacturing, 2015 has also seen AstraZeneca move forward with plans to close its active pharmaceutical ingredient (API) production facility in Avlon near Bristol. The site – which has been earmarked for closure since 2008 – produces the APIs for the cholesterol drug Crestor, which loses patent protection in the US in 2016.

AstraZeneca's planned API plant closure contrasts with a move made by UK rival GSK, which contracted construction firm Doosan Babcock to build a £25 million drug actives plant in Montrose in Angus, Scotland in January. The facility will produce APIs for respiratory drug products and is expected to be operational 2016. The investment, which will create 25 jobs according to GSK, reverses a previously announced plan to close the plant at the end of 2007.

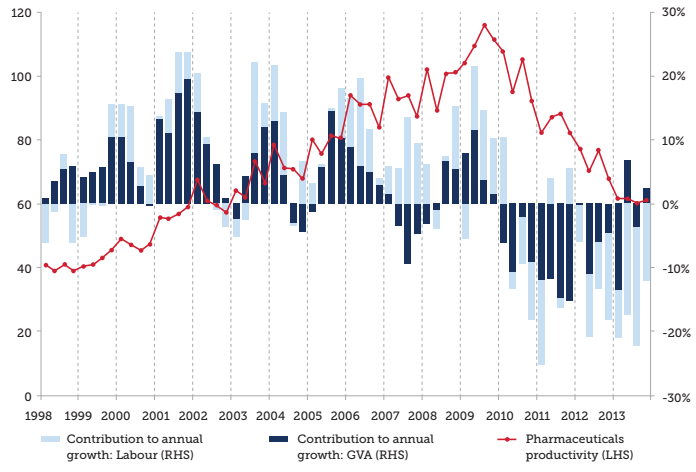
GSK has also continued development and construction of a £500 million biologics manufacturing facility Ulverston, Cumbria in 2015. The firm announced the project in 2012, citing the then planned 'patent box' – a batch of tax incentives – as a motivation for choosing to build in the UK. The UK has also attracted investment from international pharmaceutical manufacturers with France's Sanofi being the highest profile example. In September the Paris-headquartered firm sought permission to expand its inhalable drug production facility in Holmes Chapel, Cheshire.

Craig Johnston of CMAC

Just days after the opening of the National Biologics Manufacturing Centre in the autumn of 2015, another government backed initiative – Cell Therapy Catapult (CTC) – announced big plans for expansion. The CTC – also supported by Innovate UK – is developing a cell therapy manufacturing facility in Stevenage with the aim of providing developers with a place to produce their candidate treatments for clinical trials and commercial launch. In October 2015 the CTC announced that German facility consultants M+W Group would design and build their £55m, 7,200 sq m facility, expected to be fully operational in 2017.

The overarching aim of overall all these government initiatives is to make the UK a more attractive place for developers of advanced therapies. Whether such efforts will attract international developers in the long term remains to be seen. The early signs, however, are encouraging. In October, US biotechnology firm Asterias Biotherapeutics said it would set up a UK subsidiary to collaborate with Cell Therapy Catapult on process development for a candidate lung cancer therapy. Added to Bayer's move to work with CMAC, it seems that the government's plan to strengthen the pharmaceutical sector's clout and flexibility – first laid out in the Strategy for UK Life Sciences back in 2011 – is working. UKMR-15

Output per hour of pharmaceutical products and preperation manufacture, and components of output per hour growth (quarter on same quarter last year)



New biotech manufacturing centre

The National Biologics Manufacturing Centre at the Centre for Process Innovation in Darlington was opened in September 2015.

The CPI is bolstering Wilton, just south of Middlesbrough, which has been an important site for industry since 1952

HOW THE CPI WORKS

RESEARCH & DISCOVERY

Research & Discovery is often limited and faces financial barriers

Manufacture is often time and cost prohibitive due to fractured supply chains

Consequentially, the research fails to penetrate the commercial market

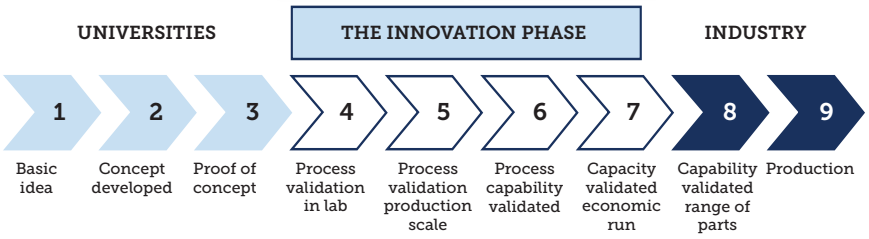
MANUFACTURE

Product Challenges

Better products
Innovative effects
Higher yields

Business Challenges

Lower material, operating and fixed costs
Faster production rates
More sustainable products



"The launch of the centre will significantly increase the UK's manufacturing capability in biologics, and strengthen our position as a location of choice for life science"

Nigel Perry, chief executive

The use of biotechnology is becoming increasingly popular across different markets within the UK. By utilising biotechnology, we can develop breakthrough products and technologies to combat debilitating and rare diseases, reduce our environmental footprint, use less and cleaner energy, and have more efficient industrial manufacturing processes.

One market in particular which can heavily benefit from the use of biotechnology is the UK Life sciences sector. The use of biopharmaceuticals as opposed to traditional chemical derived pharmaceuticals are becoming increasingly popular in the fight against disease. Biotechnology is allowing us to develop therapies which can be tailored to meet the specific needs of patients, creating a more personalised approach to medicine.

The Strategy for UK life sciences announced by the government in 2011 acknowledged that the UK is under-utilising our strengths in this sector. By closely integrating universities, our clinical research base, industry and the NHS we can attract new investment to the UK, create new jobs and economic opportunities but most importantly develop new treatments to care for an ever demanding population both in the UK and across the globe.

There is huge potential to capitalise on the excellent proven research base which already exists in the UK, the next stage is to take these ideas and develop them into a tangible product or process which can be used to create the future innovations of the life sciences sector.

In order to address this, in December 2012 Prime Minister, David Cameron announced that the Centre for Process Innovation (CPI), part of the High Value Manufacturing Catapult, would manage a £38m large scale open access facility to support the manufacture of biologic medicines.

The centre was officially opened in September 2015 by Jo Johnson, Minister of State for Universities and Science and Steve Bagshaw, CEO of Fujifilm Diosynth Biotechnologies.

Utilising the National Biologics Manufacturing Centre, CPI can help companies of all sizes to understand the technical feasibility of their new biologic process or technology, helping to get it to market faster and with less risk. CPI enables ideas, research and knowledge to be translated into commercial business propositions by providing the facilities and technical expertise to help companies overcome their innovation challenges.

The centre was opened in September 2015 by Jo Johnson, Minister of State for Universities.

With a focus on the development and integration of improved process and analytical technologies; formulation, fill and finish; process development; training and workforce development and the factory of the future. CPI is equipped to support the industry at every stage of the supply chain and help the UK capitalise on its excellent proven research base.

Nigel Perry, CEO of CPI said, "The launch of the National Biologics Manufacturing Centre will significantly increase the UK's manufacturing capability in biologics and strengthen the UK's position as the location of choice for life science companies. This open access facility will enable companies to test and trial new ideas cheaply and quickly with minimised risk, allowing new innovative medicines to reach the market faster and provide improved care for patients and better opportunities for businesses". UKMR-15

Image courtesy of Tata UK

ANNUS HORRIBILIS FOR STEEL

Redcar, Tata Steel, Caparo: cheap steel imports to the EU from China were blamed for a trail of devastation in the UK steel industry in the autumn. But new techniques in areas like aluminum casting shows some bright spots in the UK metals sector.

2015 was a difficult year for much of the metals industry. For the steel industry it was disastrous as global overcapacity, weak demand and falling prices were aggravated by high costs and cheap imports.

The most notable casualty was SSI UK's steelworks in Redcar, which ceased production with the loss of 1,700 jobs. The plant closed and the UK subsidiary of the Thai-owned Sahaviriya Steel Industries (SSI) went into liquidation after months of financial difficulties as the price of steel slab dropped from $500 a tonne to $300 a tonne.

Tata Steel, which sold the Redcar plant to SSI in 2011, also announced job losses and the mothballing of plants. In July it said it was reducing employee numbers by around 700 people as it refocused its speciality steels and bar business on higher-value markets such as aerospace. A month later it also announced changes in its strip products business in order to 'reduce costs and focus on manufacturing higher-value products'. This included taking the hot strip mill at Llanwern out of production until market conditions improved. Later in the year, having failed to sell its European long products business to the Klesch Group, Tata announced that plate mills at Scunthorpe, Dalzell and Clydebridge would be moth-balled, along with two coke ovens at Scunthorpe, at a cost of 1,200 jobs. In the same week as this was announced, metal processing group Caparo Industries plc went into liquidation, threatening 1,700 more jobs.

According to trade body UK Steel, one of the key issues affecting UK iron and steelmaking is a dramatic rise in the level of imports of Chinese commodity-grade steel – which have exacerbated the problems of high exchange rates, high energy costs and high business rates.

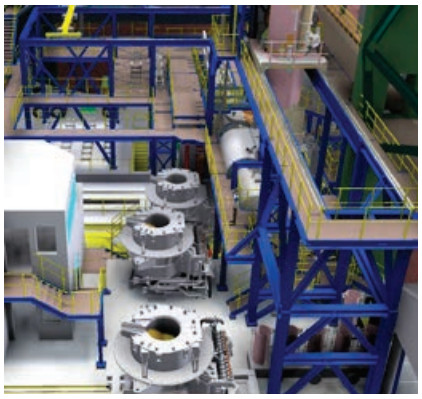
The steel manufacturing capacity of China is around 250 to 300 million tonnes – compared to the UK steel capacity of 12 million tonnes – and as domestic demand declines, Chinese steel is flooding onto international markets at prices that are seen by some as tantamount to dumping.

What has startled the UK steelmakers is the rate at which Chinese imports have grown from a relatively low base.

Industry trade body UK Steel says that in the first six months of 2012, for example, imports of Chinese steel reinforcing bar represented less than 1% of the UK market, but by the second half of 2015 they had grown to 41% of the market. The concern is that the same thing will now happen in areas such as hot rolled coil, plate and heavy sections, where Chinese imports have not previously been a concern.

As well as the problems of cheap imports, the UK steel sector also pays around twice as much for its electricity as French and German competitors.

UK Steel says that the effects of energy and climate change policies add £130m a year to the UK steel sector's costs and that although these are mitigated by the Government's Energy Intensive Users Compensation scheme, it doesn't yet cover all the costs.

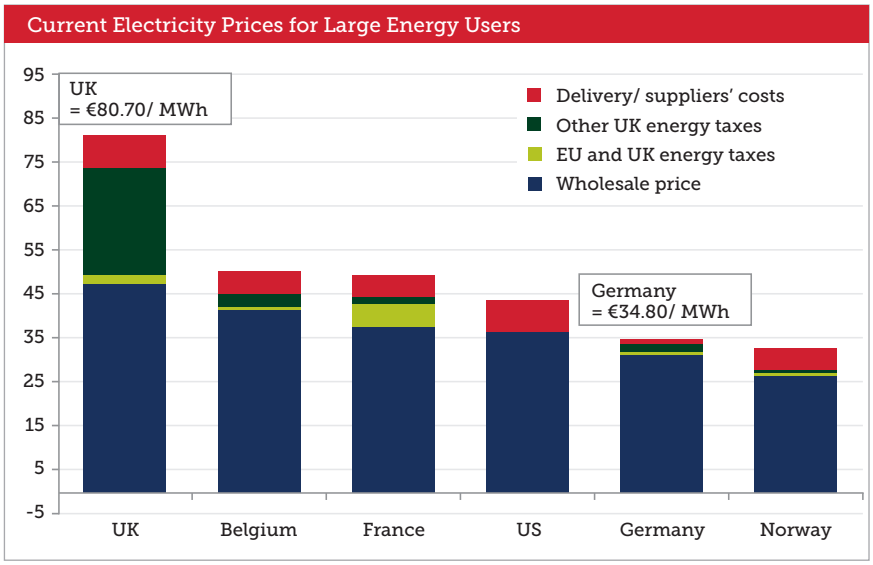


Images courtesy of Tata UK

Above: The installation of a custom-built slitting line represents the culmination of a two-year, £4m investment programme at Vetchberry Steels

Top right: The new Vacuum Induction Melting Furnace at Tata Speciality Steels, Stocksbridge, will allow the company produce high-value steels for safety-critical markets

Right: Electricity Prices: The UK steel industry pays around twice as much for its electricity than its counterparts in France and Germany – source Tata Steel



Source: Tata Steel

Around 70% of the total costs are as a result of renewables policies and the Government has yet to obtain EU state aid approval for these – UK Steel is pressing the Government to fully implement the scheme ahead of April 2016.

HIGHER ADDED VALUE

There was some positive news from the steelmaking industry. Supporting the new focus of its speciality steels business on higher-value products, Tata Steel entered the commissioning phase on a new vacuum induction melting (VIM) furnace at its Stocksbridge plant. This allows metal to be melted, and cast into ingot in an oxygen-free atmosphere to create very clean steels with a very low gas content. The ingots are then further refined in a vacuum arc re-melting (VAR) furnace before being used to manufacture products such as aero engine and landing gear components.

The VIM furnace will also allow Tata Steel's speciality steels business to expand into new markets.

A Tata Steel spokesman said: "The feedstock is steel, but the materials that come out of it are very different and will all be for safety-critical applications such as aerospace, automotive and down-hole oil and gas components. This really is 21st century steelmaking."

The total investment in the VIM furnace and two complementary VAR furnaces came to £20m.

There was also good news with the announcement that the hot rolled coil plant at the former MIR plant in Newport, now owned by the international Liberty House Group, was being brought back into production more than two years after it was mothballed.

PLANS FOR A NEW STEEL PLANT

In the face of announcements of plants closing, a new company, Albion Steel Limited, announced plans for what would be the UK's first new carbon steel plant to be built in the UK since the 1970s.

Albion wants to build a new steel melting and finishing facility in Sheffield using an advanced net shape casting technology with the aim of producing around 450,000 tonnes a year of finished product – mainly hot dip galvanised (HDG) strip. This would create 200 jobs and could potentially replace imports of HDG strip worth around £200m a year.

The plant would be based around the Castrip process, which was developed in the USA and casts molten steel between two rollers to produce continuous strip that is as close as possible to the final net thickness required – in this case around 1.5 to 1.8mm. The strip can be rolled to less than one millimetre using just one rolling stand – this compares to six or seven hot rolling stages and subsequent cold rolling to produce strip from slab.

The plant will recycle large volumes of low-quality scrap and the directors say they expect it to be the most efficient, compact and environmentally sustainable steel plant in the world.

Site preparation is set to start in January 2016, with production commencing by June 2018 and ramping up to full capacity over the following 18 months.

DISTRIBUTION CHAIN INVESTMENTS

The UK metals distribution chain has also seen considerable continued investment in 2015 – as well as the development of more added-value services.

Tata Steel completed a £15m programme of investments at its Steelpark service centre in Wednesfield,

Bridgenorth Aluminium has created 75,000 tonnes of new capacity for lithographic plate

Image courtesy of The Aluminium Federation

UK metals industry in numbers

- £200bn of UK GDP based on metals
- 11,100 companies with an annual turnover of £33bn
- 1700 jobs lost with closure of SSI UK
- 41% of UK market taken by Chinese rebar
- 1.5 to 1.8mm strip produced by Castrip process
- £130m annual cost to steel industry of energy and climate change policies
- 80% aluminium in the new Jaguar F-Pace
- 220,000 tonnes capacity of Novelis aluminium recycling plant
- 75,000 tonnes of new litho plate capacity at Bridgenorth Aluminium
- £3 - 4bn Metals Strategy could add to UK GDP

which it says is the UK's largest steel processing centre. This year it added a further multi-strand blanking line to its light gauge service centre, complementing the opening in 2014 of the UK's largest plate profiling centre. The automotive service centre at Steelpark also saw investment in new and upgraded press blanking and tailored blank welding lines.

ThyssenKrupp Materials (UK) Ltd commissioned a new flagship 1,850mm wide slitting line at Vetchberry Steels, its coil-processing division in Birmingham. The installations of the custom-built line represents the culmination of a two-year, £4m investment programme. The company says it expects the new line to be the most efficient slitting line in the UK for stainless steel and also aluminium coil production.

Aluminium on the up

Although facing some similar challenges to steel – in the form of energy costs and imports from China of semi-manufactured products such as extruded profiles – the UK aluminium sector has had a much happier year. The driver for much of this has been the continuing trend towards lightweight structures to improve performance while reducing fuel usage and carbon footprint.

According to the Aluminium Federation, this has seen growth in the use of aluminium in areas such as construction, the rail industry and above all automotive manufacture – in particular by Jaguar Land Rover.

The Federation's own membership has seen an increase in the number of members who are not aluminium producers or processors, but use aluminium in their manufacturing – from Jaguar Land Rover down to the smaller companies that supply them.

With the launch of the XE in 2014 and the new XF and F-Pace high-performance crossover car in 2015, Jaguar now uses a light, stiff aluminium-intensive body structure across its range. The body structure of the F-Pace comprises 80% aluminium and the vehicle as a whole contains the highest aluminium content yet of any of Jaguar's cars.

The cars use a high proportion of recycled material, including special alloys developed in conjunction with Novelis that enable closed loop recycling of scrap and offcuts from the manufacturing process.

Novelis is now reaping the benefits of its £6m investment in 2013 to expand capacity at its Warrington plant to 220,000 tonnes a year of rolled aluminium products.

UK IMPORTS OF STEEL FROM CHINA									
YEAR	TONNES	RODS & BARS	HOT ROLLED	COLD ROLLED	COATED	TUBES	OTHERS	TOTAL IMPORTS	% FROM CHINA
2001	48,285	60	1,950	21	11,983	14,119	20,152	8,108,930	0.6
2002	66,164	451	12,932	4	13,639	10,510	28,628	8,892,966	0.7
2003	50,868	345	0	23	16,154	21,865	12,481	8,191,429	0.6
2004	83,025	11,234	7	308	27,848	26,045	17,583	8,772,850	0.9
2005	143,573	15,374	5,390	663	25,325	61,917	34,904	7,756,087	1.9
2006	342,410	19,011	97,282	16,826	87,391	66,262	55,638	8,862,310	3.9
2007	829,962	87,232	258,588	24,466	152,796	144,782	162,098	9,349,564	8.9
2008	455,783	6,087	174,471	44,009	60,529	80,071	90,616	8,049,193	5.7
2009	114,427	6,234	23,959	4,713	14,214	33,592	31,715	4,373,490	2.6
2010	322,943	1,602	76,249	9,529	160,234	35,697	39,632	6,241,370	5.2
2011	445,646	10,865	66,525	72,468	202,056	43,607	50,125	7,329,462	6.1
2012	339,610	9,242	35,917	45,996	145,061	46,834	56,560	7,174,822	4.7
2013	360,553	53,167	58,986	33,629	126,203	37,077	51,491	6,392,215	5.6
2014	751,885	278,285	84,137	56,922	225,803	44,502	62,236	7,409,902	10.1
2015*	484,696	181,688	89,773	21,391	128,190	21,316	42,338	4,165,832	11.6

* 2015 figures for January to July only

Source: ISSB Ltd

Away from the automotive sector, Bridgenorth Aluminium has invested in a new production facility for lithographic sheet. A new cast house, cold rolling mill and finishing line add 75,000 tonnes of new capacity – more than doubling the previous maximum production.

A strategy for the metals sector

Although it was rather overshadowed by events in the steel industry, 2015 also saw the launch of the Industrial Strategy for Metals. Ten trade bodies from across the industry came together to set out their vision for the future of the metals sector and the pathways that need to be taken in areas including skills, supply chain, innovation and sustainability.

One of the central initiatives was the creation of a Metals Council that will bring together a fragmented industry and drive delivery of the strategy's objectives and action plans.

Phil Rawnson, Chairman of the Cast Metals Federation, one of the trade bodies involved in developing the strategy, says: "Sector strategies have been developed over the past few years for a lot of the key industries including automotive, aerospace, nuclear and renewables. All of the industries have identified in their strategies that they need a strong supply chain and one of the most critical elements of that supply chain is the metals industry."

Michael Ward, Technical Director of the Advanced Forming Research Centre, which had a strong input into the strategy, says innovation is central to ensuring that metals industry SMEs are able to support UK supply chains.

"You need to have a local industry that can operate as a supply chain for the automotive industry, aerospace, renewables and so on, and can provide quality products that allow the OEMs to differentiate their products," he says.

The problem is that many SMEs in those supply chains have not invested in new technology. So when OEMS look to produce their next-generation products, the UK supply chain isn't set up to deal with the scale and pace of change required.

"If you are a traditional company with your own niche, it is possibly unlikely that you are going to be able to make the transition to the next generation of totally different component designs," says Michael Ward.

Jaguar's new F-Pace performance crossover uses 80% aluminium

Jaguar Land Rover

To address this, part of the Metals Strategy has been to develop some approaches for SMEs that help take the risk out of innovation. These include diagnostics and support to determine whether a company is ready to invest, 'Innovation for SMEs' business process tools to maximise the chance of success when introducing a new process, and signposting to make sure that the SME understands trends, timing and drivers in the OEM customer base.

When this is in place, the next step will be to identify clusters of companies for collaborative innovation.

Overall, the Industrial Strategy for Metals aims to add £3-4bn to UK GDP and to create 150,000 jobs.

Future outlook

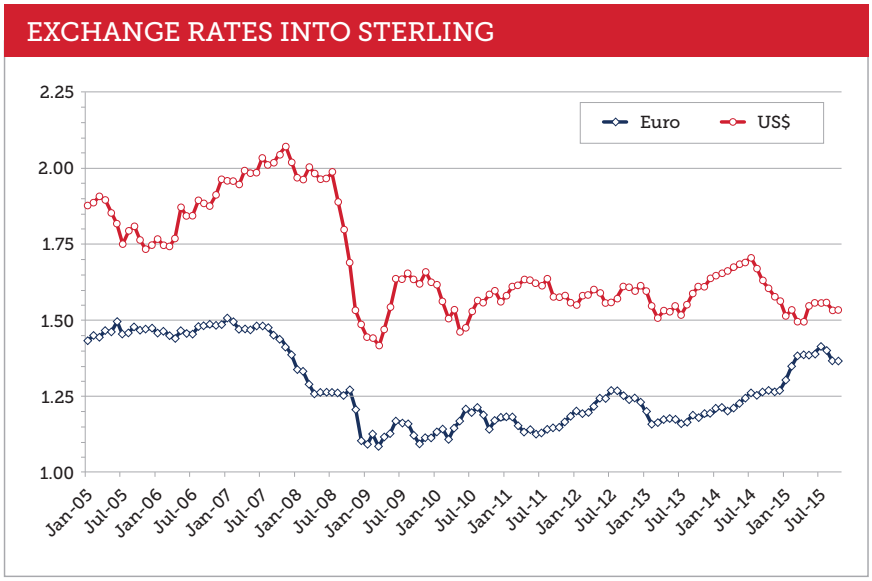
Global oversupply and the strong pound are likely to continue to drag the steel industry down, but the Government has now taken steps to address some of the other key issues. Following a high-level Steel Summit it agreed to set up three minister-led working groups to urgently address public procurement, international comparisons and competitiveness and productivity. The latter will look at energy and environmental costs, business rates and regulation as well as the actions the industry can take to drive up competitiveness.

What many are hoping is that the Industrial Strategy for Metals will be a true game changer. We might not immediately see its effects, but a concerted effort to build up UK supply chains should provide a boost for the British economy as a whole. UKMR-15

Advanced engineering: 2015 economic overview

BY GEOFF NOON, THE MANUFACTURING TECHNOLOGIES ASSOCIATION

Across the summer there were plenty of economic headlines that would suggest doom and gloom, but the bad news is not really as bad as it sounds. The UK's manufacturing economy situation has plenty of bright spots.



EXCHANGE RATES WITH £: Eurozone countries are better placed exporting to dollar-using countries than the UK

The gloom emanating from the slowdown in China is often overdone. It is true that there are significant impacts for some countries and industries with investment in China slowing sharply (from a rate that was both unprecedented and unsustainable), especially in relation to construction and heavy industry, but China is moving to the next stage of development and starting to look more like a developed economy. This means that the middle classes continue to grow, supported by the growth of the service sector, thereby generating growing demand for cars and flights which is good news for these industries.

The slowdown in China is also a large part of the story behind falling oil (and other commodity) prices. While this is bad news for those countries supplying these items - including the oil & gas sector in the UK, although there are other factors at work in this sector with excess global supply - it is good news for consumer spending in the global economy and is helping to keep inflation (and, therefore, interest rates) low.

Returning to the UK economy, we see this reflected in autumn 2015's marginally negative rate of inflation, with falling motor fuel prices one of the main drivers. We expect this to continue with the Bank of England pushing its expectations for inflation to get back to its target of +2% out to the end of 2017. A surprisingly dovish announcement of the MPC's decision on interest rates following their November meeting has led commentators to move expectations of a UK rate rise out to the end of 2016.

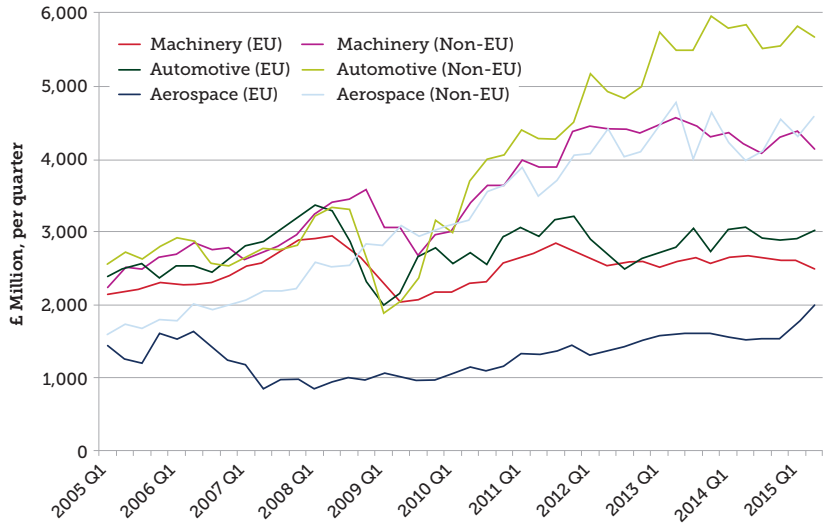
Coupled with a strong financial position for the corporate sector, this should support investment in the UK and although we have seen investment intentions weaken over 2015, they are still point to steady growth in investment over the coming 12 months.

The other main macro-economic items are the trade balance and exchange rates – not entirely unrelated issues. The UK's trade deficit in goods narrowed in the 2nd quarter of 2015 to its lowest level since the 3rd quarter of 2012, but has widened again over the summer, although not quite back to where it was at the start of the year. The improvement in the 2nd quarter was due to a spike in exports and a fall in imports from outside of the EU, but this appears to be, at least in part a one-off effect In Chemicals, although the improvement in exports of Machinery & Transport Equipment looks to have been retained a bit better.

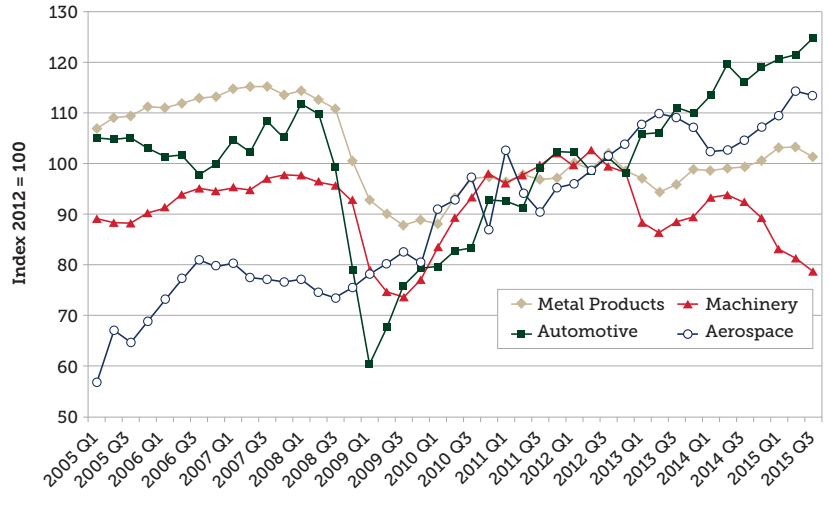
The UK currently lies between a strong US dollar and a weak euro; we, therefore, have an advantage in trade with those markets of the world which use the US$, including China, although the Euro-zone countries have even more of an advantage and, of course, the UK is at a relative disadvantage in Europe.

Economic theory tells us that UK exports should be boosted by a weak currency and vice-versa when Sterling is strong; however, this is far from the whole story and in the modern industrial world, other factors are far more important. For example, companies manufacturing products which require significant investment in factories and supply chains such as cars and aeroplanes cannot make quick changes in the deployment of those resources. It is not, therefore, possible for companies making such products to switch production from the strong currency country to the place where the currency advantage is being accrued. In addition globalised supply

UK EXPORTS OF KEY INDUSTRIES



OUTPUT BY INDUSTRIAL SECTOR



Output of advanced engineering machinery in the UK has fallen since Q3 2012. But MTA members found the sharp drop in 2013 portrayed by ONS bore no resemblance to the market conditions they experienced, which has raised a question mark over the ONS's methodology for recording machine sales

chains may well include a number of currencies in the transactions at different their different stages making specific effects harder to identify.

It is true that while exports of key engineering industries, Machinery, Automotive and Aerospace, have all seen exports to non-EU countries move ahead, this trend is not linked to the timing of changes in exchange rates; Sterling gained an advantage vis-à-vis the US$ from about July 2014 and the Euro weakened significantly from January 2015, but there is only a marginal fall in Machinery exports to the EU in 2015 and deliveries for the Aerospace industry have grown in 2015 to their highest level since the current series began in 1998.

The key driver of export performance, at least in the short-term, is the demand for the products in the various world markets. It is our argument that exchange rates (and in this case expectations about the future as much as the current or recent situation) only have a major impact at the point of investment decisions, at least for those industries where global firms will, typically, only have one factory or, perhaps, one per continent.

So, before we turn to forecasting, we need to take a quick look at the industrial landscape in the UK; the chart shows the value of output in the 4 key industries that we track - we excluded Metal Products from the export analysis as it is traded much less than the other 3 sectors, although for UK output it is of similar value to the Machinery industry and is larger than Aerospace.

Output of the Automotive industry - much more of course than just the cars, with the UK making more engines than it does vehicles - is at a record high and looks set to expand further; assuming that the issues being faced by VW are restricted to that company (and there is every sign at the time of writing, autumn 2015, that this is the case), then UK producers such as BMW, Nissan and Jaguar Land-Rover should be well placed to grab market share. The Aerospace sector also looks likely to continue growing with Airbus recently announcing that it plans to accelerate production of the A320 family to 60 aircraft per month by 2019 – the delay is because it will take that long for the supply chain to ramp up to meet this level of output and, while not all of it will be in Europe, the UK will share in this growth.

The major weakness is in the Machinery industry; this is a diverse sector which includes pumps & valves - essential components in the oil & gas sector - and construction equipment have faced slowing demand from China with their reduction in spending on construction. The UK also faces headwinds in the Basic Metals industry where global over capacity and high energy prices in the UK have led to a crisis in this sector.

Metal Products, which covers both specific products such as boilers and furniture and sub-contract activity in both machining and forging/pressing, lies between the divergent trends of the other 3 key sectors for suppliers of manufacturing technology equipment. There had been an improvement in this industry in 2015 and although output fell back in the 3rd quarter, it was still above where it had been during 2014.

Given all these trends, we expect 2015 to see a small reduction in the UK market for both machine tools and cutting tools, before a positive trend for 2016. It is worth noting, however, that all this is at a high level with all of the totals from 2012 onwards being above anything we have seen in the earlier part of this century. UKMR-15

Automation in the food and drink industry

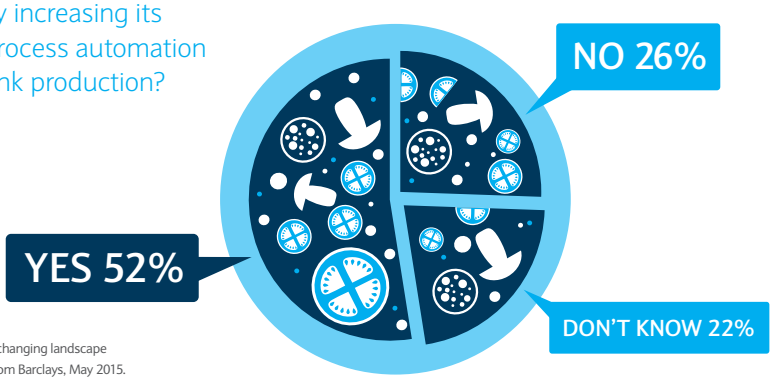
The food and drink industry faces particular pressures in terms of hygiene and uniformity of product that make it a prime candidate for increasing automation. This is a priority for more than half of the companies surveyed in Barclays' food and drink industry survey in May.

However, the diversity of the sector, its products and manufacturers' markets mean within this overall picture of increasing automation there is wide variance.

For some companies – especially drink manufacturers where standard beverages are produced in defined sizes and huge numbers – automation and control systems are a crucial part of a broader plant management strategy. On the other hand, food is different from other manufactured goods. This is because opportunities for automation within the production process can be limited by product variables – for instance, butchery is often difficult to automate as animals come in different shapes and sizes. Nevertheless, some operations that are essential in many food processing and preparation factories, such as tasting samples from the production line of a ready meal to ensure it meets quality and customer expectations, are impossible to automate.

Overall, increasing automation could be a positive move for food and drink manufacturers to make sure they remain competitive in a challenging marketplace.

Is your company increasing its investment in process automation for food and drink production?



Source: Food for thought – The changing landscape of the food and drink industry from Barclays, May 2015.

Tim Burton's 'The Kelpies', runner-up of the amateur photographer category in the EEF/Lombard 'Make it Britain' photography competition 2014

Image courtesy of Aldi

Budget bonanza: discounters such as Aldi are enjoying a boom with consumers and changing the food retail landscape

SECTORS - FOOD AND DRINK

BY PAUL GANDER

FALLOUT FROM THE BATTLE OF THE AISLES

The dominance of the big supermarket chains is under threat from a voracious band of budget retailers – and food and beverage manufacturers are adapting to take advantage of the new market

Food and drink makers – one of the largest manufacturing sectors in the UK – are under pressure.

They are suffering from skills shortages, a familiar complaint, but the biggest problem they face concerns getting goods to cost-conscious consumers in 2015.

Whether supplying private-label or branded products, manufacturers have traditionally grown in line with whichever of the "big four" supermarket chains they supplied.

This was the year that brought such expectations to a juddering halt. In 2015, the big story was the contrast between the poor performance of the established supermarkets, and the boom enjoyed by the hard discounters – particularly Aldi and Lidl.

Sales through these chains grew by 17.3% and 16% respectively between summer 2014 and 2015 (see table), enormous compared to growth among the big four – which only scraped into positive territory in the case of Sainsbury's.

In fact, the discounters have been increasing their store openings since 2008, when food prices became the top priority for consumers.

"Aldi and Lidl now have just under 10% of grocery sales between them, but they have plans to double the number of their stores by the early 2020s, by which time they could have 15% or 17% of the market," says head of retail and consumer insight Fraser McKevitt.

The discounters offer possibly even less long-term security for suppliers than the mainstream supermarkets.

"The dilemma for manufacturers is that they want their products to be where the shoppers are," says director of economics and commercial services at the Food & Drink Federation (FDF) Steve Barnes. "How do you move into new areas without disenfranchising your existing customer base which you've grown up with?"

But one positive impact of the rise of Aldi and Lidl could be to make supply agreements simpler. "Rather than finding 25 ways of extracting money from suppliers, the discounters are more likely to say: 'We agree a price, and you deliver'," says Barnes. "People are moving away from complex buying processes."

The growth in convenience-format stores, particularly Tesco's and Sainsbury's, and the rise of online sales and home delivery, have also contributed to the sense of a fast-changing landscape in food retail.

HORSE TRADING

If manufacturers are concerned about downstream sales, there has been equal pressure to focus on the upstream supply chain. The echoes of the 2013 horsemeat furore are still heard thanks, in part, to the Elliott Review, set up by the government to look into the issues around criminal

KANTAR WORLDPANEL MARKET SHARE - TOTAL TILL ROLL					
Includes all expenditure through main store tills and excludes petrol & instore concessions					
Total Till Roll - GB Consumer Spend					
	12 Weeks to 14 September 2014		12 Weeks to 13 September 2015		% Change
	£ millions	% **	£ millions	% **	%
Total Grocers	24,500	100.0%	24,718	100.0%	0.9%
Total Multiples	23,985	97.9%	24,206	97.9%	0.9%
Tesco	7,046	28.8%	6,975	28.2%	-1.0%
Asda	4,248	17.3%	4,123	16.7%	-2.9%
Sainsbury's	3,971	16.2%	4,007	16.2%	-2.9%
Morrisons	2,675	10.9%	2,638	10.7%	-1.4%
The Co-operative	1,570	6.4%	1,585	6.4%	1.0%
Waitrose	1,241	5.1%	1,277	5.2%	2.9%
Aldi	1,178	4.8%	1,382	5.6%	17.3%
Lidl	892	3.6%	1,034	4.2%	16.0%
Iceland	472	1.9%	487	2.0%	3.4%
Other Multiples	692	2.8%	699	2.8%	0.9%
Symbols & Independents	515	2.1%	512	2.1%	-0.7%

Kantar

Below: Quorn NPD from 2014, ahead of the £550M acquisition in 2015 by Monde Nissin

Quorn

food adulteration and food security. There has been a considerable tightening up of assurance and traceability processes. There is also more interest in foods of British origin.

The review published its findings in 2014, with some important recommendations implemented during 2015. A National Food Crime Unit (NFCU) was established under the auspices of the Food Standards Agency (FSA), with Andy Morling joining as head of the NFCU in March. When it comes to food crime, Morling admits: "I'd be the first to accept that there are significant gaps in our understanding of the threat."

Whether the newly set up NFCU has "teeth appears to be uncertain. In September 2015, reports suggested Morling's superiors at the FSA were considering the possibility that the unit may never have investigative powers in its own right. Instead, those powers could remain with the police and local authorities, running counter to the review's recommendations.

But Morling maps out a wider role for the unit: "In addition to pursuing offenders, the NFCU will also have an important wider role to play in helping to prevent criminals from exploiting similar vulnerabilities in future."

Nor will most manufacturers be relying on the NFCU – or any other national institution – to ensure the safety and credibility of their food.

SELLING ENGLAND BY THE LB?

One of the beneficiaries of the horsemeat scandal was non-meat protein. Perhaps the best-known UK brand in this segment – Quorn – attracted international as well as domestic attention, to the extent that the business was snapped up by Philippines-based Monde Nissin from its private-equity owners in October 2015 for £550 million.

This is part of a pattern whereby efficient, quality-conscious UK brands with strong innovation and food safety credentials are acquired by foreign buyers. While those non-European buyers were, in the past, most likely to be US-based, today's investors tend to arrive from the East – rather than the West. For example, November 2014 saw United Biscuits sold, again from private equity ownership, to Turkey's Yildiz Holding, owner of the Ülker biscuit brand. The deal was reportedly worth £2 billion.

The new owners of these brands are showing themselves to be no less canny than their private-equity partners. Having taken a 60% slice of breakfast cereal business Weetabix in 2012, China's Bright Food acquired the remaining 40% of the company, again, from a private equity owner, in August 2015. But it immediately sold that minority stake on to Baring Private Equity Asia for a tidy profit.

Kiddyum

The Kiddyum frozen range went into 324 branches of Sainsbury's in September 2015

Mike Rigby, head of manufacturing, transport and logistics at Barclays, says it is flattering that attractive, UK businesses with strong brands and investment are being snapped up by overseas purchasers. But, Rigby says, this also means that "British brands may fall into overseas ownership and profits may go up, but investment decisions are then made from a global perspective. British manufacturing brands may face dilution."

Meanwhile, established food manufacturers in Britain struggling to adapt their offer to meet the fast-changing requirements of traditional retail are finding their job made harder by the number – and success – of start-ups in the sector.

According to Startup Direct, a government-backed loans organisation, there was a year-on-year increase in overall funding applications from 713 in the first four months of 2014, to 2,000 over the same period in 2015. Just seven of these applications were for food and drink startups in 2014 – while the number for 2015 was more than 370.

Just one example of many new brands which reached retail shelves during 2015 was Kiddyum, a range of frozen ready meals for kids. Set up by entrepreneur Jayne Hynes and business partner Paul Hearne in 2013, the company had to wait until August 2015 to begin stocking freezers in Sainsbury's.

"I've met lots of people from startups or small businesses, and they will often start with just 50 or 100 stores," says Hynes. "By September, we were in no fewer than 324 branches of Sainsbury's."

It is significant that Kiddyum is one of many new brands which claim the ethical high ground by using almost fully-recyclable packaging and sourcing both packaging and ingredients from the UK, wherever possible.

Kiddyum is also Sainsbury's first frozen food brand for kids. Supermarkets are having to fight price wars with highly-visible economy ranges, but they are also seeking differentiation through exclusivity.

As Rigby at Barclays puts it: "Fashion has favoured niche and bespoke products recently, and this has encouraged a string of startups, many of which have been highly successful. I don't see this as a bubble, as the consumer's demand for something new shows no sign of waning."

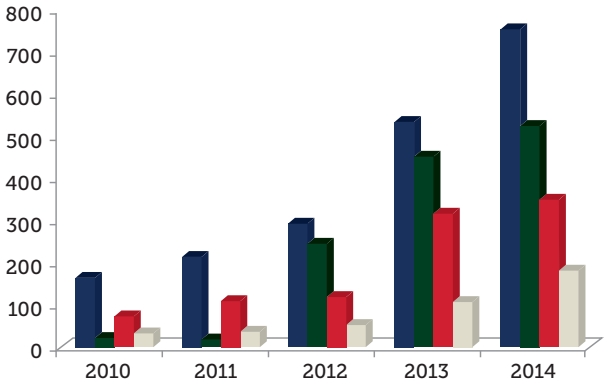
WASTE NOT, WANT NOT

Contrary to many predictions following the 2008 financial crisis, sustainability has evolved as an issue – but not gone away, as some thought it might. There remains an assumption on the part of consumers that companies will take environmental concerns seriously.

With £1.3 billion in turnover and 11,000 employees across 28 sites in the UK, Ireland and the US, Greencore is doing just that. "Our priority for waste remains to eliminate and reduce at source," explains director Michael Evans. "Our enhanced Lean Environment programme, rolled out across a number of our sites, has helped deliver reductions in waste in all forms, and tackled issues at source rather than the 'end-of-pipe' solution."

Within overall sustainability, food waste has become a specific focus. Working with partners such as the Waste & Resources Action Programme (WRAP) and IGD, the research and training charity, manufacturers have made efforts to reduce food waste both in the supply chain and in the home. WRAP estimates that UK households generate 4.2 million tonnes of food waste every year.

Food and drink launches using stevia extract, global by region 2010-2014



Like other producers, Greencore has introduced systems to ensure that residual stock is diverted to human consumption rather than disposal. "Greencore signed up to the IGD's industry-wide Working on Waste campaign, with the aim of encouraging our employees to reduce household food waste," says Evans.

Marks & Spencer (M&S) has signalled the seriousness with which it takes the issue of food waste in its own stores by announcing a partnership with the Neighbourly app to build links between individual stores and local charities. By spring 2016, all of its UK branches should be using the app to redistribute surplus food, it claims.

M&S has undertaken to make a 20% reduction to its in-store food waste by 2020.

As well as highlighting waste as an issue, the IGD used its autumn 2015 annual conference to stress the danger of the obesity crisis and the fact that the debate around healthy eating is at "a tipping point".

Many would agree. But opinions regarding possible solutions span the entire spectrum from individual responsibility, to regulatory intervention by the government. As concern has

Added cost: the introduction in 2016 of the National Living Wage could put food manufacturers under pressure

Image courtesy of Cadbury/Trebor

"The superstores are trying to adapt, leading to an enormous adjustment in terms of price and the range of stock-keeping units."

Clive Black, director and head of research, Shore Capital

grown over the over-sugaring of food, one effect has been an increase in the use of new-generation sweeteners, especially stevia. The number of European product launches using stevia more than doubled between 2012 and 2014 to more than 500, according to Mintel.

Despite pressure from campaigning groups and celebrities, to date the Government has not shown many signs of wanting to bring in top-down regulation, or more red tape on food formulation or marketing – nor intervene with new health-driven taxes. Says Clive Black, director and head of research, Shore Capital: "For the moment, it's more about the status quo."

That is more than can be said for manufacturers' costs – specifically, their wages bills. "During 2016, the introduction of the National Living Wage is going to be a big feature, representing increased costs for manufacturers," Black says: "It invites the question: how will they cope?"

Selga Speakman-Havard of the FDF says: "Most companies in the sector pay above the National Living Wage. But in the future, if the baseline is raised, this could lead to pressure to raise pay rates still further."

Of course, this is an issue affecting all industry sectors, the same being true of the impending referendum on EU membership. But both could have a significant impact on the profitability of food businesses big and small.

On the other hand, food will continue to be the sector most directly affected by ongoing shifts in the retail landscape. New entrants to the home delivery segment, including Amazon Fresh, will battle it out during 2016 – no doubt racking up some spectacular losses in the meantime.

The FDF's Barnes emphasises that the largest stores belonging to the big four supermarkets continue to dominate food retail volumes. But within and around that, much seems set to change.

"It does feel like it's going to be one of the biggest once-in-a-generation shifts," he says.

Many of those changes, especially as they relate to online sales and home delivery, seem certain to shake up the market during 2016. UKMR-15

ON COURSE FOR NEW SKILLS

The first full year of a new MEng Food Engineering degree might not sound like major news in the context of an industry which employs 400,000 people. But the establishment of the new National Centre of Excellence at Sheffield Hallam University, with the support of the Food & Drink Federation (FDF) and industry, is a significant statement of intent.

"UK food and drink manufacturing will require 109,000 new entrants by 2022, just to meet the skills needs of our sector," explains the FDF's competitiveness policy manager, Selga Speakman-Havard.

Estimates put the proportion of the current workforce which will have retired by 2020 at 15%, but Speakman-Havard believes this figure is on the conservative side.

Shore Capital's Black adds: "Clearly, companies have got an awful lot of in-house graduate training schemes. But at the same time, it would be better if the education system went further in delivering what the economy needs."

THE FOOD AND DRINK SECTOR

It is the single largest manufacturing sector in the UK, with a turnover of £95.4bn.

Directly employing 400,000 people, the UK food and drink industry produces some of the world's best loved brands.

There are positive signs for the UK economy and consumer confidence seems to be lifting. However, with competition pressures leading to price-cutting amongst the retailers the sector has actually witnessed price deflation. The continued growth of the discounters has led to the big four retailers taking some drastic measures with several signing up to long term price guarantees. This all spells great news for a more confident consumer but who is going to pay for the price cuts?

CONSUMER BEHAVIOUR

Pressures on disposable income throughout the recession have had a lasting effect on consumer spending habits and despite the macro-economic picture looking more positive and consumer confidence on the increase, savvy shopping habits look like they are here to stay. Whilst consumers might be demanding more choice, they remain incredibly price sensitive, investing time to shop in multiple retailers to source the best deals and increasingly shopping at discounters.

With all four of the major supermarkets using various forms of price matching, these long-term price reductions look set to stay. And it's the food and drink suppliers that are feeling the impact - margins have been squeezed for many years and the impact of long-term price commitments will squeeze margins further.

OVERSTATING PROFITS

In the wake of the Tesco accounting scandal, which led to the overstatement of the group's profits by £263m, the Financial Reporting Council ("FRC") has announced that it will focus on food retail in its upcoming audit inspections. The scandal has highlighted the complexity of some commercial arrangements within the supply chain and the FRC will be looking at the quality of the audits of both food retailers and their suppliers. These arrangements directly impact upon the recognition of revenue in the financial statements of both a supplier and a customer.

> "The overstatement of reported profit by Tesco has brought to light common practices in commercial dealings throughout the supply chain. Although trading conditions continue to be challenging for many suppliers, this should at least lead to more transparency and simplification of agreements with customers."

PAUL DAVIES
Partner and Head of Food and Drink at BDO

SKILLS

The food and drink sector in the UK accounts for 13% of all UK manufacturing jobs and, with 170,000 workers in the industry due to retire by 2020, the sector is facing a skills crisis. The skills gap in the sector has been well documented and a report by Engineering UK reveals that failure to meet the demand for engineering jobs could cost the UK's economy £27bn.

The options for school leavers today are wider than ever before with more emphasis now being placed on apprenticeship opportunities. It is hoped that this will help to close the gap in the long term. However, the short term impact is still a concern. Labour inflation could still hit the sector as demand for skilled workers outstrips supply. Those companies that can entice and hold onto the skilled few are likely to hold a competitive edge over rivals.

MERGERS AND ACQUISITIONS

Recently M&A activity in the food and drink sector has three apparent key drivers: the demand for big brands; supply chain security; and an increase in healthy eating. Growing consumer confidence coupled with improving debt markets and a trend of improved valuation multiples are all likely to drive further deal activity.

> "The UK food and drink sector is well placed to take advantage of the improving economy. Whilst there remain challenges over margins there will continue to be increasing demand for investment in high growth businesses driven by brands and product innovation into areas such as healthy eating. Outside of this, pressure will build to drive further consolidation to deliver operational efficiencies."

JASON WHITWORTH
Corporate Finance Partner at BDO

£425M

INVESTED IN RESEARCH AND DEVELOPMENT IN THE FOOD AND DRINK SECTOR

13%

ACCOUNTS OF ALL UK MANUFACTURING JOBS IN THE FOOD AND DRINK INDUSTRY IN THE UK

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SECTORS - ELECTRONICS

Niche electronics powers ahead

The UK electronics sector of today is producing a range of innovative esoteric components and products for a range of users

BY PETER MARSH

Over the past 30 years, UK manufacturing has become a collection of small to mid-sized companies making specialist goods in low volumes.

Few industries illustrate this trend more vividly than the business of producing electronics and electrical goods.

A few decades ago, the sector was populated by companies that were large and well-known, if somewhat unwieldy in structure and erratic in the way they were managed.

In place of GEC, Plessey and ICL, which made products such as white goods and telephones that were familiar to just about everyone, these companies' equivalents today are businesses excelling in niche areas of electronics – in fields that in many cases are barely recognisable.

The companies that are the leaders today are a lot smaller than the giants of the past. And as Britain, along with most other high-cost nations, has retreated from consumer-facing sectors of electronics, the fields where the UK remains strong are involved in making products bought by businesses.

Illustrative of such goods are esoteric items of hardware used for testing products in factories or on the laboratory bench, and complex components that are never seen by the ordinary man or woman, and end up embedded inside items such as machine tools or aircraft.

In addition to products such as these – a description of which would bring a blank stare to the face of the average person in the High Street – are a few specialist consumer items where the UK can lay claim to having some sort of competitive advantage.

SONIC BOOM

One such field is high-end hi-fi equipment. Companies such as Linn, Bowers & Wilkins, Ruark and Naim, have built up a global following for extremely sophisticated, and expensive, audio systems.

Taking in a diverse range of products, the electronics sector as a whole adds

Plastic fantastic: the future of electronics manufacturing is thought to lie in plastic printed designs

Both images: EPSRC Centre for Innovative Manufacturing in Large-Area Electronics

up to one of the UK's biggest manufacturing businesses. According to data from the Office of National Statistics (ONS), the UK's electronics and electrical goods industries employ more than 220,000 people – almost one in 10 of the manufacturing workforce – and account for a similar proportion of the industry's annual output.

Fairly typical of the companies that feature in the sector is Wright Industries, a group of businesses controlled by chairman and owner Craig Wright. Subsidiaries of his company make items including control equipment for drilling rigs that help discover information about oil and gas deposits.

Other products made by Wright Industries include ultra-reliable radio equipment for police and military forces and where the flows of data and voice traffic must meet security requirements be encrypted.

Another set of items, made by a Wright Industries subsidiary called Custom Interconnect, are generating a considerable of buzz – or at least certainly among zoologists interested in the movement of bees.

These products constitute tiny sensors – weighing just 26 micrograms – that can be carried on the backs of the insects as they fly around people's gardens or in the countryside.

The devices enable scientists to monitor bees' behaviour to keep track of breeding and feeding patterns.

Wright says his company has know-how in a set of specialist fields, capable of being deployed in a range of sectors. "We work for a variety of customers who increasingly rely on suppliers to provide expertise in areas such as high frequency radio communications," he says.

While a key group of employees at the company are development engineers, Wright is also keen to play up his group's expertise in shop floor manufacturing skills.

"It's vital for us to ensure we have the best people working in making products," says Wright, pointing out that some of his employees have won prizes as "champion soldering specialists" in competitions judging skills in hands-on fabrication.

The EPSRC CIM in Large-Area Electronics is helping to develop a future generation of manufacturing techniques

LINKS IN THE CHAIN

Another little known business that creates products used in the supply chain of mainly bigger businesses is Surface Technology International.

It has its main manufacturing centres in Hampshire and near Manchester, as well as a plant in the Philippines. The company – with projected sales in 2015 of £80 million and 900 employees, 550 of them in the UK – sells to customers in fields such as defence, energy metering and engineering control equipment.

It also has a specialty line in making goods in areas far more familiar to most people – including the control systems used in soap dispensers in toilets and washrooms.

"We can go to customers and offer a complete solution to the problems that they might have in sourcing components and assemblies," says Simon Best, STI's managing director and majority owner.

He says the company's manufacturing operation in east Asia – which it started in 2010 – has been vital to remaining competitive.

"We saw a lot of existing and potential customers were sourcing items from low cost nations so we thought we needed to add a manufacturing operation in one such country, to complement our overall activity and help strengthen the business," says Best.

Larger and better-known businesses in UK electronics that make their own products and which have built up high-level of brand recognition among global customers include Renishaw, the world's biggest maker of the touch-sensitive probes used in metal-cutting machinery.

Another is Halma, which produces specialist sensors and other equipment used in control systems, especially for applications involving health and safety.

Included in the cadre of the large number of businesses focusing on

Crime busters: electronics-based sensor systems are being used to protect vehicles or personnel transporting money

avionics and other areas of defence and aerospace hardware are Cobham, Meggitt and Ultra Electronics.

Many companies that can be classified as part of the electronics industry also use substantial amounts of expertise in other areas, notably mechanical engineering.

Among the examples of such businesses are Plymouth-based Spinnaker which makes banknote protection systems – for use by security companies when moving cash between banks.

Its products require some fairly straightforward metal-based components – similar to those found in ordinary safes for cash storage – designed to prevent criminals using physical force from gaining access to boxes containing notes and coins.

But equally important are electronics-based systems that use sensors to spot signs of criminal behaviour such as efforts to tamper with boxes containing cash, or channel data about the whereabouts of the boxes through wireless links.

The electronics systems used in Spinnaker's products also use advanced logarithms to track the movement of security guards given the job of looking after the cash. If their gait abruptly changes, and can no longer be identified, that can provide a clue that the guard has been attacked by a criminal and bundled out of position – in which case an alarm is sounded.

NIC Instruments, based in Kent, uses a similar mix of skills. The company is a world-leader in bomb disposal equipment and its products include remote-controlled 'wheeled robots' that can move to a suspect package without a human being present and make it safe through destroying vital elements, such as detonation systems, using jets of high pressure water.

Much of NIC's expertise is based around developing and making the mechanical systems needed to ensure the company's devices can move semi-autonomously over rough ground for up to 500 metres.

But according to Steve Wisbey, managing director, a key point to making sure the robots work effectively is specialist software needed to control their electronic parts. In the 20-strong company, its team of four development engineers is particularly strong in software expertise, Wisbey says.

Malvern Instruments is another business that shows how software – plus other electronics-based skills such as in sensor technology – plays a key role in the success of specialist parts of the broader electronics industry. Malvern is owned by Spectris, a large maker of industrial and analytical instruments based in the UK, that has operations around the world.

Malvern's niche field is making machines for measuring fine particles, that can be as little as 10 nanometres in size.

"Demand for particle analysis is increasing in a range of industries partly to help in product development but also because of the increased need to monitor environmental effects [of particles] due to health and safety regulations," says Duncan Roberts, business development director.

The company bases roughly 350 of its 870 staff worldwide in the UK, and the country is home to one of its three global

A GIFT FOR THE PERSON WHO HAS EVERYTHING: A CUSTOMISED MOBILE PHONE

While many of the products produced by the UK electronics industry are highly unlikely to be used – or even seen – by anyone other than a specialist scientist or engineer, one business making much more recognisable items is Surrey-based Vertu.

The company is a leader in a small but valuable niche: making "luxury" mobile phones that work similarly to conventional phones but are made from exotic materials, and can be hand-crafted to give a look of ultra-sophistication.

The phones – which can cost up to £15,000 – use materials such as titanium, mother-of-pearl, carbon fibre and Japanese lacquer. The company – which has 900 employees, half of them in the UK where it has its main manufacturing operation – generally makes each item according to order.

"We aspire to the quality of a Swiss watchmaker, blending luxury with technology and engineering," says Martin Blades, Vertu's head of manufacturing.

Products such as Vertu's, that most people would recognise, are a far cry from items being created by another cadre of businesses, which make novel components for packaging into new categories of electronic equipment.

At the forefront of such companies is a group with a close association with the Centre for Process Innovation (CPI), a government/industry innovation group based in Sedgefield, Durham, and part of the government's network of Catapult centres.

Novel uses: research is goIng into making new components sufficiently cheap that they can be used in everyday objects, such as clothing or food packaging

Image Courtesy of the Centre for Process Innovation

plants, the others being in the US and China. Out of a team of 120 development scientists and engineers, a large core of whom are in the UK, a third work mainly in software. The company sells into a diverse range of end markets.

"Our instruments can be used for analysis in fields from monoclonal antibodies to concrete," Roberts says.

The EPSRC CIM in Large-Area Electronics plays a fundamental role in advancing innovation in UK electronics sector. "We work with industry building the UK value chain for future electronics manufacturing, with impact on multiple markets, from consumer electronics to healthcare. Collaboration with the HVM Catapult and innovative SMEs in the field offers a unique opportunity to test ideas and research outputs, assess and mature technology readiness level and accelerate impact in the UK," says Chris Rider at the Centre in LAE.

One area of expertise the Sedgefield centre has is in providing production facilities for small companies in new areas of technology. Smaller firms may lack the money and staff to make products in their own plants.

Of the 250 people at the centre, a quarter work in "printable electronics". This concentrates on making new electronic items such as displays, processors and sensors, using substrates not of conventional semiconductors, but made from organic materials such as plastics.

PRAGMATIC THINKING

Cambridge-based Pragmatic Printing is one such business, using the CPI as a production base. Of its 30 staff, 15 work in the centre, where they are creating small plastics-based components.

The components – once they are developed fully enough to go into volume production – could be sufficiently cheap to form part of everyday objects, such as clothing or food packages.

According to Scott White, chief executive, the components could store information about the way the product they form part of has been manufactured – useful in checking for quality. They would also channel messages to stores selling the items, and people buying them – with the information being obtained by special electronic readers and used to keep track of shipments, or to give consumers instructions about how to use the items during their lifetime.

"We think we should be able to make highly sophisticated products that have a great deal of processing, sensing and communications capability, but be much cheaper than conventional semiconductors made from materials such as silicon,"

Scott White, Chief Executive, Pragmatic Printing

"We think we should be able to make highly sophisticated products that have a great deal of processing, sensing and communications capability, but be much cheaper than conventional semiconductors made from materials such as silicon," says White.

He says the lower cost will follow from the considerably cheaper production methods used in making plastic components, compared with those created using conventional silicon chips.

"Because we avoid [in plastics electronics] the complicated manufacturing processes that involve high temperatures that are used in a silicon fabrication unit, the sort of plant we will need for our components is likely to cost less than $10 million while a state of the art silicon chip plant can easily cost $10 billion," he says.

Other small businesses assisted by the CPI in a similar way – with the small company providing the main ideas for products and the centre supplying production facilities and related know-how – include Polyphotonix, which is producing novel light sources.

Another such company is Sapient Sensors, working on diagnostic methods for animal diseases, and Smartkem, which is making "foldable" displays for text and graphics that could be sewn into clothing or worn on the wrist to provide an array of information – from material called up from the internet, to data obtained from sensors fixed to a person's body providing updates on health and fitness. UKMR-15

Wind blows away nuclear in power gen market

SECTORS - POWER GENERATION

The past few years have been difficult for many within the UK power generation industry, but there may be better times ahead in the wind and nuclear sectors

The power generation industry had contrasting fortunes in 2015.

While the last 12 months has been busy for some suppliers in the renewables sector, especially those supplying equipment to the offshore wind industry, a lack of new developments in the fossil fuel and nuclear industries has left demand flat.

And although the promised renaissance in the nuclear industry offers hope of greater demand for suppliers to the sector in the future, the UK government is yet to signal when the country's ageing coal-fired power stations will be replaced with new combined cycle gas turbine (CCGT) plants.

BLADE RUNNERS

In the offshore wind industry, several companies invested in UK manufacturing in 2015. In May, MHI Vestas began manufacturing 80-metre turbine blades at its Isle of Wight production facility for the 258 MW Burbo Bank Extension offshore wind farm in Liverpool Bay. The company says the move was the first stage in a larger £200 million industrial strategy for the UK, which will result in the safeguarding or creation of 800 jobs.

More than 200 full-time jobs have already been created to manufacture the blades for the company's 8MW turbines.

Siemens' £160 million investment in UK wind turbine production also got underway, when construction of its new blade factory at Alexandra Dock in Hull began in January. Construction is ahead of schedule, and the factory is set to open in September 2016, according to Matthew Knight, director of energy strategy for Siemens.

Siemens Transmission and Distribution, based in Manchester, designs and subcontracts the manufacturing of electrical substations for offshore wind farms. This year, for example, Siemens' subcontractor Sembmarine, based in Lowestoft, began manufacturing the substation platform for the Dudgeon wind farm off the coast of Norfolk.

"Grid connections for offshore wind farms are designed in Manchester and Newcastle by Siemens, and then we get them fabricated around the coast of the UK," says Knight. "Manchester is our centre of competence for AC grid connections and is involved in projects across Europe."

Similarly, GE Power Conversion has manufactured technologies and components for onshore and offshore turbines at its facility in Rugby, while Babcock Engineering recently secured a contract to build the substation for E.on's 400MW Rampion offshore wind farm off the coast of Sussex. The company will build the substation at its Rosyth production facility in Scotland, which is where the new Queen Elizabeth-class aircraft carriers were assembled.

When construction of Siemen's blade factory in Hull is completed in September 2016, the company plans to begin producing around 600 blades per year. That amounts to 200 7MW wind turbines, according to Knight.

"The factory is primarily for the UK market, but we certainly expect it to produce blades that will go all over Europe, and beyond," he says.

Building a blade production facility in the UK will give the company an important opportunity to develop new materials and manufacturing technologies, Knight says.

"There are some great skills in the UK, we have the Renewable Energy Catapult and the National Composites Centre, as well as other centres doing leading-edge work in composite materials and we want to work with them, and with UK universities, to make the best blades in the world," he adds.

ONSHORE WIND	2013	2014
New projects go operational	166	236
New turbines	694	651
Installed capacity	1336MW	1093MW
OFFSHORE WIND	**2013**	**2014**
New projects go operational	5	1
New turbines	280	108
Installed capacity	981MW	389MW

Source: RenewableUK

Opportunity: the HVM Catapult helps power generation manufacturers, infrastructure contractors and operators to apply technologies developed in the automotive and aerospace industries to the energy sector

EXPORT SUCCESS

Although the global turbine blade manufacturing industry is dominated by multinational companies such as Siemens, Vestas Wind Systems and GE Energy, some UK-based manufacturers are producing parts for the export market.

This export success is particularly marked in the small and medium wind market, where for every 100-500kW turbine installed domestically, one is exported overseas, according to Oankar Birdi, policy manager for supply chain at industry body RenewableUK.

More than 2,200 small and medium wind turbines were installed in the UK in 2014, of which many are being used to provide power for rural businesses. This amounts to 391GWh hours of energy produced, and savings of almost 170,000 tonnes of carbon dioxide. In the same year, 2,614 turbines were exported to Europe, the US and Asia.

"The UK currently exports more small and medium wind systems than any other country," Birdi says.

Similarly, there is also a thriving small and medium-sized gas turbine market. Siemens builds medium-sized gas turbines, for use in powering facilities such as factories and hospitals, at its plant in Lincoln. The company has also recently purchased the former Rolls-Royce Industrial Power plant in Warwick.

"There is quite a strong manufacturing base in the UK for medium-sized fossil power generators," says Matthew Knight. "There is an enormous overseas market, something like 90% of what we build is exported."

Although most tidal power generation projects remain at the testing stage, with approximately 6MW of generators currently on trial in the UK, Meygen is moving ahead with construction of its project at the Inner Sound on the Pentland Firth in Scotland, after securing funding in 2014. The project, the first stage of which will involve the installation of four turbines at the site with a capacity of 6MW, could ultimately generate up to 398MW from 269 turbines.

One of the four initial turbines is being manufactured in the UK by Atlantis Resources and its partner Lockheed Martin, while the remaining three are being built in Bavaria by Andritz Hydro Hammerfest, according to the company.

Elsewhere in the power generation industry, the situation is less rosy, however. With no new fossil power plants built in the UK for some time, there has been little demand for large power generation equipment. What's more, this lack of demand is not limited to the UK, according to Richard Warren, senior energy and environment policy adviser at manufacturers' organisation the EEF.

"Supply into fossil fuel power stations is dampened at present right across the European Union, due partly to renewables policy," he says. "However, this may well change in the UK as more coal plants come off line and will need to be replaced by combined cycle gas turbine (CCGT) plants."

Unlike countries such as China and Brazil, which have invested heavily in their power systems and have been expanding dramatically over the past 15 to 20 years, most power plants in the UK are now between 25 to 50 years old. As a result, much of the supply chain is focused around servicing and upgrading existing plant, rather than building new equipment.

"The power generation industry was privatised in 1990, and we didn't have many power stations to build here, while globally there has been a consolidation," says Siemens' Knight. "The large power generation sector of the industry is now much more focused on servicing, repairing, modifying and upgrading."

The lack of investment in UK power generation in recent years presents significant challenges for integrating new technology into the industry while maintaining and replacing the ageing assets, according to Phillip Cartwright, chief technology officer at the High Value Manufacturing (HVM) Catapult.

For example, modern power plants recently implemented in other countries are equipped with monitoring systems that provide proactive maintenance scheduling. These data-driven diagnostic systems detect problems before they become too serious, in the same way that cars and aircraft have on-board computers to provide vehicle and engine health management systems, says Cartwright.

"As we renew our aging infrastructure we have got to find a better way of constructing, commissioning and maintaining it, through technology," he says.

The HVM Catapult will allow power generation manufacturers, infrastructure contractors and operators to take the best monitoring and diagnostic technologies developed in the automotive and aerospace industries and apply them to energy systems, he says.

"There is a huge opportunity to provide infrastructure programme certainty, cost certainty, increased health and safety and reduced operational costs by adopting these technologies within the next five to 10 years," says Cartwright.

The HVM Catapult, along with eight

NUMBER OF UK SMALL AND MEDIUM WIND TURBINES SOLD TO DOMESTIC MARKET					
Size of unit	2010	2011	2012	2013	2014
0-1.5kW	2036	1943	2008	1840	1388
1.5-15kW	748	975	1359	1257	318
15-100kW	69	150	348	439	318
100-500kW	0	18	28	100	211
Total	**2853**	**3086**	**3743**	**3636**	**2235**
NUMBER OF UK SMALL AND MEDIUM WIND TURBINES SOLD TO EXPORT MARKET					
Size of unit	2010	2011	2012	2013	2014
0-1.5kW	3208	2777	3096	3320	2474
1.5-15kW	181	209	119	449	138
15-100kW	0	150	0	5	4
100-500kW	0	18	10	0	0
Total	**3392**	**2986**	**3215**	**3774**	**2616**

Turnover: UK export sales for small and medium wind systems are thriving

similar strategic initiatives in different sectors, forms part of the Catapult programme established by the UK government in 2010, following extensive independent research. It combines the strengths of seven existing centres across key manufacturing processes, with significant government investment planned over a six-year period, and investment matched by private industry.

The HVM centres have been helping small to medium-sized companies (SMEs) and some large manufacturers to develop technologies and manufacturing processes. Fit 4 Nuclear, for example, is a successful programme run with the Manufacturing Advisory Service, to help UK SMEs prepare themselves for supplying into the civil nuclear industry.

NUCLEAR RENAISSANCE

The UK's newest power station is Sizewell B in Suffolk, which began producing electricity in 1995. However, with the eight ageing plants all due to be decommissioned within a little over a decade, there are hopes that a programme of new nuclear build, due to start with EDF's plans for a new plant at Hinkley Point C in Somerset, will allow the UK's industry to expand once again.

Hinkley Point C will mark the biggest inward investment in British history and create up to 25,000 jobs during construction, according to EDF.

The company has already announced preferred bidders for contracts for the plant worth over £1.5 billion, including a £25 million contract for Rolls-Royce to supply heat exchangers to the power station. A partnership between Rolls-Royce and Nuvia has also been chosen as preferred bidder for a £75 million contract to provide waste processing and treatment systems.

And Hinkley Point C is just the start.

> "The opportunities for manufacturers looking to supply into the nuclear industry are likely to expand considerably."
>
> *John Ransford, sector manager at the Manufacturing Advisory Service*

Once other reactors at Sizewell C in Suffolk, Wylfa in Anglesey, Oldbury in Gloucestershire and Moorside near Sellafield get underway, the opportunities for manufacturers looking to supply into the nuclear industry are likely to expand considerably, says John Ransford, sector manager at the Manufacturing Advisory Service.

"Each of the companies behind these reactors are offering to source up to 60% of their content from the UK, which is likely to include a lot of building works, as well as turbine and other equipment manufacturing," he says.

At a cost of around £16 billion to build and equip each unit, there are billions of pounds in potential business at stake for UK manufacturers.

However, with other major infrastructure projects also planned or already underway in the UK, including the High Speed Two railway line, London's Crossrail, and the Thames Tideway "super sewer", companies may struggle to meet such a huge spike in demand, says Ransford.

Companies looking to supply to the nuclear industry must ensure they have the right systems in place to keep track of all the materials they use and the components they produce, to confirm these meet the sector's exacting quality and safety standards, he says. These records must be kept for 60 years, or the life of the unit.

Finally, any component that is designed for use in the nuclear environment of the power plant must be manufactured in isolation from other products, to ensure its cleanliness, he says. "You must submit parts that are absolutely spotlessly clean, with no contamination," he says.

For those companies that make the necessary investment in their control systems and manufacturing processes to allow them to move into the nuclear industry, there will undoubtedly be opportunities over the next few years and beyond, says Ransford.

And the building programme is likely to open up opportunities for manufacturers in other sectors, as large companies move into the nuclear industry. This, in turn, will leave gaps in capacity in other areas that could be filled by smaller suppliers, he says.

So while the last few years may have been difficult for many within the UK power generation industry, it appears there may be better times ahead, particularly for those in the wind and nuclear sectors. UKMR-15

Virgin Trains

SECTORS - RAIL

ENGINEERING IN THE FIRING LINE

BY CHRISTIAN WOLMAR

Despite record levels of investment, an outstanding safety record and ambitious plans for the future, passenger satisfaction with rail travel is at rock-bottom

On the face of it the rail industry is in a state of rude health. With a £38 billion investment programme for the five-year period between 2014 and 2019, and growth in passenger numbers at a very healthy 3-4% annually, well above the rate of population or income increases, no longer are there suggestions of closures, or cutbacks in services.

The improvement in rail safety has been an unequivocal success. In the aftermath of privatisation, there was a series of accidents caused by the upheaval in the industry. However, since the Potters Bar crash of 2002, there has only been one passenger fatality caused by the railway – the Virgin derailment in Cumbria in 2006 – and other indicators are all pointing in the right direction. Britain's railway is the safest in Europe, a record of which the industry is rightly proud.

However, the body partly responsible for that record, Network Rail, is under fire for other reasons. Its engineering enhancement programme, it emerged in the summer, is simply undeliverable. There has been a series of high-profile incidents in which engineering work has overrun, leading to major disruption for passengers.

Transport secretary Patrick McLoughlin announced in July that the electrification programmes for the Midland Main Line and Transpennine routes were under question because Network Rail could not cope with the amount of work it was undertaking, but reassured passengers that work on the Great Western line would proceed as planned.

McLoughlin subsequently "unpaused" the two electrification programmes, with somewhat later deadlines than originally given, but Network Rail's performance as an engineering project delivery and maintenance organisation is under intense scrutiny from the civil service and government – not to mention groups representing beleaguered commuters and the train operating companies themselves, who are on the receiving end of passengers' vitriol.

The appointment of a high-profile Labour stalwart as the new cross-bench infrastructure czar – Lord Andrew Adonis – during party conference season in October indicated that the government recognises the scale of the problem. Virgin, which has endured flak from passengers for years over the performance of its services on the West Coast mainline, timed the announcement of a policy that speeded up compensation for disruption to advance ticket purchase customers – that is, those on a budget – to coincide.

STORIES OF SUCCESS

There are several major engineering schemes that are proceeding in the programme such as Thameslink – originally called Thameslink 2000 but now scheduled to be finished in 2018/9 – and the Northern Hub, a series of increases in capacity in the North, mostly centred around Manchester. The engineering work for Crossrail, the east-west route under

Customer comfort: France's Alstom is planning to build a range of more commuter-friendly trains in a bid to win HS2 rail contracts

Alstom

London, and the biggest transport construction scheme in Europe, has proceeded remarkably smoothly – and safely – given its complexity, which saw its 26 miles of tunnelling completed in 2015.

Two other schemes of note also came to fruition. The complete rebuilding of Birmingham New Street was completed in September with magnificent arches now dominating the interior, but the £600 million project has been criticised as no new tracks or platforms have been added.

The other major scheme to be completed was the 30-mile long Borders Railway from Edinburgh to Tweedbank. It was an unusual reopening as, apart from the section through the suburbs of the Scottish capital, the line runs through sparsely populated country. Early indications are that passenger numbers are exceeding expectations, a good portent for campaigners around the country pushing for reopening lines.

The most exciting project is, of course, HS2, the £50 billion new high speed line that will ultimately link Manchester and Leeds as well as Birmingham with London on a railway capable of running at 400km/h. The High Speed Rail (London – West Midlands) Bill to give permission for the scheme to be built is currently in Parliament and is expected to emerge in spring 2016, almost three years after the Bill was published.

The massive InterCity Express Programme, to replace the current InterCity fleet, is being funded and built by a consortium led by Japan's Hitachi Rail, which opened its assembly plant in Newton Aycliffe, County Durham, in September. Notably, it has also located its European rail research and design centre, which opened in 2012, in London.

"The key to passengers' satisfaction is getting trains to run on time. Now many are being let down with fewer trains on time together with fare increases. The billions in government investment and promises of improvement don't appear to be delivering change on the ground."

Anthony Smith, Head of Transport Focus

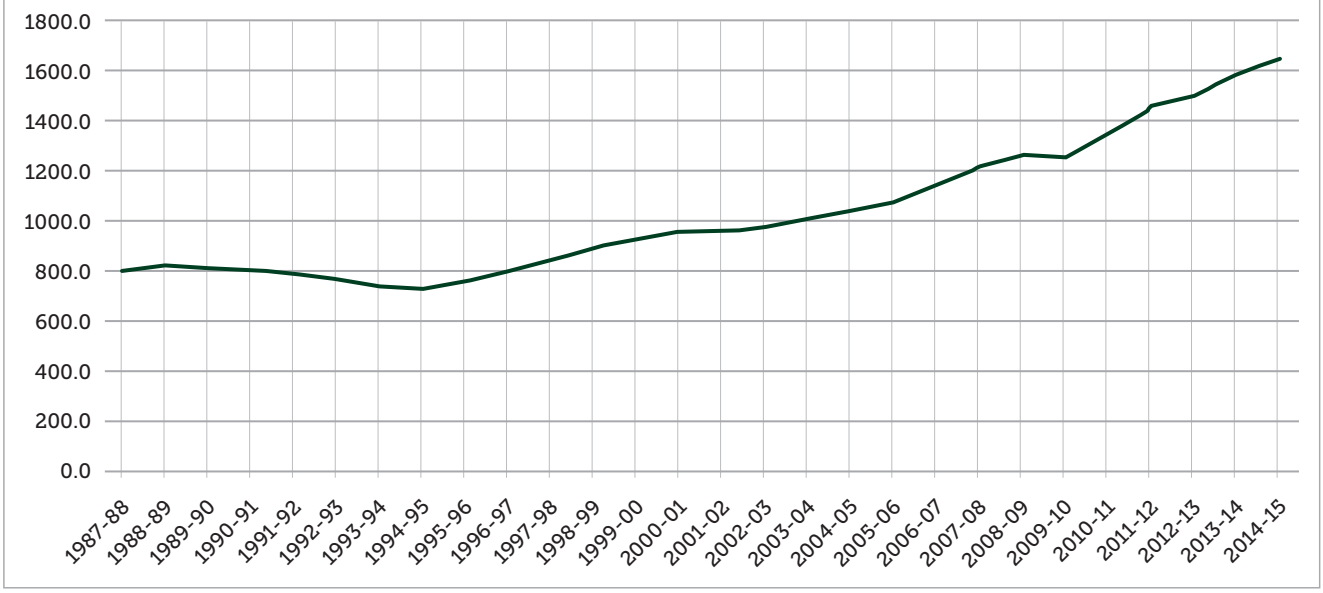
GROWTH BUT NO CIGAR

Despite all the financial and managerial mishaps, the numbers using the railways keep on growing (see table). There are now twice as many passengers as at privatisation 20 years ago, and there is no sign of the rise abating. This has led to complaints about overcrowding given that, since 1997/1978, the number of trains running daily has increased by only 28% and the number of carriages by just 22%.

Passenger satisfaction is at rock-bottom and Anthony Smith, the head of Transport Focus, which oversees the interests of passengers, says the industry must confront the issue: "The key to passengers' satisfaction is getting trains to run on time. Now many are being let down with fewer trains on time together with fare increases. The billions in government investment and promises of improvement don't appear to be delivering change on the ground."

That is the key issue facing the industry in the future. It is in a state of flux, probably facing the most major challenges it has had since privatisation. There is much talk of devolution, a key issue for government, and there is the possibility that some regions could be hived off to create integrated units with the train operators. Moreover, there is both talk of privatising

TOTAL PASSENGER JOURNEYS



Source: Office of Rail and Road

Network Rail, and of nationalising the franchises, a plan supported by Labour under Jeremy Corbyn.

The railway industry needs a stable political and financial environment although it remains something of a political football, even though it has been privatised, and, in fact, part-renationalised, given that the East Coast franchise is being run by the government.

For the moment it is benefiting from unprecedented levels of investment, but this could be put in jeopardy if the mishaps of recent times undermine politicians' confidence in the industry.

The industry is living through interesting times: not necessarily happy ones. UKMR-15

RAIL RECOVERY REQUIRES INVESTMENT, SAYS PHILIPPA OLDHAM, HEAD OF TRANSPORT, IMECHE

The UK railway sector has been subject to negative headlines this year, due primarily to delays to some of the vital work needed to upgrade the network. However, it should be recognised that our network is actually a great success story: the safest in Europe and experiencing sustained growth, with the number of passengers doubling over the last 20 years.

Many major projects such as Crossrail in London, electrification in Scotland and the delivery of 4,000 new electric and bi-mode vehicles are on schedule. Britain is in effect trying to catch up from the low level of railway infrastructure investment in the last 25 years, and is finding this more difficult because of the very high levels of growth in passenger and freight traffic which has occurred during this time.

Nevertheless, capacity must be increased if we are to maintain and improve on current levels of performance, and electrification is required to reduce emissions from diesel engines, so it is crucial to understand why costs have escalated and timings been missed on deliverables.

So what may have been the problems in meeting these timescales? One answer is the scale and expectation over some these projects. Engineers and project managers are working to deliver countless improvement projects to enhance our railways, and easing the need for maintenance, while still running a seven days a week service. This can be very difficult to achieve. The rail industry has often suffered from cycles of 'feast and famine' in infrastructure investment. For example, there has been no significant mainline electrification in this country in the last 25 years, so attempting such a large programme now requires supply chains to be developed.

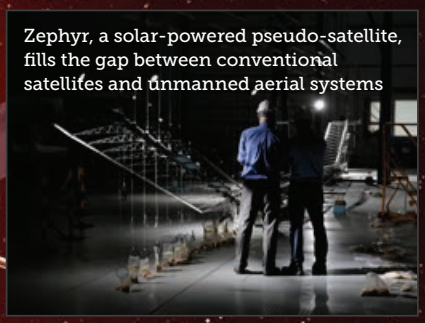
To succeed with the delivery of these large infrastructure projects, Network Rail needs to make sure that plans are properly formulated and design and development work is sufficiently advanced before timescales and costs are committed. Network Rail's major projects teams must in future work more closely with the management teams in the company's strategic route organisations, and with the passenger and freight operating companies.

The Train Operating Companies and Freight Operating Companies must maintain strong relationships and engagement with customers, communities and stakeholders as well as their partnerships with franchisors, Network Rail and other suppliers.

One of the biggest challenges will be to ensure that we train sufficient technicians and engineers for the country's internal requirements. The engineering skills needed to develop major projects like these cannot be created overnight.

500 million reasons to celebrate UK space industry

Airbus Defence and Space in the UK is engineering technology for several space projects including Solar Orbiter, the European Space Agency's mission to study the Sun



Zephyr, a solar-powered pseudo-satellite, fills the gap between conventional satellites and unmanned aerial systems

All images © Airbus Defence and Space

On 12 November 2014, the European Space Agency's Rosetta orbiter landed on a comet more than 500 million kilometres away, travelling at 66,000 kilometres per hour, after a 10-year journey through our solar system

This stunning feat was another illustration of how Airbus Defence and Space, the prime industrial contractor for Rosetta, is pushing the boundaries of science and space exploration. Other space projects led by Airbus in the UK include Solar Orbiter, the ESA mission to study the sun, the ESA ExoMars mission to search for life on Mars, and LISA Pathfinder which will take the first steps in the hunt for gravitational waves.

Airbus satellite technology also directly benefits people's lives on our own planet. At its Stevenage and Portsmouth sites, Airbus designs and manufactures payloads, structures, propulsion systems and electronics for telecommunications and Earth observation satellites.

Airbus has developed Zephyr, a solar-powered high altitude pseudo satellite that fills the gap between conventional satellites and unmanned aerial systems which typically fly at lower altitudes. Flying above the weather, Zephyr will be able to stay airborne for months at a time. Meanwhile, Surrey Satellite Technology Ltd, an Airbus subsidiary, is building key payloads for Galileo, the future European GPS system.

In the military sphere, Airbus's world-leading technology and expertise enable governments and institutions in the UK and abroad to protect natural resources, as well as social and individual freedoms. Through Skynet 5, a next-generation satellite programme, Airbus provides the UK's Ministry of Defence with all secure communications until 2022, leasing excess capacity to NATO and other allies. At its site in Newport, South Wales, Airbus specialises in secure information services for private and public customers, including the UK Houses of Parliament. Airbus's 'Ectocryp' encryption technology, dubbed the 'Enigma for the 21st century', is used by the UK police, military and intelligence agencies, while Airbus is the only non-US defence contractor to provide 'High Grade' (a level above 'Secret') encryption to the US government and military.

Airbus Defence and Space's employees are at the heart of Britain and Europe's production of some of the world's leading military aircraft. Airbus designs and builds more than 45% of every Tornado and Eurofighter Typhoon. In addition, Airbus in the UK manufactures all the wings for the RAF's next generation tactical airlifter, the A400M. AirTanker, a joint venture between Airbus and other UK-based defence contractors, delivers the RAF refuelling aircraft Voyager, which has a fuel capacity of 111 tonnes. Voyager is not just the largest RAF aircraft, but one of the most versatile. Its operations range from airborne refuelling of fast jets, through movement of assets and personnel for the UK military, NATO and other partner nations, to providing critical support for the Falklands Air Bridge, a civilian charter service for the islands.

At sea, ATLAS ELECTRONIK UK, which Airbus jointly owns with Germany's ThyssenKrupp, is a world leader in underwater defence technology. Based in Winfrith, Dorset, the company has more than 60 years' experience in UK maritime defence. Today, it offers a full suite of underwater technology, including harbour security systems and countermeasures.

Airbus also holds a 37.5 per cent stake in MBDA, the world's only company capable of designing and producing missiles and missile systems to meet the full range of needs of land, sea and air armed services. With 3,000 employees, mostly engineers, MBDA serves more than 90 customers worldwide from its main sites at Stevenage, Bristol and Lostock, near Bolton. UKMR-15

FAST FACTS: AIRBUS AND CYBER SECURITY

- Airbus is the only non-US defence contractor to provide 'High Grade' encryption to the US government and military, the near-highest level of security in use by the US state.
- Airbus provides cyber security for UK Parliament and for 90% of Ministry of Defence networks.

ROTARY CLUB

Airbus Helicopters UK Ltd and its predecessor companies have been active in the UK for more than 40 years and today Airbus Helicopters' H135 and H145 family of aircraft account for 75% of the UK's police fleet and 60% of UK ambulance helicopters. Furthermore, the company's Super Puma family of heavy helicopters makes up almost 50 per cent of the UK's offshore gas and oil industry fleet

Airbus Helicopters' headquarters at Oxford Airport is the UK's civil helicopter hub, while its base at Hawarden, North Wales is a customer maintenance centre. The company also provides premium training, technical assistance and maintenance services to domestic and international customers. It is the only onshore helicopter manufacturer in the UK to deliver support for its aircraft throughout their entire life cycle. At its site in Oxford, Airbus Helicopters also directs ground-breaking research and conducts bespoke design work on the development and installation of rotary wing solutions for customers worldwide.

At Aberdeen, home to the world's largest rotary wing airport, Airbus Helicopters' critical importance to the UK's offshore oil and gas industry is highlighted by its fleet support centre, which allows operators to reach availability rates of 90% and above. In collaboration with wider industry, Airbus Helicopters' Safety Partnership initiative offers operators the benefits of first-class material management, technical support and training services, helping to improve safety standards and survivability rates.

"Over the last 35 years, every UK military pilot has been trained on an Airbus Helicopters aircraft"

One of Airbus Helicopters' six H225 simulators is located at Aberdeen, illustrating the UK's key role in the division's global business. In 2014, more than 600 pilots – representing 30 different customers from over 10 countries, including Australia, Brazil and China – received training in Aberdeen. In total, they accumulated nearly 3,000 'flying' hours during the year.

Airbus Helicopters also aims to leverage its expertise in the civilian market to become a UK champion in military helicopters, building on the group's close, long-standing partnership with the Ministry of Defence. Over the last 35 years, every UK military pilot has been trained on an Airbus Helicopters aircraft. Today, UK armed forces use a variety of Airbus Helicopters' models for operations at home and overseas, with the recently delivered RAF Puma Mk 2 functioning as the RAF's 'workhorse'.

Airbus Helicopters provides onsite and deployed maintenance and upgrades for UK military helicopters operating around the world. Vector Aerospace, an Airbus Helicopters subsidiary, plays a central role in providing this service from its bases in Perth, Stevenage and Gosport, where it runs the UK's largest military helicopter maintenance, repair and overhaul business. UKMR-15

Police, camera, action: The H135 and H145 family of helicopters makes up 75% of the UK police fleet.

Material world

The NCC is the UK's leading centre of excellence and innovation in composites technology. The NCC provides open-access, collaborative research, technology and people development opportunities. The centre delivers world-class innovation and knowledge transfer in the design, manufacture and application of composites.

Alison Starr, National Composite Centre

"These are very exciting times for the UK composites industry," says Alison Starr, Executive Director, Strategy and Business, at the National Composites Centre, part of the High Value Manufacturing Catapult. "Composite materials bring considerable benefits by enabling light, and right-weighting of products. Additionally, using carbon, glass and other polymer-reinforced fibre materials can improve corrosion and fatigue resistance; meaning lower levels of maintenance, and significantly reducing the cost of ownership."

The NCC is the UK's leading centre of excellence and innovation in composites technology. The NCC provides collaborative, open-access, research, technology and people development; delivering world-class innovation and knowledge transfer for the design, manufacture and application of composites.

Current research into new processes such as automated fibre placement and high-rate manufacturing will significantly increase productivity by reducing manufacturing cycle times. The use of new materials such as bio-fibres and recyclable fibre systems can contribute to increased reprocessing and drive down waste, the NCC says. Advanced composite materials also offer flexibility and engineered properties which allow integration and embedding of smart sensor technologies.

In 2009, the UK Government published its first Composites Strategy. Many of the initial aims of the strategy have been achieved. In late 2012, the composites industry, in partnership with the UK government, formed the Composites Leadership Forum (CLF), as the 'voice' of the UK composites industry.

The CLF's role is to determine and support actions that will enable the continued growth necessary for the UK to capture a significant share of the global composites market. The CLF worked with industry to understand the growing market for the use of composites, and to identify the UK opportunity. It believes that "with the right support a paradigm shift can be achieved in the UK, capturing the growing global opportunity in the application the composite materials to multiple sectors".

People are central to the success of UK manufacturing. There is a need to update and convert the existing UK workforce to adapt to the latest technologies such as automation, composites, and additive manufacturing. The NCC has over 170 staff, working across a range of highly specialised technology area. Over 18.6% of these are involved in work-based training, that includes; workplace Apprentices, Graduate Engineers, Full-time Eng. Docs, Trainees, Year in Industry (YINI) students

Automating production and improving productivity with fibre placement

as well as encouraging CPD across all levels.

One of the NCC's highlights of the year saw the opening of a new flexible composites pipe test rig, a significant first milestone in supporting the oil and gas industry as it capitalises on composites opportunities.

The 2009 Composites Strategy indicated that the government is taking the development of composite materials seriously, and enabled the NCC's impressive industrial-scale facilities to be built, in response to industry demand. It is hosted by the University of Bristol.

Since opening in 2011, the NCC has worked with over 131 companies, totaling over £46m in work delivered. The NCC membership scheme which provides 1-3 years guaranteed project work has now topped 50 industrial partners from across more than 10 sectors. Initially the NCC had strong backing from aerospace: there is an increasing involvement from automotive, rail, oil and gas, marine, renewables, materials, simulation, tooling and equipment enterprises.

Initial investment in the NCC was £25 million of government – BIS, RDA and ERDF – funding but in response to further industry demand, HM Treasury awarded an additional £28 million in 2012 to enhance the capability offering.

The extended building opened in the autumn of 2014, and provides extensive new facilities, including a training and skills centre, with additional equipment and capability. Continuing Catapult funding has provided the largest publicly available short upstroke press in Europe, for high-rate manufacture of composites parts.

The new facilities will further the NCC's expertise in high pressure resin transfer moulding (HP RTM), and research with industry will reduce current six or seven hour processes down to just minutes. UKMR-15

OPPORTUNITY KNOCKS

The Composites Leadership Forum has also identified that there is a major opportunity for 'lightening the load' in many sectors, accelerating the growth in traditional composites-using industries including aerospace, motorsport and renewables, together with the emergence of substantial new markets for composite products in automotive, rail, infrastructure, oil and gas.

The global market for composite products is expected to grow at around 6.5% to about $105 billion in 2020 [source, Lucintel 2014]. The UK has the opportunity to grow its current sub-£2 billion composites market to more than £11 billion by 2030, according to the NCC and UKTI.

"The UK's Catapult centres will be critical to support industry on the journey to turn commercialisation of that knowledge and innovation into real economic value add," says Alison Starr.

"So, in order for these opportunities to be maximised, support is required from government to secure the supply of knowledge from our excellent academic base and capability in the centres.

"With the right mix of commitment from industry and government, the UK composites industry is set to grow as a significant contributor to the UK's manufacturing economy, and will be a critical element in achieving a greater productivity."

ACTION for 2016

What should both government and industry do next year to strengthen manufacturing in Britain?

Neil Burns, co-founder and director at Croft Filters and Croft Additive Manufacturing:

"If the manufacturing sector is to overcome the skills shortage it is currently facing, the Government needs to ensure sufficient support is available, not only to close the gap, but also encourage the next generation to consider a career in STEM.

"At the same time, the industry must acknowledge that the responsibility for tackling the issue lies in its own hands."

Tony Hague, managing director, Power Panels:

"With constant issues in terms of Eurozone bureaucracy and uncertainty, and the weak euro putting UK manufacturers at a disadvantage, let's look to North America.

"A growing, stable economy: and we talk the same language (nearly). Geographic distance is not a constraint – but perhaps mindset is?

David Sheppard, managing director, Sponmech Safety Systems:

"If you are manufacturing in the UK, paying the living wage, giving proper long-term contracts of employment, profit sharing and paying proper levels of tax, you are a special company.

"In 2016 I want to see companies like ours who do the right things be rewarded. Government should be on the side of those of us that are in it for the long-term."

Robin Weston, additive manufacturing division, Renishaw:

"In Germany, engineering enjoys a higher status. It gets noticed; people are proud of it. It has a beneficial impact in terms of GDP: the more we export, the better off we are."

Guy Mollart, managing director, Mollart

"The vacuum created by an historic lack of engineering apprentices has been plugged in recent years. At an average cost of £100,000 per apprentice, over the three years of a typical programme, this is a high cost for an SME to sustain.

"We would appreciate a tax deduction scheme that could offset some of these high training costs against profits."

Rachel Jarvis, managing director, Cobra Sport Performance Exhaust Systems

"In order to support UK manufacturers, services such as UKTI and the Manufacturing Advisory Service need more funding as this has been cut in recent years.

"In addition, more needs to be done to address skills shortages in all age groups. Larger organisations don't face the same issues as SMEs when it comes to recruitment: it's a constant battle trying to find the right people, manufacturing isn't perceived as a good career option for most semi-skilled workers."

Terry Scuoler, chief executive, manufacturers' organisation, the EEF

"The watchword for 2016 has to be boosting our productivity performance. This can only be done by upping our game on investment in skills and innovation. If that sounds like more than one wish, then it is because they are inextricably linked, and have to go hand in hand."

James Selka, chief executive officer, MTA:

"The main thing I'm looking forward to next year is MACH 2016. I make no apologies for highlighting the event. It is an unrivalled opportunity to catch up with latest technology and ideas in manufacturing.

"As well as being a superb shop window MACH is a precious part of the infrastructure of UK manufacturing enabling all the sector's players to interact."

Charles Turner, managing director, Durham-Duplex:

"The investment in manufacturing skills in the Sheffield City Region is a key part of ensuring 'Made in Sheffield' continues its reputation for manufacturing excellence from a distinct geographical location."

Gordon Macrae, special projects manager, Gripple:

"The government should do more to encourage employee ownership. It delivers enhanced productivity, improved profitability, more engaged staff – and most importantly a fairer, values-driven environment."

Andrew Churchill, chief executive, JJ Churchill:

"From government, we need predictability against which to invest for the long-term – be that in skills, automation, or innovation.

"Political priorities will necessarily inform policy, but above this should sit our Industrial Strategy, taking a longer and less politically partisan view."

Mike Berry, managing director, 600 UK

"As a UK-based manufacturer of machine tools and employer of a highly skilled, dedicated workforce, we need additional export support, with particular emphasis on the growing markets of India and the Far East.

"We need more assistance to help compete on a level playing field, with lower-cost overseas competition. This includes protection from the dumping of cheap and non-conforming machinery into the UK and European machine tool market."

Matthew Aldridge, director, Igus:

'The much-vaunted Internet of Things is still a long way off for most UK manufacturers, but factory automation is available today. We must start automating certain processes more widely to improve efficiency and redeploy workers where they can truly add value."

Richard Bruges, chief executive, Productiv:

"The coalition did a great job in developing the relationship between manufacturing and government, particularly in automotive. The current Government must continue the catalytic support that targeted funding provides.

"The Proving Factory is an excellent example of the private sector creating cutting-edge manufacturing solutions – but we need the business and fiscal environment to encourage long term investment."

Anne Wilson, managing director, Numill

"I joined Numill as bookkeeper. It is nine years since I became 100% shareholder and sole director. It has been a rocky road, but I want to employ more people in this region, it's one of my drivers.

But look at productivity with automation; if you increase productivity it does not increase jobs. If I buy a new CNC machine we could increase productivity if the guys we have know how to run the machine; productivity rises but not employment. How do you balance automation and be more efficient and then employ more people in your operation?"

Andrea Rodney, MD of Hone-All Precision

"As much as the Government can do more to help the current issues within manufacturing by showing support for our steel industry and oil & gas sectors, we can do more to guide them correctly by speaking with a unified voice and representing all sizes of manufacturing companies rather than numerous voices each with separate agendas."

Philippa Oldham, head of transport and manufacturing, Institution of Mechanical Engineers:

"Removing the bottlenecks on the network to improve the efficiency and increase capacity is fundamental to bridging the North-South divide.

"However, projects like HS2 are only a small part of the transport network jigsaw. The UK Government needs to move away from piecemeal transport projects and work with the new National Infrastructure Commission and Transport Systems Catapult to develop an integrated transport network, which includes road, rail, sea and air travel.

"Having a clear plan would provide investor confidence and allow for forward planning and the preservation of skills."

Emily Barker, managing director, Odin Engineering (Winner, Made in the Midlands, Manufacturer of the Year, 2015):

"Unfortunately due to recent events relating to oil and gas, and domestic steel, the industry is slightly unnerved as we enter 2016.

"We need support for UK manufacturing, perhaps by capping energy costs, and incentives for the older generation to train the upcoming generation – we need to bridge the skills gap, that is undoubtedly noticeable."

Andy Page, chief executive officer, Sharing in Growth:

"To quote the economist Paul Krugman: 'Productivity isn't everything, but in the long-run it is almost everything'.

"Sharing in Growth and NATEP will continue to work with government and manufacturing to enable UK aerospace firms to secure contracts and jobs through productivity and innovation improvement.

"We know there is a real urgency given the productivity gap to our major aerospace competitor countries and the opportunity derived from enormous sector growth."

Marcus Burton, group managing director Europe, Yamazaki Mazak:

"We need to address the UK's continuing productivity problem.

"We need the government to do everything in its power to create conditions which encourage further investment in capital equipment by business and our country's infrastructure.

"And we need to settle our relationship with Europe, and end the sense of uncertainty which risks impacting business confidence and the willingness to invest."

Mark Ridgway, chairman and chief executive, Joseph Rhodes:

"2016 will prove to be a critical year for UK manufacturing. Recent positive employment figures for the UK economy as a whole mask underlying weaknesses.

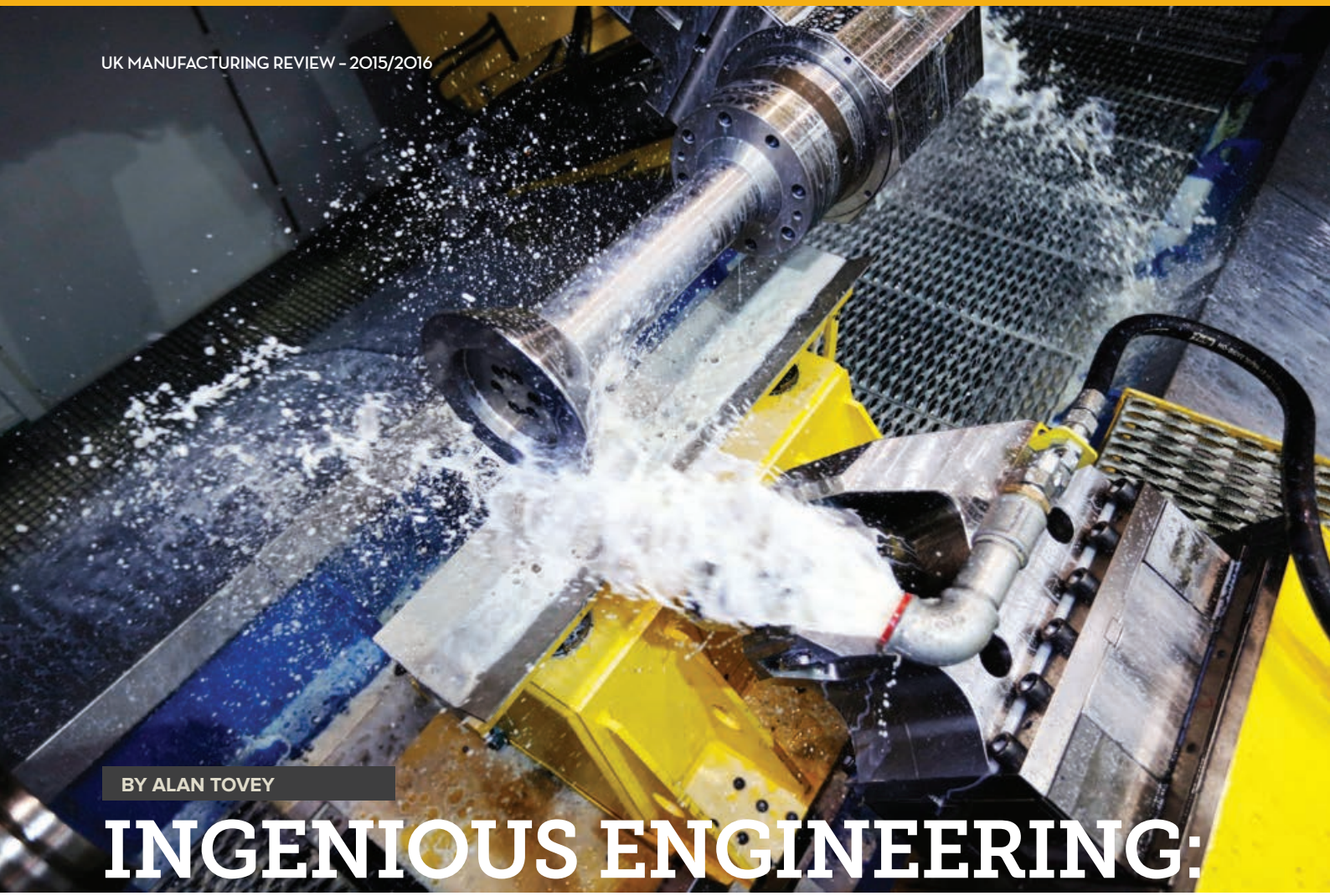
"Falls in international growth, combined with the strength of sterling, threaten the very exports on which both the manufacturing sector – and the UK economy – so heavily depend.

"A high level of investment in finance, training and innovation is critical if the UK is to protect its world-leading status in sectors such as advanced engineering and aerospace.

"Such support in turn serves to attract further foreign direct investment. Retaining the UK's status within the EU is therefore essential for the manufacturing sector."

2

Business Subjects



BY ALAN TOVEY

INGENIOUS ENGINEERING:

New methods to keep UK industry competitive

The High Value Manufacturing (HVM) Catapult had a strong 2015, proving several big, commercially-viable manufacturing techniques with industry. Some of the work of four of the seven centres is reviewed here

High finance and high-tech manufacturing might seem worlds apart, but Mark Carney, Governor of the Bank of England, signalled the industrial sector's importance to the economy with a visit to the Nuclear Advanced Manufacturing Research Centre (NAMRC) in March.

"No one knows better than the people in this room that manufacturing needs to become ever-more productive to prosper in a world of steadily falling prices and relentless international competition," Mr Carney told his audience at the Rotherham centre.

With the chancellor having called for a "March of the Makers" to rebalance the economy away from its dependence on services and setting a target of doubling exports to £1 trillion by 2020, there is a recognition that manufacturing has a vital role in boosting the UK's finances.

The value of that role is borne out by data. The annual report for 2014/15 of the High Value Manufacturing Catapult – of which NAMRC is just one of seven centres – showed that for the £107m of core public funding received, £1.6bn in net benefits have been delivered to the UK economy, with a forecast return of £6.1bn by 2020.

The form those returns come in varies, something highlighted by the Advanced Forming Research Centre's (AFRC) part in trying to solve the problems that have become one of the year's biggest industrial stories: the crisis in Britain's steel industry.

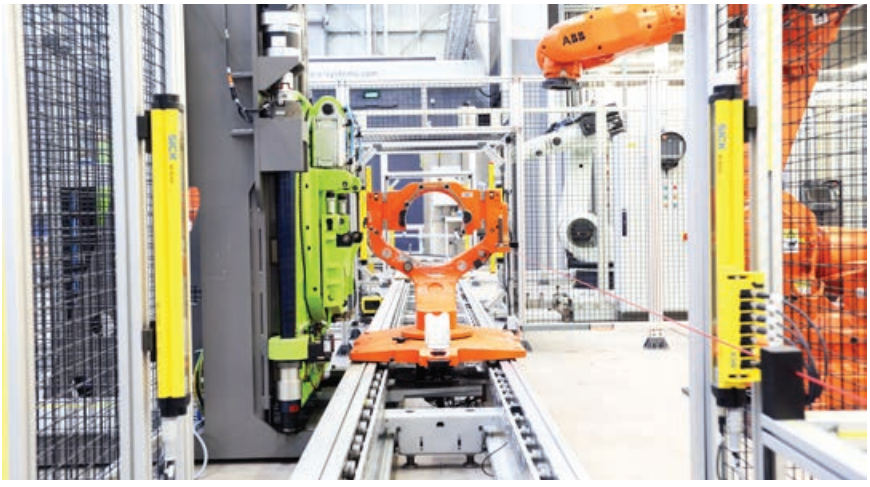
Based at the University of Strathclyde, the AFRC helped deliver Britain's Metal Strategy, with a focus on accelerating innovation and R&D. With UK steelmakers facing cheap imports from China, helping them develop the tools to speed the introduction of new products in the high value sector where they can compete best could be key to safeguarding their future.

This year the AFRC has also opened a Tool & Die Centre of Excellence to step up its work developing the tools that manufacture components. In a world of 3D printing, these tools might seem outdated but the properties that metal forming techniques such as forging can embed in a component are often unequalled.

Michael Ward, AFRC technical director, said: "The economics of processes driven by tooling work when you're making millions of components, but the problem comes when you want customisable tooling for small batch sizes: it's too expensive to make a single tool and die set if you throw it away after making one component."

AFRC is looking at how to make tools that are economic for small production runs by developing configurable and customisable equipment, meaning that forming techniques that add characteristics such as strength or hardness can still be used.

"Our dream is for the UK to become the leading place for economical shaping technology that works at small volumes," said Ward.



Left: The AFRC is helping to deliver Britain's Metal Strategy, accelerating new products in the high-value steel sector to counter cheap Chinese steel imports

Above: Warwick Manufacturing Group (WMG)'s £14m automotive battery pack research facility was announced in September 2015. The research centre is funded by OLEV via Innovate UK and is a co-funded public/private collaborative R&D project to create a UK supply chain for vehicle battery systems

SOME 2015 HVM CATAPULT HIGHLIGHTS

Annual report: Converts of £107 million of public funding into £1.6bn in net benefits to the UK economy

AFRC helps deliver Britain's Metal Strategy, accelerating new products in high-value steel sector to counter cheap Chinese steel imports

Nuclear AMRC accelerates production of a baffle cage for a heat exchanger in a nuclear reactor for Rolls-Royce

MTC produces largest ever 3D-printed civil aerospace engine part – a 1.5 metre-diameter engine bearing housing

MTC achieves more accurate robot control in real time

WMG wins bid for new £14 million battery manufacturing facility

NUCLEAR RESEARCH CENTRE BRINGS WORK HOME

High on the national agenda is the NAMRC's work with Rolls-Royce this year on nuclear power. The centre helped the FTSE 100 group accelerate production of a "baffle cage" for a heat exchanger in a nuclear reactor, using laser tracking to control the exact arrangement of the component's 5,000 six-metre tubes. Rolls later landed a £25m order to supply Hinkley Point C.

Mike Tynan, NAMRC chief executive, said the centre is "bringing work home".

"The key challenge in the nuclear new-build programme is that it' s full of overseas technology," he said. "To be competitive in the face of that you have to demonstrate you can deliver innovative technology on time and on cost. We are trying to deliver UK manufacturing with a reputation for innovative solutions that de-risk a programme – giving certainty on cost, delivery timing and safety specification – after all, some of these components are going to be in service for 60 years."

It's not just the blue-chip giants NAMRC is working with: it has helped companies large and small in the nuclear supply chain to develop processes which have seen them win £600m of contracts this year.

Rolls was also involved in a headline-grabbing achievement in June when engineers at the Manufacturing Technology Centre (MTC) in Coventry helped produce the largest ever 3D-printed civil aerospace engine part – a 1.5 metre-diameter engine bearing housing for the company's Trent XWB engine. Built to demonstrate the opportunities presented by additive manufacturing, the tractor wheel-size part was formed by melting super-thin layers of titanium powder, with complex features incorporated into the process that could one day power Airbus' A350XWB airliners.

Additive manufacturing was a big feature of the MTC's year with the opening of the Aerospace Research Centre and the National Centre for Net Shape and Additive Manufacturing (NSAM), which looks into how metal powders can be formed into components. Already a $30bn global industry, this figure is rising and NSAM is placed to bridge the gap between market requirements and process reality.

MTC also scored another world-first in August by solving a long-standing problem with robots. While they have been used in manufacturing for decades, accuracy much better than 1mm in industrial applications has proved a challenge. MTC developed a system that combined an ultra-accurate, high-speed laser tracker with a robot that allowed it to correct its movements during a process. This delivered accuracy levels of better than 0.2mm in a robot moving at 50mm a second, opening the way to productivity gains in manufacturing as robots will be more precise at higher speeds, reducing defect rates.

"By combining the robot, the laser metrology device and a real-time controller we were able to ensure the robot could follow complex paths with an extreme degree of accuracy not previously achievable," said project leader Richard Kingston. "This has proved it is possible to correct a robot's path in real time, another first."

A highlight of the year for the Warwick Manufacturing Group (WMG) Catapult was its successful bid in September to create a £14m automotive battery manufacturing research facility. By combining human and automated assembly techniques, it hopes to lay the foundations for a new British supply chain in a market of increasing demand as vehicle manufacturers look at new and greener forms of power.

Announcing the facility, Professor Lord Bhattacharyya, WMG chairman, spelled out the potential in the automotive sector. "The global energy storage market will be worth $50bn by 2020 and of this, $21bn will be in transportation," he said. "Automotive is well on its way to displacing consumer electronics as the biggest user of energy storage. This project will play a significant role in the evolution of that market by creating a UK supply chain for battery packs to suit hybrid and electric vehicles requiring volumes from hundreds to thousands of units per year."

Connecting the country by rail is also on WMG's agenda after it was part of a consortium which won £1.6m to develop a low-cost, low-carbon, lightweight train. One of the bid's key features was its strategy of using tried-and-trusted off-the shelf components to cut manufacturing costs and boost reliability. UKMR-15

SECTORS - BIG DATA

"If a sensor somewhere is seeing and reporting something, then there need to be controls over how that information is accessed and shared, so that I can see it, but my competitors can't. Right now, those rules don't exist."

Prof Amar Ramudhin, Hull University Business School's Logistics Institute

Image: Shutterstock

Visibility and control

BY MALCOLM WHEATLEY

The humble bed sheet isn't an especially high-value item – which can be a distinct problem for a business such as FTSE 250-listed textile services specialist Berendsen.

Operating out of 30 factories spread across the country, it hires and launders bed linen and towels to customers such as hotels and hospitals, each factory equipped with a fleet of vehicles collecting used linen and delivering freshly cleaned replacements.

The problem? Keeping tabs on what linen assets are where, in order to optimise asset utilisation, and – more importantly – maintain a regular flow of laundry-fresh towels, sheets and pillow cases, available as and when customers want them. Each day, for instance, the business handles close to a million pieces of hotel linen.

"At root, these are low-value items, which significantly impacts the cost-benefit equation," points out Duncan Macmillan, Berendsen's IT director.

"The cost of manually barcode-scanning bag after bag of incoming and outgoing linen was simply prohibitive."

MORE INFORMATION, NOT TOTAL INFORMATION

Until 2015, that is – the year in which it became possible for Berendsen to cost-effectively combine a whole series of cutting-edge technologies. The starting point: low-cost, passive UHF RFID tags, sewn onto items such as sheets and bath towels. Trials showed that an entire rollcage pallet of incoming or outgoing linen could be read in a single pass past the RFID reader.

"We could reliably get a first-pass read rate of 995 items or so – that's a 99.5% success rate," explains Macmillan. "For our purposes, that was more than adequate: the goal was more information, not total information."

But what would be the best way to store, analyse and extract value from what was very quickly going to become a deluge of RFID data? For even rough estimates of the data streams involved took the proposed project firmly into Big Data territory: there were four million RFID tags in place with, on

average, four tags being read each second of the day.

The answer: the open source Apache Hadoop data processing and analytics engine – a technology that is purpose-designed to scalably handle Big Data volumes – running as a pre-packaged service on Microsoft's cloud-based Azure platform. Deployed under Windows or Linux, it could process structured or unstructured data, and scaled to petabytes on demand – and yet was fully-integrated with familiar Microsoft analysis and visualisation tools such as Excel and Power BI.

XML-encoded messages are sent to Berendsen's central IT facility from RFID scanners located at the despatch, processing and inwards return points at each factory, from where they are automatically sent to Microsoft's Azure cloud platform processing.

About 20 files are received every minute, explains Macmillan, with each file containing multiple transactions, equating to more than four transactions per second. Via dashboards on mobile devices, real-time analytics – again located in the cloud – then provide Berendsen factory and administration personnel with real-time insights into linen availability and location.

CONTROL TECHNIQUES YIELD GREATER VISIBILITY

The result has been a transformation in visibility and control, claims the company. And while asset utilisation will increase, asset losses will decrease, and operational efficiencies will be delivered, the real benefit, insists Macmillan, is the ability for Berendsen to deliver a better service to its customers.

"For hoteliers and hospitals, a daily supply of fresh linen simply isn't front-of-mind," he says. "They view that as our job – and this investment allows us to perform that job to a higher standard."

Writ large, the Berendsen case study is a story which impressively combines some of industry's hottest IT technologies. 2015 – as at Berendsen – was the year that showed just what could be achieved not just by using these technologies on their own, in isolation, but by combining them together for greater effect. And not just within the four walls of the enterprise, but externally, along the upstream and downstream supply chain, pulling in data from suppliers, customers, and logistics partners.

At a high level, there's the Internet of Things, which permits two-way communications with intelligent devices – sensors, micro-controllers and embedded computers installed in equipment, for instance. This enables the equipment in question to be controlled remotely, or to report that it needs maintenance or replenishment.

Analyst firm Gartner Group has forecast a thirty-fold increase in internet-connected physical devices by 2020, with the overall size of the Internet of Things likely to reach 26 billion installed units by 2020, up from 0.9 billion just five years ago. This, it adds, will "significantly alter how supply chains operate".

For while the applications of the Internet of Things within the four walls of the enterprise are obvious enough, as at Berendsen, it's those applications within the supply chain that may turn out to be significant.

Internet-connected intelligent devices, located at strategic points within the manufacturing supply chain, can do much to eliminate the uncertainty that drives raw material and component inventories. Visibility is transformed, too. With the Internet of Things, individual consignments – shipping containers or pallets, for instance – can also keep in touch in real time.

That said, businesses are understandably asking searching questions about the security and resilience of Internet of Things-enabled supply chains. The World Economic Forum, for example, has commissioned Hull University Business School's Logistics Institute to explore models of how the associated policies and governance might work.

"Billions of devices will be automatically transmitting potentially sensitive information across national boundaries," points out the Institute's Prof Amar Ramudhin. "If a sensor somewhere is seeing and reporting something, then there need to be controls over how that information is accessed and shared, so that I can see it, but my competitors can't. Right now, those rules don't exist."

Again, manufacturers can build Internet of Things capabilities into their products, adding value in the process. German industrial giant Bosch's UK gas boiler manufacturing subsidiary Worcester Bosch, for instance, has launched an Internet of Things-enabled remote gas boiler controller.

An easy-to-use app, installed on consumers' smartphones or tablets, provides at-a-glance information on such things as the current temperature of consumers' homes, energy usage, and the present boiler settings, explains Bosch UK's president Steffen Hoffmann. And provided that they have access to a wireless internet connection, consumers can then switch their boiler on (or off), from wherever they happen to be, ensuring that they never return home to a cold house.

Coming during 2016, Hoffmann adds, is a further Internet of Things-enabled boiler enhancement, developed in conjunction with British Gas, which will automatically report problems to British Gas' maintenance team, summoning a technician to service the equipment.

Nor is this all. Even more fundamentally, whole new business models open up. The concept of servitisation, for example, sees customers paying for equipment on a usage basis, rather than through outright capital purchase – palletisers, say, paid for per pallet, rather than on a time-rental basis, or purchase.

TRIGGERING INVOICES, ISSUING ALERTS...

Again, it's Internet-connected intelligent devices that enable the equipment in question to "call home", triggering invoices, and issuing alerts when consumables need topping-up or replacing.

That said, successfully enabling all this is likely to call for more than just an

INTERNET OF THINGS, SURVEY OF COMPANIES, 2015

Only a small number of respondents – **4%** – were planning an Internet of Things initiative in the next six months

A further **16%** of respondents were planning an investment over a longer six to 12-month period; an additional **16%** were planning an investment over a still longer period of one to two years

The remainder of the respondents – some **64%** – were unclear as to the precise timing of any Internet of Things investment

Source: Henrik Research / Microsoft

Source: Richard Wilding

Interfacing the Internet of Things to back office systems will pose challenges.

Richard Wilding, Cranfield School Of Management

in-house Internet of Things initiative. Richard Wilding, professor of supply chain strategy at Cranfield University's Cranfield School Of Management, for instance, worries about how businesses will interface their conventional – and sometimes batch-based – back office systems to the real-time streams of high-volume data arriving, as at Berendsen, from the Internet of Things.

"With the Internet of Things delivering signals at frequent intervals, ERP systems and processes such as sales and operations planning can struggle to keep up," he says. "They're running at different clock speeds, and ways will have to be found to synchronise the two."

HIGH VELOCITY, HIGH VARIETY HIGH VOLUME

Big Data is characterised as data with high levels of what are known as the three Vs – velocity, variety, and volume: it typically requires specialist technologies such as Hadoop or MongoDB in order to handle data at a scale that would choke conventional database technology.

On its own, however, Big Data is of only negligible use. What matters is the ability to interrogate and analyse data at Big Data scale. Only that way can companies glean meaningful insights and understanding not previously possible.

Hence, although the term Big Data is often bandied about, the value comes only partially from acquiring the data – although, as seen at Berendsen, the challenges involved in this should not be underestimated.

But the real benefit arises from the underlying analysis of the data, either in terms of conventional business intelligence, customer analytics, predictive analytics, or ad hoc analyses of any number of specific business problems involving data of Big Data proportions.

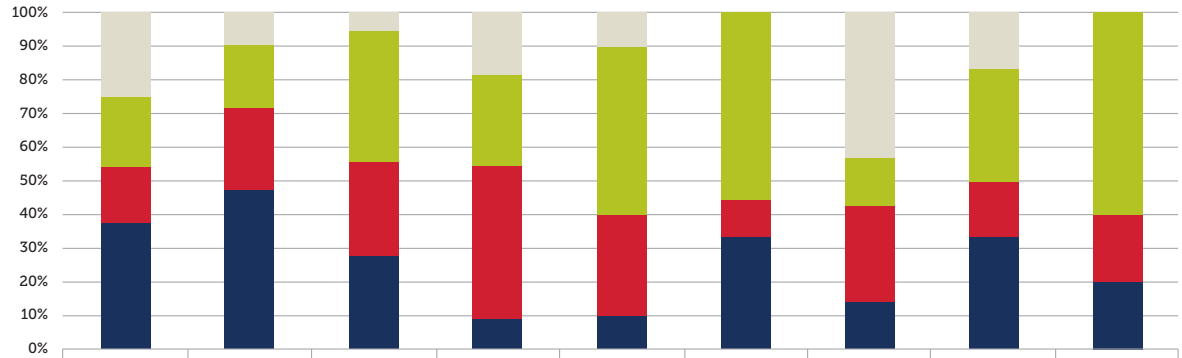
That said, the ROI from such analytics exercises depends significantly on the rigour with which the process is undertaken, says Bernard Marr. Marr is a regular contributor to the World Economic Forum and a consultant in strategic performance, analytics, KPIs and big data.

"It's not about simply collecting and gathering data on the off chance that it might be useful," he is quick to point out. "It is also important to start with significant business problems, formulate the questions which will shed light on those problems, and then go looking for the data which will provide the answers. Today, too many companies are doing it the wrong way round."

So who is getting it right? Marr, who is also chief executive of the analytics and consulting firm the Advanced Performance Institute, points to recent Big Data initiatives from companies such as oil giant Royal Dutch Shell and aero-engine manufacturer Rolls-Royce, each featured in his book *Big Data In Practice*.

Roll-Royce, for instance, which pioneered servitisation with its power by hour Total Care offering, is harnessing its clusters of high-power supercomputers to analyse the manufacturing data on the fan blades that go into each of its jet

BIG DATA DEVELOPMENT BY SECTOR



	Technology Media & Telecoms	Financial Services	Retail	Hospitality	Manufacturing & Engineering	Healthcare & Pharmaceuticals	Other	Public Services	Utilities
No requirement	25%	10%	6%	18%	10%	0%	43%	17%	0%
In development	21%	19%	39%	27%	50%	56%	14%	33%	60%
Expected 1-3 yrs	17%	24%	28%	45%	30%	11%	29%	17%	20%
Already have it	38%	48%	28%	9%	10%	33%	14%	33%	20%

Source: Coeus Consulting

BIG DATA, BIGGER PICTURE

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At a high level, there's the Internet of Things, which permits two-way communications with intelligent devices – sensors, micro-controllers and embedded computers installed in equipment, for instance. This enables the equipment in question to be controlled remotely, or to report that it needs maintenance or replenishment.

"In the case of small and mid-sized manufacturers, technologies such as the Internet of Things and Big Data haven't yet really filtered into businesses' thinking. UK industry is still playing catch-up."

Tom Lawton, partner and head of manufacturing at business advisors BDO.

engines. Capturing half a terabyte of manufacturing data on each individual fan blade quickly adds up to Big Data proportions, he points out: the company's new factory in Singapore produces 6,000 fan blades a year, generating three petabytes of data.

That said, hard data on the precise ROI of such initiatives remains hard to come by – partly because adoption levels are still low, and partly for competitive reasons, says Steve Dunbar, head of Microsoft's Internet of Things business group.

Source: Coeus Consulting

Despite expressing a need for Big Data, manufacturers have been slower than average to invest in it.

Matthew Headford

"The ROI being achieved is very real, but a lot of companies are particularly reluctant to put the numbers in the public domain," he points out.

Moreover, few of the most compelling case studies – at least in the public domain – are British, he adds.

"British companies are traditionally very sceptical about new technologies, and the Internet of Things is no different. Manufacturers in the Nordic countries, and in North America, tend to be more open to the possibilities," he observes.

Paul Saxton, business intelligence expert and analytics product manager at eBECS – the IT provider which built the Berendsen solution – agrees.

"There's a real need for compelling public domain use cases, to make it clearer to businesses what exactly the applications might be, and where exactly the gains will come from," he stresses.

"The more complicated the initiative – initiatives linking the Internet of Things, Big Data, and analytics, for instance – the more important it is to see the synergies that are involved."

Which may be one reason why manufacturers seem to be taking a nuanced view of timing their initiatives in the areas of Big Data and the Internet of Things.

That almost two-thirds of manufacturers were found to have no clear plan is hardly a ringing endorsement of the technology. That said, it is still consistent with Microsoft's recommendation that manufacturers should adopt a staged, exploratory, step-by-step approach to the Internet of Things.

Likewise with Big Data, reports Matthew Headford, chief technology officer at IT strategy consulting firm Coeus Consulting. In a cross-industry survey carried out in the autumn of 2015, manufacturers' exploitation of Big Data sharply that of lagged other industry sectors.

"90% of manufacturers are saying that they have a need for Big Data, but only 10% are reporting that they have already invested in a Big Data capability," he observes. "That's against an industry average of 30% – placing manufacturers in the second-lowest sector for Big Data exploitation, ahead only of the hospitality industry."

FROM DISRUPTIVE TO READILY ADOPTED

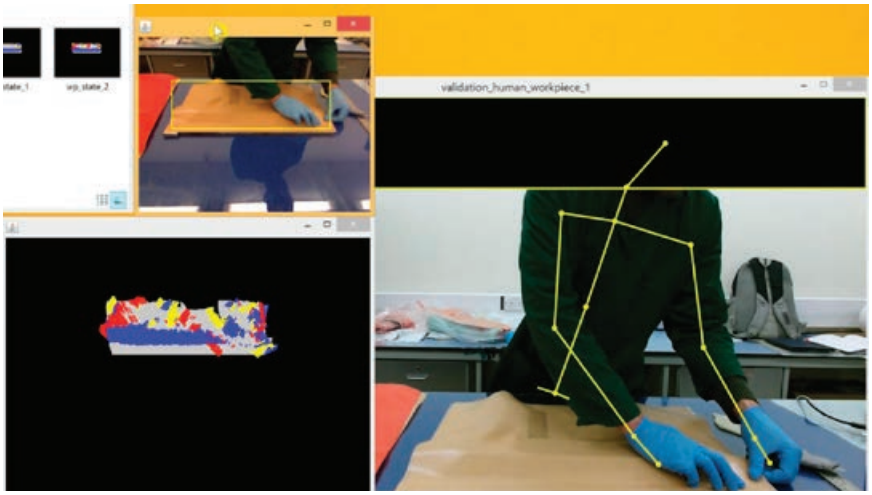
That said, observers are hopeful that 2016 will see adoption levels increase.

"In the short term, people are making these technologies out to be more disruptive than they really are," adds Ken Young, technology director at the Manufacturing Technology Centre. "Yes, they're disruptive, but adoption will build gradually, as businesses figure out their own particular use cases."

And, as Berendsen's experience highlights, if a use case can be found for low-value items such as towels and sheets, then the odds are good that such use cases will indeed emerge more generally across British industry. For technology watchers, 2016 will be interesting.

UKMR-15

Digitising complex manufacturing environments



Technology used for videogame motion capture could be employed in factory simulation

Could technology used in the gaming industry be used elsewhere and introduce change and efficiencies into other sectors, such as manufacturing?

A team from Cranfield University says a resounding 'yes'.

High-tech gaming consoles combined with human motion capture sensors enable people to immerse themselves completely in game environments.

This technology enables people to accomplish tasks using human actions and analysis of games situations, based on observation and instinctive reactions.

Cranfield's Manufacturing Informatics Research Group aims to develop an ICT framework which will capture, model and use information about how people physically do complicated jobs in manufacturing industry.

The thinking behind this is that every manual manufacturing task comprises an interaction between a person and an inanimate object: a person's action on an object is followed by feedback from it, to which the worker subsequently reacts. This reaction could be verbal, physical or audible.

GAME THEORY

By recording these actions and reactions using 3D sensing devices, such as the Kinect and PrimeSense3D, which can now capture and track human skeletal motion, the human response to expected and unexpected behaviours can be digitally recorded.

Until Kinect launched in 2010 it was difficult to track human and workplace movements simultaneously and virtually impossible in manufacturing environments. The availability of human skeletal motion data and the ability to track changes within a workplace in three-dimensions together means human/environment interactions can be captured and tracked inexpensively.

"The ambition is to digitally record human physical response to expected and unexpected behaviours which could pave the way for intelligent automation of skill-intensive manual manufacturing tasks," says Professor Ashutosh Tiwari – head of the Manufacturing Informatics Centre, Cranfield University.

Eventually this could be used to create virtual representations of factory environments to predict and evaluate the impact of different factors on production efficiency, or for people to 'meet' and 'walk through' the environment – virtually.

This technology could boost the competitiveness of the manufacturing industry. In the short term, analysing the digitised human/ workplace interaction could provide information useful for ergonomic assessment and redesign of workstation. In the medium range, the skills of experienced workpeople 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-workpiece interactions could provide the intelligence behind automating such tasks – providing a solution to the threat of a reduced supply of skilled workers.

Using gaming interface technology, the Cranfield University team has already shown it is possible to simultaneously track and digitise human actions plus resultant reactions, such as their project to record the knowledge of how to lay composite resin pre-impregnated fibre plies on to a complex metallic mould, manually. Each sequence of steps was recorded as continuous digital data (x, y and z co-ordinates of human hands and the conformance of the composite ply to the mould surface as it is laid up by the hands), creating motion charts.

Since human actions and layup progress were captured synchronously, the effect of those actions on the composite ply during a specific time can be analysed by looking at the changes in the ply conformance during this period. This complex task could be taught to a robot for automating this task in the future. UKMR-15

FACTORY 2050

Factory 2050, the latest addition to the Advanced Manufacturing Research Centre, part of the High Value Manufacturing Catapult, will be one of the most advanced factories in the world.

It is the first building on a new Advanced Manufacturing Campus. The landmark, circular, glass-walled structure, with its long rectangular extension, has been built with the support of a £10 million grant from the Research Partnership Investment Fund and £10 million from the European Regional Development Fund.

Factory 2050 will be the UK's first, fully reconfigurable component manufacturing and assembly facility, combining cutting-edge technologies including advanced robotics, flexible automation and virtual environments, linked to plug-and-play machine tools, robots and 3D printing technology which can be moved around the shopfloor.

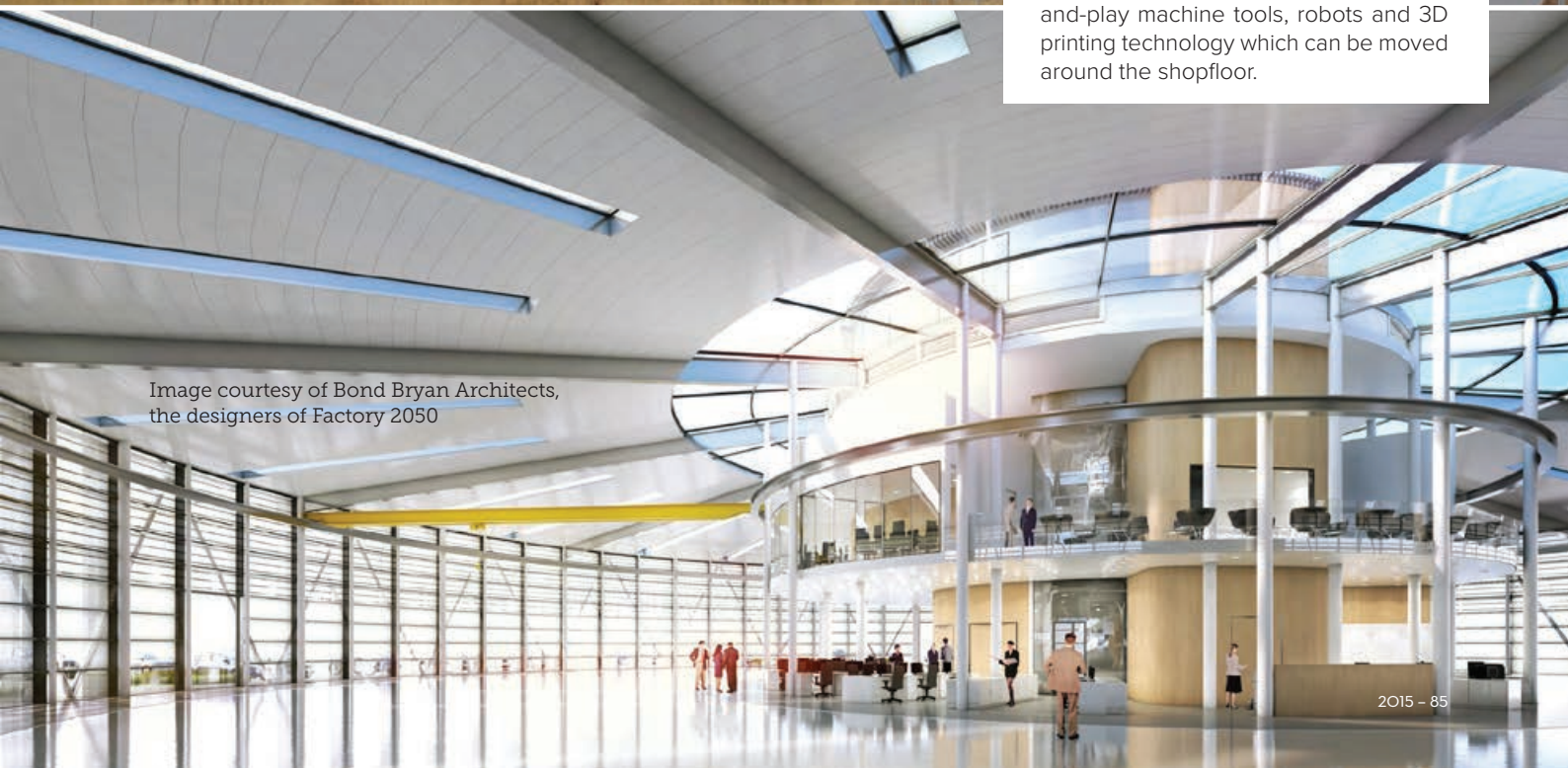
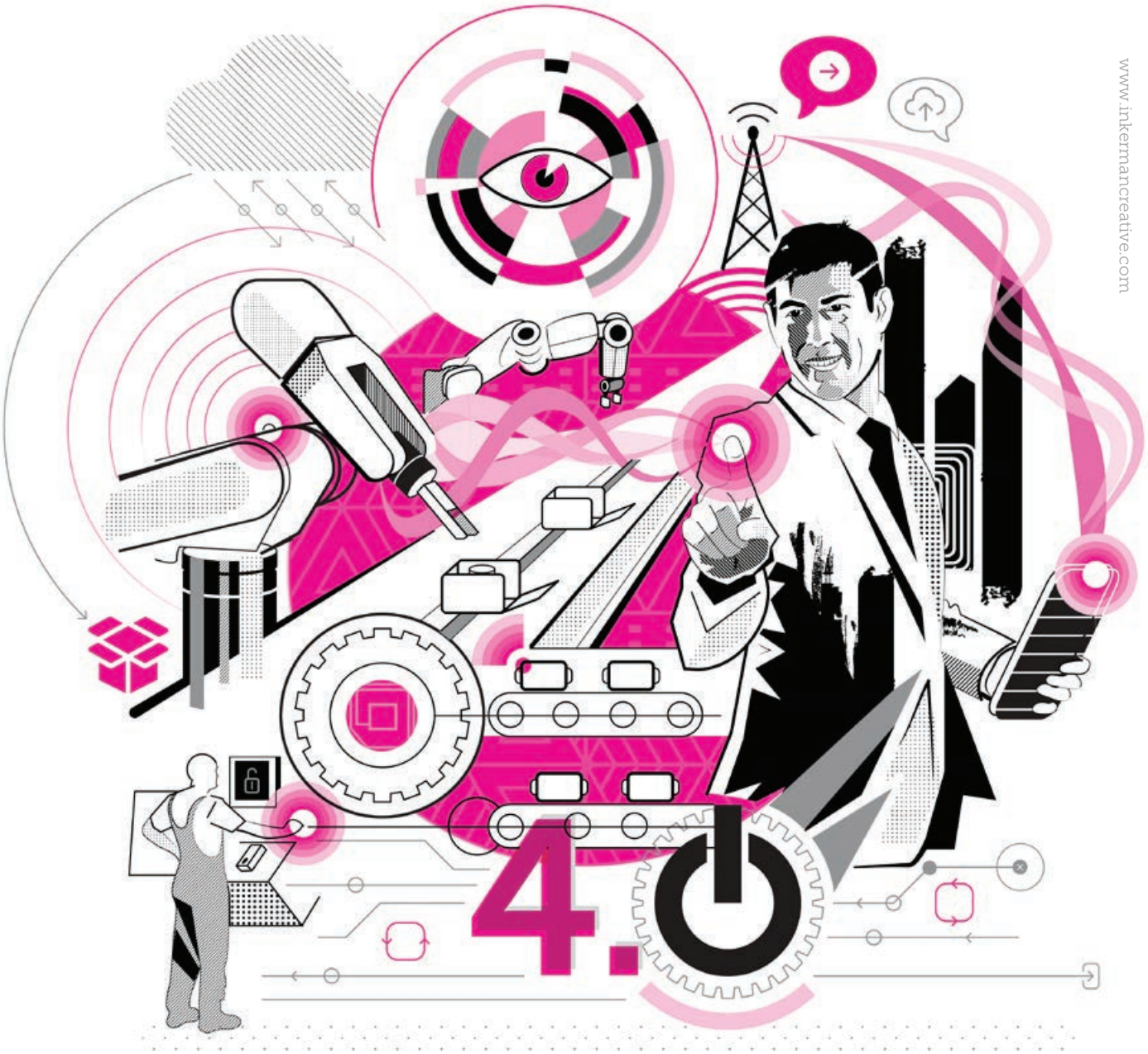


Image courtesy of Bond Bryan Architects, the designers of Factory 2050



SECTORS - INDUSTRY 4.0

Digital factories to solve the productivity puzzle

The digital factory can be a solution to low productivity, and provides an opportunity to redindustrialise the UK in a radical, futureproof way. Business needs to better understand "Industry 4.0" and its effect on jobs and corporate liability, for the tech evolution to match customer demands. Will Stirling reports.

Connected industry: standardised machines in the Blaichach plant. The work pieces of Industry 4.0 are intelligent. They are equipped either with barcodes, RFID chips, or internet-enabled sensors. Thanks to partially or fully automated information gathering and transmission, a virtual copy of the physical world can be created. The network of software programs, mechanical parts, and electronic parts communicates around the world via the internet. This makes constant coordination and improvements between locations or even beyond the walls of the company possible

Left: the future of manufacturing. Factories are becoming more connected to the internet and "the Internet of Things". The goal is to make manufacturing more personalised and productive, but there are also cyber security risks

A production engineer presses a touch-screen to optimise flow lines in a simulated factory line. A modular factory cell for this variant of a complex product, an aircraft fuselage for example, is activated to assemble the bill of materials for this customised fuselage for the airline's specific needs. A co-worker wears a wristband using technology that receives and transmits operational data from an ordering system to the automated material handling vehicle that delivers parts, autonomously, to each correct assembly station. No paper changes hands, all information is conveyed wirelessly.

These parts have embedded sensors that talk to the machines, informing them how much metal to cut or grind, or how much torque to apply to the bolt. More parts, in their precise order and number, are delivered to the correct assembly station, just in time, with no human intervention – and no tea break. Every key performance indicator is recorded, analysed and distributed to the worker's personal performance record, and the CEO, highlighting areas for improvement. Gigabytes of data fly around

ROBOTS ARE USEFUL, BUT IS MY JOB SAFE?

The concept of more intelligent machines is not just "automation to get rid of people," says the Manufacturing Training Centre's (MTC) Lina Huertas. "Industry 4.0 is about producing more value, either by optimising the way people do their jobs, getting them to exploit their intellectual capital and to make different kinds of decisions as opposed to doing manual jobs that do not add value." This, she says, requires infrastructure and policy support from government, to understand and support future labour mobility, rather than seeing technology as a divisive force. This is about moving people from a, some might say, trivial job, to add value and increase their quality of life.

"One of the biggest challenges with I4.0 is understanding how a job is going to change, what are the new skills that will be required, and changing the education system." Here there is some tangible progress. The MTC's new Advanced Manufacturing Training Centre, a stunning new building that opened in September, combines practical mechanical engineering skills with degree-level theory as well as modules on informatics and mechatronics, the fusion of mechanical and electronic engineering. In addition, the EPSRC Centre for Innovative Manufacturing in Intelligent Automation at Loughborough and Cranfield universities is working with the MTC and partners including Airbus and Aero Engine Controls on the most optimised assembly methods that combine robot and human actions. Psychology will play an important role, with Cranfield under Prof Phil Webb studying the effects of working with robots on human mood and performance.

Technology business groups such as Gambica and BARA, the British Automation and Robot Association, firmly maintain that the displacement of less skilled labour in factories by automation, will be more than offset by the job creation that such successful companies can affect in more skilled jobs – design, logistics management – as the business grows. But hard evidence of this really happening is, to date, scant.

invisibly, optimising everything in a relentless performance feedback loop.

This is a vision of the digital factory of the future, of what has become known as "Industry 4.0", a fusion of cyber physical systems – humans and machines cooperating at work – the Internet of Things and the Internet of Services. First coined in Germany, the German government pushed it forward as part of its High-Tech Strategy 2020 Action Plan. One aspect of this was to sell more industrial automation equipment, which Germany makes a lot of, but the long term goal is industrial security.

Despite rising evidence of reshoring manufacturing from lower cost countries, high labour costs in the West still make the manufacturing of many goods vulnerable to relocation. Automating manufacturing will, it follows, cut costs and keep more production here. While widespread adoption of I4.0 has not happened, it is appearing in many countries and increasingly in Britain, which has arguably come a little late to the realisation of the fourth industrial revolution but is now embracing it on many fronts.

BUT IS ALL THIS RELEVANT TO A NORMAL UK FACTORY?

The main drivers for this revolution, or evolution, are real: productivity, product customisation, supply chain responsiveness, quality control. Siemens UK's central technology officer Alan Norbury says companies, including his own, are faced with a productivity puzzle and customisation conundrum.

"Our drives factory in Congleton is given productivity improvement targets year-on-year of 5%. Each year we surpass them, using innovation. But increasingly customers want variation in their drives, so now the challenge is to hit high productivity and offer increasing customisation – that's hard."

Congleton is a step change factory – it used to take 90 hours to produce one drive from the order, today it takes 60 minutes. The big challenge is to deliver this every year, customise more orders, and grow the business simultaneously. Mass customisation is being driven by consumer power and technology. We have the technology to customize a pizza order – and even track its delivery in real-time on an app – or personalised doll, our mobile phone case – so we demand it. Manufacturing has to catch up with social technology.

Other large companies, equally challenged by productivity and customer requirement variation, are embracing aspects of the digital factory. Jaguar Land Rover and Rolls-Royce use a 3D computer-aided design (CAD) "cave" at the Manufacturing Technology Centre in Ansty near Coventry, with a similar facility at the Advanced Manufacturing Research Centre in Rotherham.

Both centres form part of the High Value Manufacturing Catapult, the public-private funded organisation tasked with delivering step change gains in manufacturing productivity, to keep production here in Britain. The cave system allows engineers to simulate how components fit inside an assembly and how that assembly would come together in manufacture i.e. virtual reality 3D CAD.

This is all before any parts are made or assembly processes are trialled, saving valuable factory time. It also permits simulated factory configurations to perfect those complex assemblies, so that engineering design and manufacturing process are considered simultaneously – often the latter has had to expensively adapt to the former.

Airbus is developing a Future Factory in Broughton, Wales using Industry 4.0-type technologies to combine human and robot actions to streamline assembly operations, luxury car brands need to use digital automation to customise every single car – the so-called "batch of one".

But is this level of intelligence across industry really necessary, in the process sector and for small businesses? Certainly in food, says Simon Keogh, Business Manager, Factory Automation at Siemens. "There is a greater need for retailers to refresh packaging and offers to suit different trends, constantly, and they are getting into more agile manufacturing," he says. "This is one of the benefits of digitisation, where a smarter manufacturing process gives you that agility to adapt to customers' whims and market changes."

Productivity: as a result of networked production processes, productivity can be increased by up to 30%. Associates receive key data about production on a tablet in real time in order to manage the manufacturing process

A REVOLUTION WITH STANDARDS

The automation world is ruled by standards, the communication protocols that convey instructions between machines. Industry 4.0 is demanding that machines talk to products, and both talk to mobile devices like tablets. How can industry get the various standards to agree on common or single ones?

Siemens' Simon Keogh: "Most of the technologies are there now, but in some instances there are standards and frameworks that need more work. The interconnections from machine-to-machine, if these do not self-organise we will need a higher level of communication between one cell and the next cell in the production line. At the moment we have good standards between ethernet-enabled machines – such as Profinet and Profibus – but this will need to be improved for I4.0 to roll out further."

Image © The Manufacturing Technology Centre

Image © Robert Bosch GmbH

Flexible factories and production: in the factory of the future, parts will tell machines how they "want" to be processed, like they do on this multi-product line in Hamburg, Germany. This will make it efficient to produce small batches and customised products

Training: The Lloyds Bank Advanced Manufacturing Training Centre at the MTC: (left) 41 engineering and two business administration apprentices started training in 2015. Engineer trainees will learn about infomatics, key skills for digital factories

GOVERNMENT SWITCHES ON TO DIGITAL

While the term "Industry 4.0 – the fourth industrial revolution" is really just a marketing catchword, the meaning and the underpinning technologies for I4.0 are serious. Companies that fail to respond to cyber physical manufacturing systems risk losing orders to far more efficient competitors.

"One recent change is that the UK government is starting to understand what I4.0 is, that this is something they need to know for manufacturing in the UK," says Dr Lina Huertas, technology manager in manufacturing infomatics at the MTC. In the summer, the Department for Business, Innovation and Skills (BIS) commissioned a study of I4.0 in the UK to create an appropriate framework for its priorities.

"Two UK reps participated in a recent Brussels roundtable on 'Digitising Manufacture', from industry and from BIS," says Huertas. "This debated what the priorities are for different nations and to coordinate a Europe-based strategy for I4.0." Today there are a plethora of projects funded by the European Commission that research and educate industry about I4.0.

I4.0 is part of a rapidly accelerating phenomenon of the automation of society. In September the BBC ran a week-long series of programmes on how intelligent machines world will affect society, including a Panorama programme called "Will a robot take my job?". The occupations up for replacement in the automated future were journalists, legal assistants and factory operatives. The MTC's Huertas says that jobs are one of the biggest issues linked to I4.0.

DATA AND THE LAW

Cyber security has shot to the top of the agenda for many big organisations – consider recent headlines about big data breaches at adultery website Ashley Maddison, for example.

As the Internet of Things and I4.0 proliferate, the two biggest legal factors, and barriers to their development, are security and liability. "In a manufacturing plant where all internal components have their own IP address for connected communications, that creates a series of potential entry points for unauthorised intrusion," says Kit Burden, technology partner at DLA Piper. "The greater then the possibility of someone visiting – or hacking – the machines, less through prurient interest but because they want to sabotage that plant, because they have a vested interest in doing or for other motives."

The single biggest hurdle for the digital factory, rather then education of industry or technology and investment, is liability. "When you enter the world of the Internet of Things there is a potential circumstance, with a multitude of information from different sources coming together, all integrated by computers rather than human beings," says Burden. "If the end result of that is an accident or mistake, it becomes much more dificult to work out who was to blame."

Burden maintains this is the main reason why there are not more driverless cars on the highways. Google Cars has clocked up millions of miles on roads with negligible incidents – on paper it should be omnipresent, but it is not. "A three-way collision involving three driverless cars, or two and a human-driven car, would be very difficult to decipher from a liability point of view." The same problem will likely restrict the pace of development of I4.0. But the combination of big economic drivers – productivity, customisation, quality control and cost reduction – means the digital factory is inevitable. UKMR-15

Big and clever: a system-wide approach to data analytics

BY PROFESSOR DUNCAN MCFARLANE AND DR AJITH PARLIKAD, BOTH UNIVERSITY OF CAMBRIDGE

Predictive maintenance gets linked-in: researchers are working on a "social network" between machines, to make a common platform allowing machines to update their status for example, to self diagnose they may fail in the next three weeks.

Boeing produces its 777 on a moving line in Everett, Wash. © Boeing

The Distributed Information and Automation Laboratory (DIAL) at the Institute for Manufacturing is working with companies such as Boeing, Exxon, Electrolux and Laing O'Rourke to develop smart ways of using data to improve performance and increase resilience. In the past, industrial analytics have tended to focus on individual machines in individual factories.

We now understand that a factory – or more often a multi-sited production network – is more than the sum of its parts and that if we are to make significant improvements to performance we need to embrace the whole system, within and across factories and their associated supply chains.

Machines tend to have individual maintenance plans designed to keep them performing optimally. But this is not necessarily a good thing for the production system as a whole and may actually result in poorer performance. At DIAL we are developing a 'social network' for machines which can deliver an optimum maintenance plan for the production system as a whole.

The "social network" provides a common platform that allows machines to "update their status". For example, a machine may self-diagnose that it will fail in three weeks' time. The system may know that maintenance for that machine is scheduled for the next week, in which case no action need be taken. But it may be that a new component is needed which is not available for five weeks.

If that is the case the life of the failing machine could be extended by a further two weeks if the machine which feeds parts into it slows itself down. By creating a social-network based, data-sharing platform which enables machines to cooperate – to behave altruistically towards one another – we can build a much smarter system which will be more resilient, more productive and better able to manage its energy consumption by intelligently adjusting machine performance as required.

Professor Duncan McFarlane

Dr Ajith Parlikad

Building resilience is critical in the face of both minor, short-term disruptions (which cumulatively have a significant impact on performance) and major global events such as climate change. Two of our current projects focus on increasing resilience through smart systems. The first is looking at more intelligent production control systems which will tolerate higher levels of product variability and can dynamically alter the balance between lean and resilient operations to cope with disruptions. The second focuses on the supply chain, using data analytics to predict when suppliers will fail to deliver on time so that the manufacturer can take pre-emptive steps to avoid potential disruption.

Creating more more resilient and more energy-efficient operations is going to become increasingly important for manufacturers in the coming years. By developing intelligent, data-enabled systems we aim to help them find smart solutions to the challenges they face. UKMR-15

KEY PROJECTS

- Smart ways of integrating data across an organisation to extract maximum business intelligence.
- An adaptive, self-learning fault data management approach and fault-diagnosis tool for train systems.
- Through-life decision-making and information management for infrastructure assets, such as buildings and rail and sewage networks.
- New IT architectures which integrate warehousing and transport information systems to meet the demands of more complex supply chains.
- Improving the resilience of manufacturing automation in the face of operational disruptions.

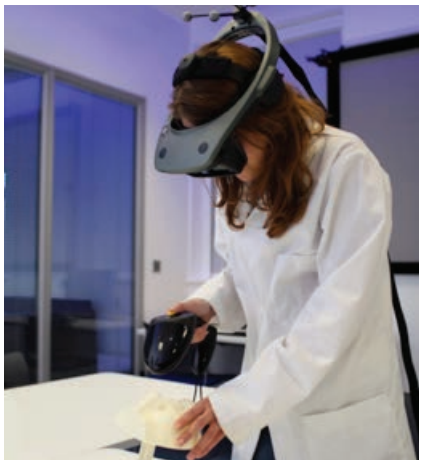
VIRTUAL SOLUTIONS

Augmented Reality (AR) and Virtual Reality (VR) technologies have a wide range of applications across industry sectors offering great potential to both reduce cost and improve operational benefits. Using AR during training, the Canadian Air force achieved improvements of more than 22% on accuracy and task completion. Cranfield University's Operations Excellence (OpEx) Institute is exploring the novel application of these technologies using its state-of-the-art AR and VR facilities

MAINTENANCE REDEFINED

The Institute is conducting research exploring how complex manufacturing and maintenance tasks can be de-skilled using AR. De-skilling reduces cost and alleviates the demand on specialised and in some cases rare workforce.

One novel application of the technology demonstrates how a mobile device such as a tablet can be used to turn a user manual in to a virtual step-by-step work flow. The tablet based demonstrator traffic light colour codes the image to shows different levels of risks experienced, reducing the operator skill level required hence reducing costs and speeding up the activity. Another demonstrator has been developed to identify which spare parts require replacing due to obsolescence. This uses the internet to connect to an obsolescence database to present up to date live data about the number of parts in storage, duration of the contract and the number of parts in the market. In this process the tablet based solution applies image recognition to identify the component of interest and links this to the database.



The OpEx institute is investigating the use of AR and VR technologies to aid the success of surgical procedures

TRAINING SOLUTIONS

Looking forward, the Institute will explore the use of AR and VR technologies in developing training for complex manufacturing and maintenance tasks. In delivering maintenance training for a new employee, trainers may want to promote hands-on practice and measure the level of capability development as an outcome of the training. The proposed audit trail makes it possible to record the actions a trainee undertakes and score the capability of the individual by comparing their actions against those predicted. The AR application can detect a mismatch in expected vs actual actions and offer insight into the correct way a maintenance action could be completed. This can improve the effective delivery of maintenance training and develop a database of individuals with different levels of skills.

"AR/VR technologies offers applications in multiple industry sectors. Moving forward the growth of affordable technological developments will further promote their adoption, the OpEx Institute aims to support organisations with fulfilling the opportunities arising from visualisation technologies." Matthew Caffrey - OpEx Institute Manager, Cranfield University.

SURGICAL OPERATIONS

Another exciting application of AR technologies lies in their use to improve the success of surgical procedures. A key project within the Institute involves designing and developing a AR solution which provides surgeons with a real-time 3D display of hard and soft tissues. This visualisation will help surgeons with accurate cancer removal in complex anatomical areas intra-operatively. The developed system helps surgeons to understand: complex anatomical relationships; the boundaries of diseased areas i.e. cancerous tissue; the implications of resection and surgical planning for reconstruction. The surgeon can overlay MRI/CT scan results on to the patient and have a better understanding of the boundaries of a tumour that needs to be removed. It is hoped the development of such technology will lead to shorter operating times and therefore a reduction in both the time a patient is under anaesthetic and the risks this involves. UKMR-15

SECTORS - PEOPLE: SKILLS AND RECRUITMENT

SOLVING THE SKILLS SHORTAGE

The government's commitment to apprenticeships is to be applauded, but the issue of where an expanded generation of engineers is to come from bedevils manufacturing

BY JOHN PULLIN

In 2015 industry's long-standing skills and recruitment issues finally made it to the top of the UK national political agenda.

But 2016, and beyond, will be when practical answers start to emerge that might tackle skills problems at regional, local and individual site levels – where they are most acute.

The big news of 2015 in industry skills and training has been the commitment, first in the election campaign by the prime minister, then in the chancellor's budget, to three million apprentice places by 2020.

Apprenticeships win almost universal support and approval. Politically, they help tackle awkward and intractable problems of youth unemployment and educational underperformance.

But they are also shown to work for the individual: a study by the Sutton Trust in October 2015 indicated that top-performing apprentices could expect to earn more across a lifetime than all but the best graduates from the best universities.

Whether they prove a panacea for the UK's skills gap will play out across 2016 and beyond. And they raise further questions whose resolution is certain to provide dominant themes for the coming year.

However, the big news on apprenticeships has not been the only news of 2015 – and other signs and statistics in education and skills have been promising. Paul Jackson, chief executive of Engineering UK, the profession's umbrella body, says there are encouraging indications of greater public awareness of the importance of engineering and the attractiveness of its careers, and progress in areas such as linking businesses with schools through the Tomorrow's Engineers programme. "Largely, things are changing for the better," he says.

APPS UP

An example is the number of applications by UK students for engineering courses at universities, up 9% in 2015 over 2014. The increase continued the trend since the introduction, in England, of £9,000 university tuition fees in 2012, when applications for all higher education courses suffered.

Over the three years since, only computer science has outperformed engineering in percentage growth in applications – many academically-respectable subjects, such as law, languages and history, have not recovered to pre-2012 numbers.

Jackson believes the relative success of engineering may not be coincidence. There's anecdotal evidence, he says, of students pragmatically opting for courses that enable them to pay off their inevitable

debts more reliably. This is because the industries that traditionally employ graduate engineers are precisely those that have been warning of skills shortages and unfillable jobs for years.

The increase in university applications is good news, but it's not nearly enough to solve the chronic skills shortage problem, and graduates are only part of industry's skill needs.

The survey of education and skills by the Confederation of British Industry with Pearson in 2015 highlights that relevant skills are in technician, craft and computer-based jobs too – traditional "skilled", "trade" and "clerical" occupations. The CBI covers all UK business, and skills issues are now much wider than just manufacturing: industries such as retail have concerns too.

The CBI carries a stark warning: "Without prompt action, there is a real risk that skills shortages will act as a brake on productivity and economic growth," it says. Some in engineering say this is more than just risk: it is already reality. And though there is now a national focus to the debate, the sharpest effects are felt at local level.

Alan Pickering, chief executive of Unison, a 70-person-strong manufacturer

The Shrewsbury apprentice training school was opened by In-Comm alongside SME manufacturers

In-Comm

CHANGING COMPOSITION OF EMPLOYMENT IN THE ENGINEERING SECTOR, BY OCCUPATION (2012-2022)

Major group	Selected sub-group (jobs likely to require engineering skills)	Expansion by 2022 (in thousands)	Replacement demand by 2022 (in thousands)	Total requirement by 2022 (in thousands
1. Managers and senior officials		138.9	299	437.9
	11 Corporate managers and directors	130	240.9	370.9
	12 Other managers and proprietors	8.9	58.1	67
2. Professional occupations		248	458.6	706.6
	21 Science, research, engineering and technology professionals	169.7	270.5	440.2
3. Associate professional and technical occupations		102.6	311.5	414.1
	31 Science, engineering and technology associate professionals	22.9	72.7	95.6
	35 Business and public service associate professionals	67	167	234
4. Administrative, clerical and secretarial occupations		-38.9	245.1	206.2
5. Skilled trades occupations		-91.5	535.3	443.9
	52 Skilled metal, electrical and electronic trades	-74.3	253.7	179.5
	53 Skilled construction and building trades	40	217.4	257.4
	54 Textiles, printing and other skilled trades	-59.4	37.4	-22
6. Personal service occupations		23.9	30.5	54.4
7. Sales and customer service occupations		21.3	82.7	104
8. Transport and machine operatives		-130	218.5	88.5
	81 Process, plant and machine operatives	-142.9	140.8	-2.1
	82 Transport and mobile machine drivers and operatives	12.9	77.7	90.6
9. Elementary occupation		-17.2	122.7	105.5
	91 Elementary trades and related occupations	-11.4	57.5	46.1
	92 Elementary administration and service occupations	-5.8	65.2	59.4
Total major group		257.1	2,303.90	2,561.00
Total selected sub-group		158	1,659	1,817

Source: Working Futures 2012-2022 engineering extension

of automated tube-bending machinery based at Scarborough in North Yorkshire, says his native town, 40 miles from the nearest university, is in danger of a kind of educational attrition where the brightest students leave and the brightest teachers simply don't arrive. "There's a huge disconnect between the needs of the town's employers and the attainment levels that the local schools are encouraged to provide," he says.

Scarborough suffers, he believes, from a blight that afflicts other coastal towns: it at least has the loyalty of a strong manufacturing base kept there by capital investments in plant and machinery made over many years, but it isn't in the centre of things.

"One of our local businesses that was doing very well shut up shop and moved to York because he couldn't get the skills here," he says. "If you look at things with only a financial head on, you'd struggle to see the logic in being sited here."

But rather than sit back and watch the town become a backwater, Pickering has become a leading figure in a local business group, the Scarborough Business Ambassadors, that brings most of the main employers together. The group conducted a skills audit across the town; it reported back that about a third of the "technical" staff, in jobs such as fabrication, machining, technical support and electrical and mechanical design, were due to retire within 10 years.

FINITE RESOURCES

Scarborough provides hard evidence of a phenomenon long-reported anecdotally: that the workforce in manufacturing is in many companies and locations demographically skewed, with product and process knowledge and problem-solving capabilities concentrated in a few wise heads nearing the ends of their careers.

These demographic difficulties are cited by some as the true skills crisis in UK manufacturing. Work done for Engineering UK in 2014 found 48% of companies in manufacturing reporting that skills issues had forced them to delay innovation. A 2012 study by the Commission for Employment and Skills suggested that UK engineering, in its broadest definition, would require 2.56 million recruits between 2012 and 2022, with 2.3 million of these "replacements".

"We trained people up to the 1970s and 1980s, and now we need to replace those people," says Jackson of Engineering UK.

The age problem in engineering is, for some commentators, part of a broader UK industrial crisis whose other symptoms include lack of investment in capital equipment such as automation, laggardly productivity, and an over-concentration on financial metrics such as share price, dividends and ownership at the expense of factors that promote growth.

Bob Bischof is a German industrialist, long resident in the UK, who heads the German-British Council and has been co-opted to government committees dealing with skills and technician training. He has written tellingly that the much-vaunted "labour flexibility" talked up by politicians and some business leaders as a prime factor in UK competitiveness may amount to no more than the ability to hire and fire easily, rather than the true flexibility geared to the kind of productivity growth that real investment in people can produce.

Initiatives that introduce children to engineering are gaining in popularity

© Sarahphotogirl

There is certainly a perverse kind of biblical attractiveness in portraying UK industry as reaping the consequences of past lack of foresight on skills and training, and some engineering subsectors, such as automotive and aerospace, have recognised that moves such as outsourcing or the abandonment of vertical integration for a supply-chain business model have implications for skills and innovation, and have taken action.

What applies within subsectors also applies within localities, and many positive moves of 2015 tackle skills problems at local level. At Scarborough, Alan Pickering and colleagues are attempting to rebuild the kind of corporate social responsibility that has loyalty to a place through initiatives such as Scarborough Engineering Week,

APPRENTICESHIPS: QUALITY NEEDED

The push to create apprenticeships fast has devalued their brand, with low level skills such as coffee-making being accredited, Ofsted has said.

Ofsted chief Sir Michael Wilshaw says some learners are not even aware they are on apprenticeship schemes.

Apprenticeships, which ministers in England say are key to tackling unemployment, are sometimes covering workers' pre-existing skills, he says.

The government says it is improving the quality of schemes through reforms.

Skills minister Nick Boles said in autumn 2015: "Putting an end to poor quality apprenticeship training lies at the heart of our reforms of apprenticeships. Ofsted's report backs up the findings of our 2012 review and provides further evidence for our decision to put employers rather than training providers in the driving seat."

Changes include legislation that will provide protection for the term "apprenticeship" to prevent misuse by providers in England, the government says.

Apprenticeships will also be included in performance tables from 2018.

where 3,000 school children are introduced to engineering by up to 40 local companies, and sponsorship of a University Technical College (UTC) for 14- to 18-year-olds from next year.

Local and sectoral initiatives make a difference but, says Stuart Turner, Stuart Turner, senior policy advisor at Semta, the employer-led group charged with developing skills provision in engineering, withdrawal of funding for skills audits to identify gaps nationally, regionally and locally has not helped: "There has been a lack of strategic insight and horizon scanning, and responses from government and industry have been more piecemeal," he says.

Others say that the Local Enterprise Partnerships, formed to deliver skills and training plans when regional agencies were dismantled, have performed patchily: some very good, some almost dormant.

SUMMARY TABLE – CHANGING COMPOSITION OF EMPLOYMENT, BY OCCUPATION IN THE ENGINEERING SECTOR (2012-2022) – UK

	Expansion by 2022 (in thousands)	Replacement demand by 2022 (in thousands)	Total requirement by 2022 (in thousands
Selected jobs likely to require engineering skills	158	1,659	1,817
Jobs likely to require engineering qualifications at level 4+ (sub codes: 11, 12, 21, and parts of 31 and 35)	360.2	706.4	1,066.5
Jobs likely to require engineering qualifications at level 3 (sub codes: 52, 53, 54 and parts of 31 and 35)	-55.3	611.3	556.1

Source: Working Futures 2012-2022 engineering extension

FIVE MILLION STRONG?

The focus on skills keeps shifting between local and national. Now there's the big national initiative on apprenticeships: three million by 2020, to build on the commitment from the last Parliament of 2.2 million, which seems to have been delivered. The national questions that will dominate the skills agenda over the next year are to do with delivery of this promise, because if the target is to be met, there's no time to be hanging about.

The most fundamental question is to determine what is meant by apprenticeships. Engineering and manufacturing have established routes tied into different levels of vocational qualification for specific jobs or tasks. Commentators such as Bischof argue that the current system needs simplifying – too many levels and classifications – and broadening, as skills in communications and business awareness are needed across all sectors.

Bischof says that higher level apprenticeships currently offered in engineering are too narrow and lack broader "educational" content. "If governments want to promote a strong brand 'apprenticeship' and sell this to employers and employees alike then it is essential that it has the same standards and meaning," he adds. "It is also important to ensure a coherent approach in line with other European countries."

The "what" question is causing concern for others, too. Verity O'Keefe, senior employment and skills policy adviser at the EEF, the manufacturers' organisation, says EEF members are comfortable with the apprenticeship concept – no surprise as 70% of EEF members, and 92% of large firms, offer apprenticeships already.

But, she says, there are concerns that schemes in other industries might be less rigorous and could dilute the brand, and that to make the numbers training provision of other types might be rebranded as "apprenticeships".

Central to this is a political question: if apprenticeships are seen as a tool to boost economic growth, then shouldn't those that directly add value, such as those in manufacturing, be prioritised over those in, say, retail, whose contribution is less clear? And if the aim is upgrading overall UK skills, why restrict apprentice-style learning to the young, when older people could benefit?

A second core question to be addressed through 2016 is how to deliver the target. Much current provision combines in-company and college learning, but further education colleges have been heavily cut in spending reviews: estimates range from 15 to 40%, and some are in dire straits.

Engineering and manufacturing have particular concerns here. In the same way that engineering professors warn that tuition fees do not cover undergraduate engineer courses, facilities in FE colleges for teaching manufacturing are expensive. Sitting students in front of a computer screen is cheap; if apprenticeships are about numbers, then cash-strapped FE colleges may opt for cheaper courses.

A pointer to future trends may come from Shropshire. There, training group In-Comm has opened an independent manufacturing apprentice school alongside the premises of one of its customers, many of whom are smaller-to-middling sized businesses.

Managing director Gareth Jones says In-Comm has long experience providing manufacturing training in its home territory of the West Midlands, where it works closely with the Black Country Local Enterprise Partnership.

The facility at Shrewsbury has grant support for the people it trains but no direct backing yet from the LEP. It is, Jones says, an investment that had to be considered carefully because of the costs, but the school has opened with 60 apprentices already signed up "so we can see the demand is there".

A different but related aspect worries the EEF and its members. The current proposal is that the apprenticeships should be funded by a levy on large companies – it's been done before and is used successfully in other European countries. The levy can be offset against training by big firms, but so far, says O'Keefe, the sums do not add up. To claim an offset, companies would train far more apprentices than they need or than they could afford to offer follow-on jobs to.

POLITICAL CONCERN

A related EEF concern is more political: if the three million target is to be met, then most 16-year-olds not heading for university will come into the system, and current levels of academic achievement within schools mean topping-up of core curriculum subjects will be needed.

But if employers are paying, should they also pay for this basic education that has always, until now, been state-funded? Stuart Turner at Semta is not alone in pointing out that other deficiencies of the wider education system, such as the shortfall of between 3,500 and 4,000 physics teachers, are important components of current skill shortages.

Apprenticeships may have emerged in 2015 as the government's main answer to most skills questions; but for 2016, there is a whole new set of questions to resolve. **UKMR-15**

First UK training scheme to combine apprenticeship with degree

Airbus has launched a programme that combines hands-on apprenticeship learning with a full engineering degree to answer a real-world problem facing all manufacturing companies.

At a ceremony in November 2015, 50 Airbus apprentices graduated from Glyndŵr University in north Wales after either completing a Foundation Degree in Aeronautical Engineering or attaining a Bachelor of Engineering. It was the inaugural graduation class for an innovative new training scheme, and the first of its kind in the UK, which combines a degree component with a traditional apprenticeship.

Airbus UK has trained more than 4,000 apprentices over the past decade, with 500 currently serving their apprenticeships.

In order to maintain its world-leading competitive edge, Airbus is committed to nurturing the next generation of highly skilled engineers, in partnership with government, schools and universities. As Airbus Group CEO Tom Enders commented recently, "we must do more to inspire, support and train tomorrow's engineers – girls and boys alike."

Every year, as part of this commitment, Airbus sponsors and organises a TeenTech event in north Wales and Bristol, close to its Broughton and Filton sites. We galvanise support from other technology firms nearby to give local students a broad range of hands-on tech experiences, with Airbus volunteers running aviation-themed activities and acting as group ambassadors at the event.

Some of those students may go on to join Airbus's apprenticeship programme, which is one of the most ambitious and wide-ranging nationwide. Airbus UK has trained more than 4,000 apprentices over the past decade, with 500 currently serving their apprenticeships. We are proud members of the 5% Club, a joint government and industry initiative which commits companies to ensuring that apprentices make up at least five per cent of their workforce.

But our engagement with training and education does not end there. Much of Airbus's significant investment in research and technology - amounting to about £500 million per year - takes place on university campuses around the country. At Cranfield University, we are one of the leading members of the Aerospace Technology Institute, a government and industry hub for aerospace research. Meanwhile, our civil aerospace division has invested in shared laboratories with the universities of Bath, Cardiff, Surrey and Edinburgh.

BIG IN UK RESEARCH

At the Morgan-Botti Lightning Laboratory in Cardiff, researchers are investigating lightning strikes on aircraft and their effect on composite materials, which are used increasingly in modern airplanes. Meanwhile, Airbus is supporting a £6 million Engineering and Physical Sciences Research Council (EPSRC) programme grant, in collaboration with Queen Mary, Imperial and City universities in London, to develop novel laminar flow control concepts for reducing drag on future aircraft.

In 2015, the University of Bristol, on the doorstep of our Filton site, signed a partnership agreement with Airbus at the Paris air show which formalised commitments from both to build on existing programmes for training, education and diversity. Airbus is presently involved in research or related activities with more than 25 University of Bristol academics across four departments. Airbus representatives also sit on the steering committees for a selection of research and technology programmes at the university which are funded by the EPSRC.

What is the dividend for Airbus from all our investment in UK training, education and research programmes? The answer can be found in our inventive, creative 14,000-strong UK workforce. Since 2000, Airbus Group companies have filed more than 11,000 patents, a substantial number originating in the UK.

Our UK research teams have been responsible for breakthroughs that have captured the world's imagination, such as Additive Layer Manufacturing (ALM), a 3D printing process that creates solid objects by fusing powder materials. The technique uses up to 90% less raw material to create lighter and stronger structures, making our products significantly more sustainable. Potentially, ALM could save billions of dollars in fuel costs through weight reduction over the next 20-years (see section beginning on page 139).

It is another example of how Airbus in the UK, as elsewhere in the world, is a business that runs on brainpower. UKMR-15

Tom Enders, CEO, Airbus Group

"We must do more to inspire, support and train tomorrow's engineers – girls and boys alike."

Unless your content is pertinent, you are wasting your time!

As B2B marketing content rises, businesses are better off doing the basics right than creating more, and more complex, marketing content.

BY SYLVIA LAWS, MANAGING DIRECTOR, TECHNICAL ASSOCIATES GROUP

The big challenge in our industry today is engaging potential customers with our products or services before the direct sales approach is needed

The most successful way to engage prospects and turn them into customers is by creating intelligent content that's of interest to them and that they care about.

Pertinent, well-implemented content, although sometimes challenging and demanding to create, lends credibility to a brand identity and makes a company stand out from the crowd. Content that is just "good enough" won't extend beyond the written word. By this I mean that truly exceptional content will engage influencers ensuring a wider distribution of the message, as these people will spread the message with an effective endorsement, one which cannot be bought, however big the marketing budget. For businesses to grow and stand out in a competitive environment, content marketing must be a key strategic driver in the overall marketing plan.

The in-person networking event is currently the most effective B2B marketing activity. Source: Uberflip

Source: Uberflip - B2B Content Marketing Trends for 2015 Infographic

"If content is king, then context is god - the way you publish and distribute your content"

According to Mashable, 61% of customers prefer companies with custom online content. For companies in the manufacturing space, limited time and budget restrictions, as well as the need for complex technical information, mean that they have to maximise usage of the content they create. It must be reworked and repurposed to be relevant and timely and most importantly, it has to fulfil the customers' needs as they progress along their individual buying journeys. A good marketing strategy focuses on the end-to-end customer journey and offers the best customer experience throughout that journey, bearing in mind there may be multiple individuals involved in different stages of the buying decision. Companies must make themselves relevant at each stage of this process – too pushy too early will lose a sale but equally we must provide superior, intelligent content which in turn makes the customer a smarter buyer.

B2B content marketing remains on the increase and now an astonishing 70% of content marketers claim that they are creating more content than they did a year ago. However, many businesses are getting caught in the hype of what they think their content plan should look like. It would be better if - instead of trying to create complex content strategies, businesses took a step back and made sure to do some of the smaller, basic things well.

Something else to bear in mind is that if content is king, then context is god. When it comes to content, context is the way you're publishing, distributing and promoting your content to your targeted audience. If you're trying to connect in the wrong context, it doesn't matter how great your content is, it's simply not going to be read, shared or discussed.

Adding to the complexity are the Ad blockers. Although some form of ad blocking has been around for years, Apple has just announced its iOS 9 operating system will now support ad blocking technology creating even more likelihood of uptake specifically for the hand held device user. Given the nature of engineers in being resistant to direct sales messages the ad blockers are likely to be more impactful in the engineering and manufacturing world than anywhere else. Intelligent paid for content will be the only way around this making the need for expert, empowering content all the more pressing. Businesses, now more than ever, need to be smart and employ professionals who understand their markets, their technology and their customer's pain points to create pertinent content in order to make an impact and stand out from the crowd. UKMR-15

IN FOR THE LONG HAUL –
No quick fix for engineering skills gap

BY SIR DAVID MCMURTRY FRENG CBE

Supporting the Greenpower Goblins electric car competition for primary schools

Renishaw STEM Ambassador and Women's Engineering Society Prize winner Lucy Ackland at Technology for Fun event building periscopes

A Renishaw "Technology Teardown" workshop

Renishaw Engineering Experience winners with a Crossrail tunnel boring machine

With 17% of STEM teachers believing that a career in engineering is undesirable for their students and only 36% of STEM teachers feeling confident enough to give engineering careers advice, the transformation of dated engineering stereotypes has a long way to go. But employers are doing many good things to affect this.

At the start of 2015 I wrote an open letter to relay my thoughts on the skills shortages that we face within UK engineering and where I believe that we need to focus our efforts, especially in relation to schools.

Fundamentally there is no quick fix and I believe that we will only progress through sustained collaborative efforts, consistency of approach and a cultural shift. As last year's Perkins Review highlighted, that collaboration goes well beyond the engineering sector alone and should include wider society including parents, teachers and the Government coming together to encourage young people from any background to regard engineering as a fulfilling and exciting career.

At Renishaw we long ago realised that we had to engage with our local schools to tell them a positive story about our sector and to identify students who had the potential to contribute to our business success. With a rural location and the absence of a strong brand name outside of our niche sector, it has always been a necessity rather than a nice CSR initiative.

With the exceptional growth we have experienced since the 2009 recession

'Girl Power' event for girls and their parents hosted by Renishaw

"In 2014 Lucy Ackland won the Women's Engineering Society Prize for her work to encourage an interest in STEM subjects. Her story underlines the challenges, as she faced some negativity when expressing her desire to leave school at 16 to become an engineering apprentice at Renishaw"

Sir David McMurtry CBE

and an ever growing range of new products, including healthcare, our efforts have re-doubled and four years ago we created a dedicated education liaison role to drive forward our schools agenda.

What we have learnt over that period is that focusing on secondary schools alone will not be enough to ensure a sufficient level of students will study, and importantly, enjoy the subjects necessary for a career in engineering.

A large body of evidence published by King's College London, and referenced by Engineering UK, shows that interest in science is formed by age 14, and that those students who had an expectation of science-related careers at age 14 were 3.4 times more likely to earn a physical science and engineering degree than students without this expectation.

Our education team is therefore focusing more efforts on the latter years of primary school, where evidence also suggests that an interest in science is formed and my own feeling is that a genuine passion for science and engineering is cultivated in our early years. Children should be encouraged and motivated to see how science can help them understand and change the world and the message should be reinforced constantly during their school years.

End the apprenticeship snobbery

It is also clear that while things are improving, there is still a need for a cultural shift to help shatter outmoded stereotypes, both about engineering and its training schemes, as there is still much snobbery around apprenticeships, despite their proven ability to provide an alternative route to academic qualifications, including an honours degree.

With 17% of STEM teachers believing that a career in engineering is undesirable for their students and only 36% of STEM teachers feeling confident enough to give engineering careers advice, we have significant challenges ahead (figures from Engineering UK report 2015).

We have to make it clear that engineering is not only for men and that we welcome people from both genders, all ethnic backgrounds and any walk of life. This year we have been working on practical measures as part of the Royal Academy of Engineering's diversity leadership group to create an Engineering Engagement Programme which specifically targets women and ethnic minorities.

To change attitudes we also need role models. Last December Lucy Ackland won the Women's Engineering Society Prize for her work to encourage an interest in STEM subjects. Her story underlines some of the challenges we face, as she faced some negativity when she expressed her desire to leave school at 16 to become an engineering apprentice at Renishaw. However, her story is also an inspiration to many as she went on to achieve a first class honours engineering degree in 2012 and has since led a project team developing our next generation of metal 3D printing machines.

There is no hasty remedy for the UK's shortage of engineers and engaging with schools is demanding and frustrating, but ultimately highly rewarding as the sharp increase in applications for our entry level schemes bear witness.

The solution to our sector's skills issue is a continuous, combined effort to make the profession more appealing to young people, their parents and teachers.

This will not take one year, five or 10 – it has to be a perennial commitment that we make to remind society that engineering is one of the most imaginative and creative professions in the world. **UKMR-15**

KEY RENISHAW EDUCATION INITIATIVES:

- Greenpower electric car racing – the company supports this competition which builds practical engineering skills and a team work ethic in both primary and secondary school pupils, whilst encouraging innovation within a competitive race environment
- The Renishaw Engineering Experience – a competition run with Young Engineers which gives six winners a week of visits and activities at leading engineering-based organisations
- Girl Power – the company hosted and co-organised an award-winning Saturday event for young girls and their parents to participate in talks and activities about engineering
- 'Technology Teardowns' – workshop sessions led by Renishaw engineers for primary and secondary schools where pupils have the opportunity to dismantle everyday electronic products and learn how they are made
- Skills Gap programme – a pilot project with the Design and Technologies Association to help upskill D&T teachers; resources are now available nationally
- STEM Ambassadors – all new graduates and 2nd year apprentices have the opportunity to be trained, with over 100 ambassadors now assisting with schools engagement programmes
- Education Days – Renishaw annually hosts around 600 students and pupils from across South Wales at its facility to the west of Cardiff, where tours and activities are available

BARCLAYS

Five routes to exporting

Barclays reveals five top strategies for businesses with aspirations to succeed in global markets.

For a business that is ready to grow, exporting offers a chance to find new markets and new customers on a much larger scale. It allows you to take advantage of benefits you can't find at home, such as lower costs of production and economies of scale. The expertise and finance required to make that first move into overseas markets can seem daunting. As the industry saying goes, "An export isn't an export until you've been paid". But there is plenty of support available to help you put the right foundations in place.

1. Get ready, go

Timing and preparation is crucial. It is important that you assess whether your business has the resources and capacity to take on the increased workload and complexity that invariably comes with trading overseas. Whilst there are clear benefits to selling into overseas markets, such as growth and diversification of sales, as well as a potential increase in sales prices, be wary of concentrating on overseas markets at the expense of your UK operations.

Questions to ask when deciding whether your business is ready for international trade include:

- Is your management team committed to trading overseas?
- Does the leadership team have the capacity, or bandwidth, to step away from day-to-day operations and focus on an exporting strategy?
- Have there been in-depth discussions about the challenges?

2. Find the right partners

Exporting means you need to find the right trading partners in the right countries. You can make this process easier by working with a UK Government agency such as UKTI which can help access the right international contacts or partners, find the best way to do business in a market and achieve a successful market entry strategy.

Once an appropriate overseas market has been identified, how can you ensure you are dealing with respectable and reputable companies which are capable of delivering on their promises? Undertake thorough due diligence on suppliers as well as end buyers. With suppliers, check that they have the capacity to deliver the goods and services they have promised, in the quality and quantity they claim is possible. Verify that your potential business partners have appropriate financial strength, and that they are legitimate and reputable, for example through a credit record search or trade & credit information (TCI) enquiry through your bank.

3. Risk mitigation

A key part of getting ready to export is to assess and manage potential risks. Buying and selling across borders can mean navigating complex foreign exchange controls. When trading margins can frequently be as thin as 4% or 5%, such margins can be wiped out by a sudden adverse currency movement. Most risks associated with currency volatility can be managed, for example, by putting a forward exchange contract in place at the time of sale, thereby locking in the sales value and underlying profit of your export sale. Most companies are in the business of providing goods and services, not in speculating or taking a view on currency movements. Therefore, in general, Barclays will suggest businesses which plan to export should consider protecting against exposure to foreign exchange rate fluctuations.

Sending your goods overseas without receiving payment from your buyer exposes your business to the risk of non-payment. Although you may be able to negotiate payment up front from your end buyer, very often winning export orders means giving an extended period of credit. It's important that you speak with your bank early in the process of negotiating the sales contract, and that you undertake the due diligence mentioned earlier, so that the right terms can be agreed with your buyer- giving you both the comfort you are looking for. A range of solutions are available, from Letters of Credit and Documentary Collections through to Credit Insurance cover, all designed to safeguard against the risk of non-payment by an end buyer.

The UK Government has also ensured that assistance is available through UK Export Finance (UKEF). UKEF provides a range of structures to support exports. For example, if you decide you want to protect your debtor book through credit insurance but this is not available from a private underwriter, then UKEF will seek to provide cover to enable the export to proceed.

4. Concentrate on cashflow

Cashflow can be a major concern for an exporter. Exporters are usually required to manage a longer trade cycle than those businesses focused solely on the domestic market. This generates cashflow challenges as an exporter's cash conversion cycle becomes extended. This is often underlined by the need for earlier purchases of raw materials through to offering longer credit terms to end buyers. The often-seen higher working capital requirement usually means that increased financial support is needed.

An example of a working capital solution is a trade loan facility. This provides a valuable source of cashflow to bridge the gap between an exporter's purchase of supplies, conversion into the end product and receipt of sales proceeds from the end buyer.

There may be an option to provide pre-shipment finance, which can be raised upon the submission of an export LoC opened by a reputable financial institution. A further way of providing finance is to provide payment early in instances where an export LoC has a usance term, i.e. it is not payable at sight but only after a stipulated number of days after shipment. This can serve to mitigate payment risk and allows a business to receive sales proceeds earlier.

5. Logical logistics

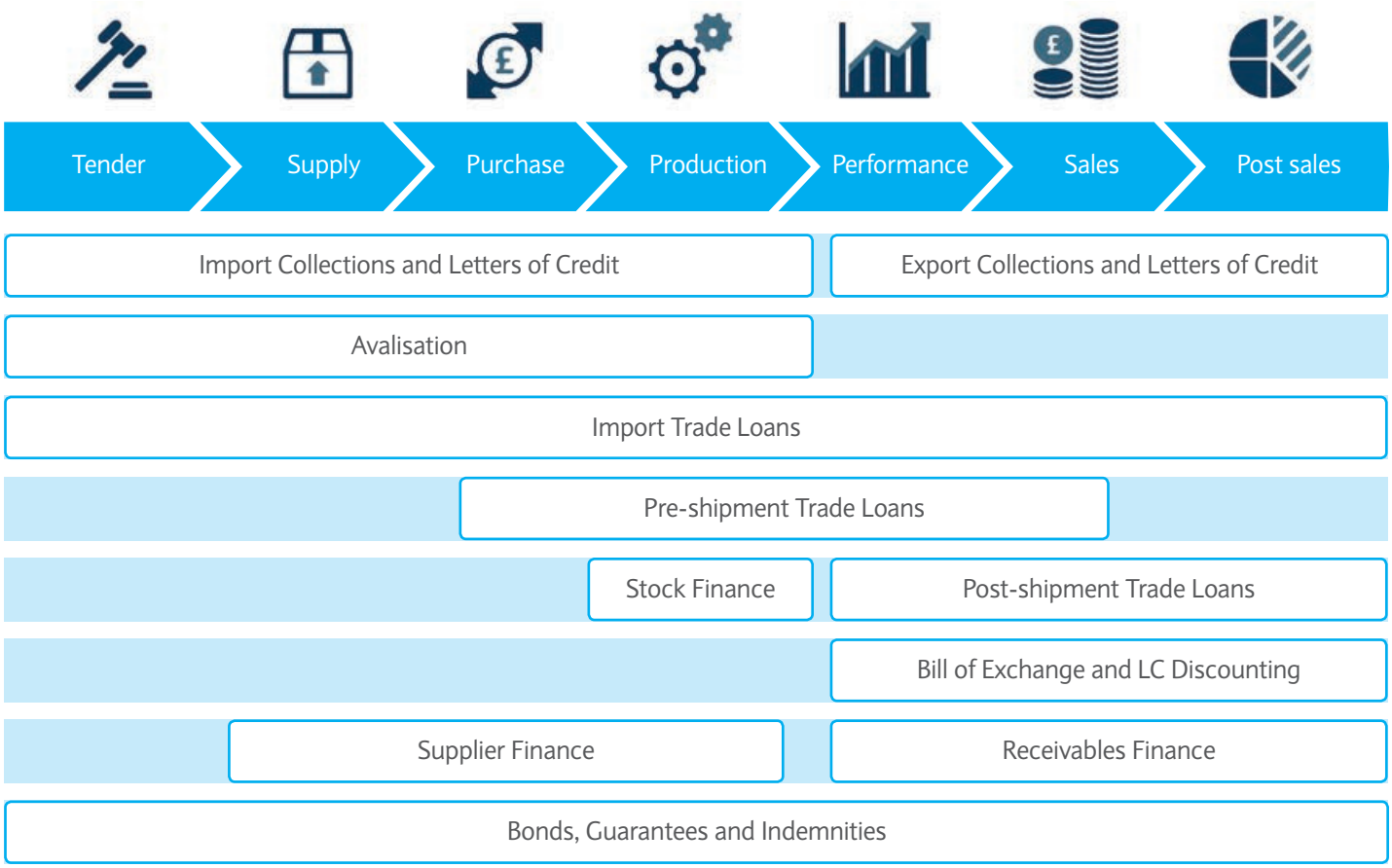
Logistics remains a key issue for both buyers and sellers; it has strong implications for risk, cost, and insurance. For example, if your buyer decides they no longer want to accept a shipment of your goods or services that have already been despatched, it may result in managing a complex logistical situation in a country you are not familiar with. Logistics should, therefore, also be part of the initial export planning process.

Transport and Logistics issues to consider:

- When exactly will the title of the goods be transferred?
- Customs and Excise requirements in the UK and destination countries
- The types of transport required and the companies to be appointed
- Details of documentation required by authorities in the UK and in those countries where an exporter is shipping goods
- How can you ensure your carriers' compliance with local port regulations?
- Whether sanctions or embargoes are in place in the countries through which your goods are moving.

Barclays is committed to providing guidance to exporters and to signpost them where and when needed so they get the right support from the right people at the right time. Through discussions with their bank and key professionals and agencies such as UKTI, UKEF and the Chambers of Commerce, a would-be exporter can move into the world of international trade with genuine confidence.

Trade Financial Solutions around your business cycle



A version of this article was previously published in 'Global Opportunity 2015'

Image © Peel Ports

Peel Ports' £300m investment in Liverpool2, a new deep-water container terminal, will strengthen the growing infrastructure of the Northern Powerhouse to create a gateway into the north of the country. L2 has a phased opening beginning in January 2016.

SECTORS - TRADE

Balancing the books

BY CHARLES ORTON-JONES

Even as the economy returns to health, there's a time bomb waiting to go off: the trade deficit. Manufacturing plays a critical role in boosting exports, while politicians are eyeing lucrative new partnerships with emerging economies outside the Eurozone

"Despite good intentions, we are heading the wrong way"

John Longworth, Director General, British Chambers of Commerce

The trade deficit is the UK's most enduring economic problem. The economy can grow, and employment soar – but the trade imbalance remains jammed in the red.

In 2014, the goods deficit was the worst since records began. Those records only go back to 1998 on a true like-for-like basis, so there might be some room for solace. In fact, economist Ed Conway dug out figures going back to 1870 – and the goods deficit in 2014 was still the worst on record.

The wider measure of cross-border activity is the current account. This includes trade in goods and services, plus investment income and remittances. It's even worse than the goods deficit. In 2012 the UK ran a current account deficit of 3.5% of GDP. This rose to 4.7% the year after. And rose further, to 5.5% of GDP, in 2014.

Should we be worried? John Longworth, director general of the British Chambers of Commerce (BCC), thinks so. "The trade deficit is an economic time-bomb waiting to go off," says Longworth on seeing the mid-year data. "Despite good intentions, we are heading the wrong way."

Larry Elliott, economics editor of The Guardian, says: "Consumers are running down their savings to fund their spending. That will suck in imports. The pound is rising on the foreign exchanges. That will make imports cheaper.

"The current account deficit is set to get bigger. Sooner or later, the markets will notice and get alarmed. A good old-fashioned sterling crisis will follow."

TROUBLE AHEAD

Even the Bank of England's Financial Policy Committee (FPC), which was established by 2012's Financial Services Act, is rattled. The FPC is tasked with spotting problems. Looking at the current account deficit, it says if investors remain confident, then the deficit is manageable, but adds: "That said, the current

account deficit is large and could, in adverse circumstances, trigger a deterioration in market sentiment towards the United Kingdom." The committee will "keep the assessment of this risk under close review".

So what's going on? Why does the UK run a persistent trade deficit? The ONS advises slicing and dicing the figures to reveal some rather disparate trends. Look country by country, and sector by sector, and a complex picture emerges, showing distinct areas of strength and weakness.

For example, the UK remains outstanding in the provision of services. Services are intangibles such as financial advice, marketing services, the arts and entertainment, tourism, education and consulting. Here the UK excels. The City of London is a powerhouse.

> "The problem is lack of demand in the Eurozone. Since its inception, growth has been slower than the UK, US and other markets. Concerns about losing our trade with the EU are overblown"
>
> *Paul Hollingsworth, Capital Economics*

In niches like maritime insurance and accounting, the UK is number one globally. The film industry is booming. Britain's schools and universities are sought after. Even tourism is a hit. This performance in services is in stark contrast to the lacklustre exporting of goods.

For example, in Q3 2014 the surplus in UK services hit 5.1% of GDP – a record high. In the same quarter the deficit in goods hit 7.1%, leading to a net deficit overall. This is why the ONS asks analysts to break down the headline figures.

The country-by-country breakdown is equally revealing. The current UK strategy is to promote trade within the European free trade area, rather than go it alone and pursue trade agreements with emerging markets. The problem is the Eurozone is mired in low, or negative, growth. This has serious consequences for British exporters. In Q2 2015 the deficit with the EU was £26.9 billion. Non EU-trade ran a surplus of £10.1 billion.

Paul Hollingsworth of Capital Economics points to Europe's dismal economic performance as the single biggest factor in the UK's trade deficit. "The problem is lack of demand in the Eurozone," says Hollingsworth. "Since its inception growth has been slower than the UK, US and other markets. We at Capital Economics are running research to see what would have happened if the Eurozone had grown at the same rate as the UK or US.

"We think that if that was the case, then the UK would have an even trade balance, or even a surplus."

It is a huge claim. With campaigns on whether to remain or leave the EU now gearing up for the referendum, the idea that the UK could solve its trade deficit by exiting the EU in order to negotiate trade deals with faster-growing emerging markets is dynamite.

The counter-argument is that leaving the EU would result in a loss of free trade with the rest of Europe – which remains our top export destination. Hollingsworth disputes this notion: "Concerns about losing our trade with the EU are overblown. There are favourable reasons to think both parties would want to continue a favourable trading relationship. And we could then negotiate with other markets. Our view is towards re-orientating to areas with fast growth."

The data show why. The UK is a vital export destination for Eurozone nations. For them to impose tariffs would risk hurting their own economies. In the case of Germany, 7.4% of exports go to the UK; for France the figure is 7%. A trade war would be in no one's interest."

BEARABLE TARIFFS

Even in the worst case scenario of a Brexit triggering tariffs, there is evidence the tariffs would be bearable. Any potential tariff would be gentle enough to encourage this transition smoothly. World Trade Organisation rules on Most Favoured Nations, mean the UK-to-EU tariff for manufacturing would be just 4%. The average effective tariff on goods and services would be 4.4%. For context, this number is lower than the currency swings endured by exporters in a typical financial year. Further, half of UK exports already go to non-EU destinations, and the long-term trend is for this share to increase. A tariff would encourage exporters to low-growth EU markets such as Greece, Italy and Spain, to move to high growth markets further afield.

Negotiating liberal trade agreements with emerging markets would have strong appeal. For example, Egypt has a population of 82 million, and is growing at over 4%. Currently trade tariffs are 35% on average. A deal could lower this barrier,

LIVERPOOL CENTRAL

By Bernard Molloy, chair, SUPERPORT

We already know that the UK economy is imbalanced. This is put into stark clarity when, despite 60% of demand being closer to northern England and Ireland, 91% of deep sea containers enter via southern ports. This adds to congestion and unnecessary environmental impacts from containers being transferred via road. This is unproductive for the UK economy.

Liverpool – part of the solution

Not only does Liverpool offer global connectivity and market proximity, it also has the infrastructure and assets to service the anticipated increase in containers.

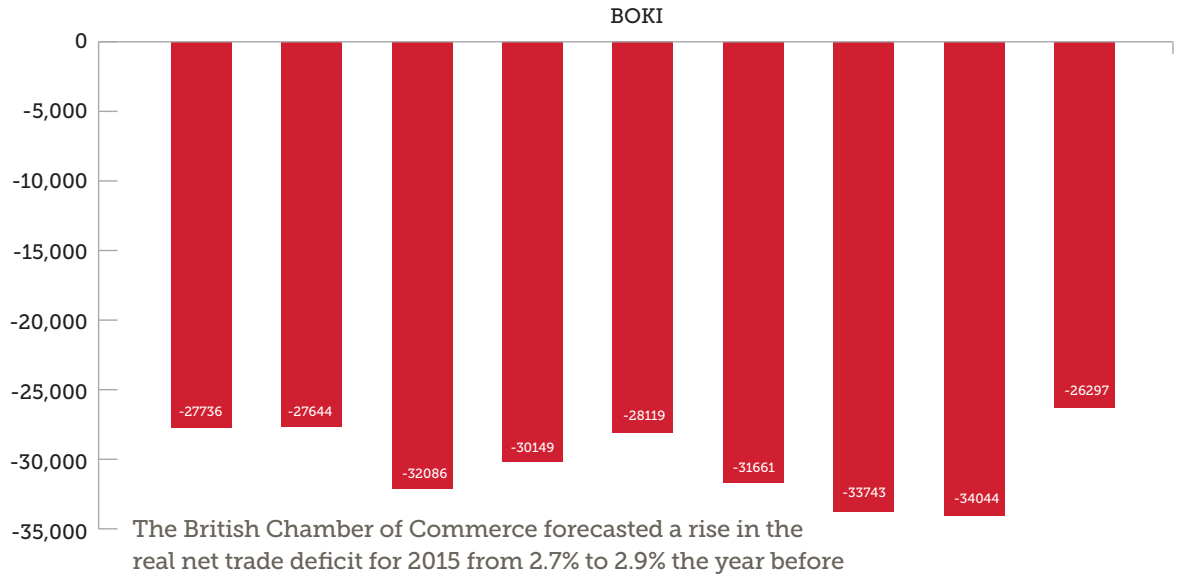
The new £300 million deep-water container terminal Liverpool2 will be the UK's central gateway, simultaneously handling two 13,500 TEU ships. As such, it will offer a viable alternative and boost productivity through more efficient supply chains.

The Northern Freight and Logistics Strategy will identify the wider infrastructure requirements to raise efficiency by reducing freight transport costs linked to major ports. It will ensure end to end connectivity as it is being led by freight operators who currently experience the frustrations of the network on a daily basis.

Superport – fast, green, global

Superport, an integrated collection of logistics assets and expertise, will deliver faster, greener global market access for business to and from the northern UK and Ireland. The initiative provides rapid reach to 35 million people within a 150-mile radius. It stretches from the historic port of Liverpool along the Manchester Ship Canal and the heart of the northern UK road and rail network, via 2 airports, and the highest density of warehousing in the UK.

EXTENSION OF DEFICIT SINCE 2013



The British Chamber of Commerce forecasted a rise in the real net trade deficit for 2015 from 2.7% to 2.9% the year before

British Chamber of Commerce

> "We have seen a decline in the industrial sector which goes back decades. That limits our ability to export. A lot of our members are going into schools and universities to address skills, but the pay-off takes a while"
>
> *Lee Hopley, chief economist, EEF*

opening up a lucrative new market to British firms. Brazil, with tariffs often exceeding the value of the goods exported, is another prime candidate for a trade deal.

ENGINEERING A SOLUTION

There is another explanation for the trade deficit. This school of thought points to the failure of the UK to produce engineers. When it comes to strong exports, engineers are the key. They are why Germany produced an annual surplus of 7.6% of GDP in 2014, a huge number forecast by the Germany finance ministry to rise to a record 8.1% in 2015.

German engineers dominate in many fields. Cars like BMW, Porsche, and VW keep the euros rolling in. Germany's Bosch is world-leading in drills, consumer goods, and auto components, while BASF dominates in chemicals, Bayer in pharmaceuticals, Viessmann in heating, and Stihl in chainsaws.

The UK is host to world-beating manufacturers, too, but performance is hampered by a chronic lack of engineers. A recent government survey revealed only 15% of British children would consider a career in engineering, with 40% calling it "boring", and more than half labelling it "dirty". Only 12% of female final year university students would consider a career in manufacturing.

India's Tata Group estimates there is a shortfall of 40,000 British science, technology, engineering and maths graduates a year. The talent shortage is so acute Tata has launched its own programme of intervention in British schools and universities.

Tata calls the radical scheme "enlightened self-interest". Without changing the mindset of British students, Tata simply won't be able to sustain its growth programme at Jaguar Land Rover – Britain's leading exporter of luxury cars.

The view from manufacturing industry is that negative views of it are changing. "We are getting there," says Lee Hopley, chief economist at manufacturers' organisation, the EEF. "But there is still so much more work to do."

There are no quick fixes, she says. "We have seen a decline in the industrial sector which goes back decades. That limits our ability to export. A lot of our members are going into schools and universities to address skills, but the pay-off takes a while."

Will the future look rosy for exporters? The British Chambers of Commerce polls companies to determine expectations, and the latest figures are dire. "In the manufacturing sector, the balances for exports, investment, confidence, employment expectations and cashflow all recorded falls between Q2 and Q3 [2015]," says the BCC survey. It adds: "The balance of firms reporting improvements in export sales is not only below its pre-recession level in 2007, but is also below its long-term historical average." The BCC chief economist David Kern describes the position of manufacturing exports as "exceptionally feeble"; ONS data indicated weaker output in manufacturing and construction in quarter three 2015, down 0.8% year-on-year.

One ray of light is the performance of UKTI, the branch of the Department for Business charged with boosting UK exports. UKTI offers direct help to first time exporters, offering grants, advice, and research. Last year it helped 55,000 businesses, up from 27,000 five years ago. Firms working with UKTI won overseas business worth £37.6 billion in 2014/15.

In May 2013, UKTI launched the pilot of the Exporting is GREAT campaign, with a goal of helping a further 100,000 UK firms become exporters by 2020. There is a plethora of case studies showing how effective UKTI can be when promoting exports. Lamp-maker Anglepoise is hoping UKTI can increase sales 500% over five years, with exports scheduled to rise from 40% of sales to 80%. Anglepoise is using UKTI grants to attend trade shows. It uses the Manufacturing Advisory Service (MAS) to streamline production, and has been advised by UKTI's local trade experts.

Closing the UK trade deficit will happen one success story at a time. If the UK is to emulate Germany and move into surplus it needs thousands more stories like Anglepoise – no matter what strategy politicians or economists pursue. **UKMR-15**

EXPORTS AND INTERNATIONALISATION

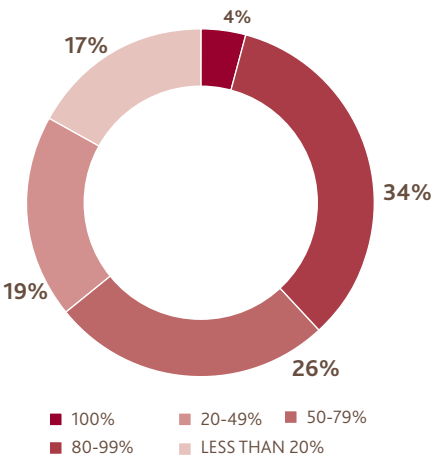
The UK is the 10th largest goods exporter in the world and there is no question that exports and further internationalisation are fundamental to the future success of UK manufacturing.

BDO recently partnered with The Institution of Mechanical Engineers (IMechE) to survey UK members working in manufacturing to consider the current state of manufacturing exports and the issues faced by engineering companies. Below are some of the findings from our survey, you can download the full report at www.bdo.co.uk/news/international-report-2015.

THE PROFILE OF UK EXPORTS

Percentage of company income from international customers

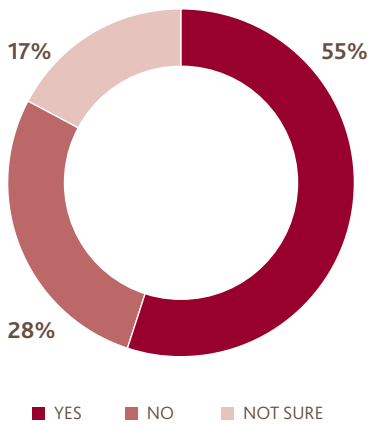
The responses from those surveyed indicates that the industry remains overwhelmingly international in its outlook. The survey asked what percentage of company income came from international customers. Almost two-thirds of the exporters say that international income accounts for more than half of their business.



INNOVATION

Respondents asked directly whether they felt their own companies allocated enough to R&D

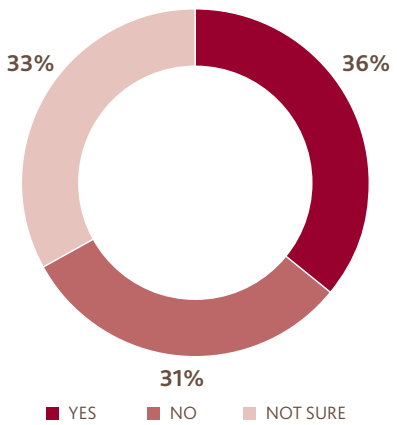
Constant innovation and re-invention of the products and services being offered are the prevalent strategies to maintain a competitive edge in the challenging global market. The survey respondents generally are positive about the corporate commitment in this area. Asked directly whether they felt their own companies allocated enough to R&D, a majority, 55% said 'Yes'.



GOVERNMENT ASSISTANCE

Recipients were asked whether, overall, they considered that UK government policy provided a supportive environment for export success

Survey recipients were asked whether, overall, they considered that UK Government policy provided a supportive environment for export success. This question produced a three-way split: 36% said 'Yes'; 31% 'No' and 33% were 'Not Sure'.

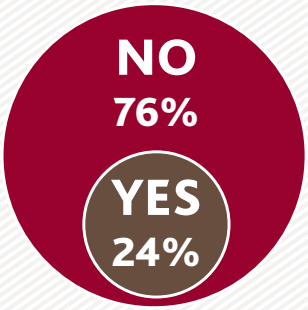


79%
PICKED OUT COMPETITION FROM GLOBAL RIVALS AS A WORRY

70%
SAID THAT GREATER AND REVISED TAX RELIEF FOR EXPORTS IS THE BEST GOVERNMENT INCENTIVE

78%
SEE QUALITY AS THE KEY TO THEIR INTERNATIONAL COMPETITIVENESS

WE ASKED WHETHER ACCESS TO FUNDING WAS A LIMITED FACTOR FOR INTERNATIONAL ASPIRATIONS...



TOM LAWTON
PARTNER
Head, BDO Manufacturing
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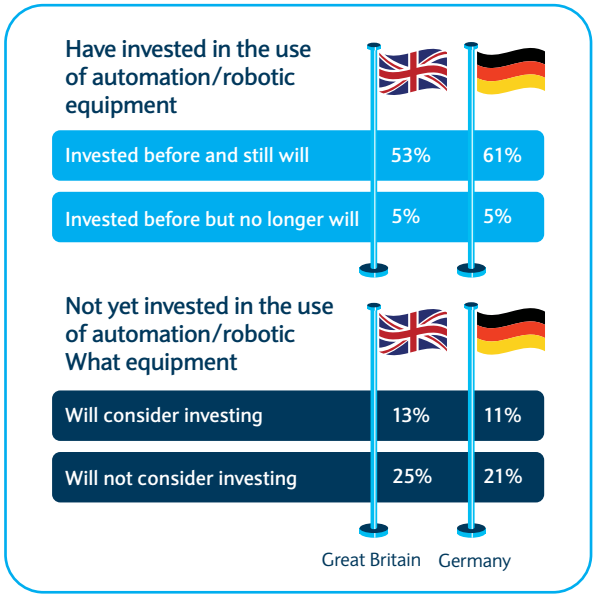
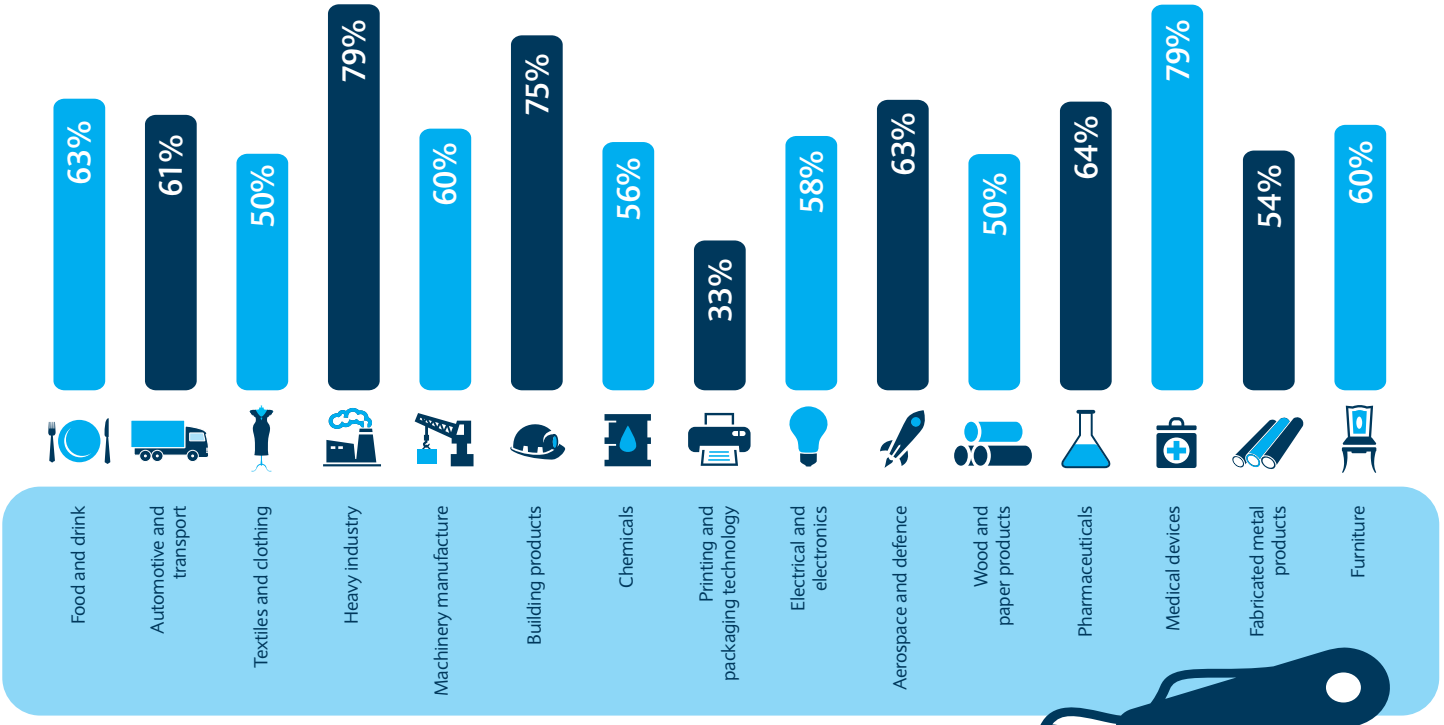
Current investment trends and future opportunities in robotic automation

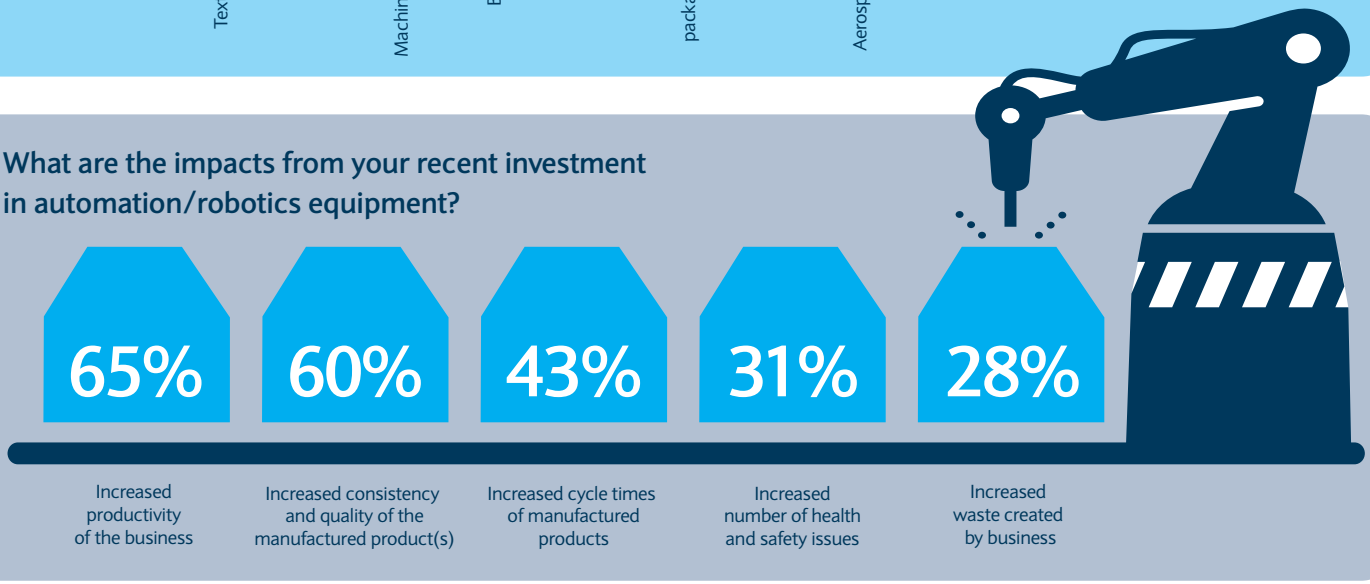
UK manufacturing is generally perceived as under-investing in robotics and other forms of automation, compared to other developed economies. There has been widespread speculation that this lack of investment could be one factor behind the UK 'productivity puzzle'. Recently we did a survey of over 700 British and German manufacturers and here is what they told us.



Subsectors that have already invested in automation/robotics equipment in Britain according to the survey*



What are the impacts from your recent investment in automation/robotics equipment?



To find out more about this report, please visit barclayscorporate.com/insight-and-research.html

*These figures should be treated with caution due to the relatively small sample size of some of the subsector and geographic data.

Exports: Language and local regulation should not be a barrier

In 2015 the Manufacturing Technologies Association supported UK companies in China, Germany, Japan, Turkey and the USA, as well as the EMO Show in Milan. If you are involved in manufacturing technologies and want to export – take note.

UK manufacturing accounts for over 50% of the UK's exports. It is a feature of much of the UK's manufacturing sector, and in particular the engineering based part of the sector, that much of it is high technology or exhibits a high degree of speciality. This means that the market is effectively global. In the manufacturing technologies sector this is particularly pronounced with UK manufacturers exporting a very high percentage of their products (over 80%).

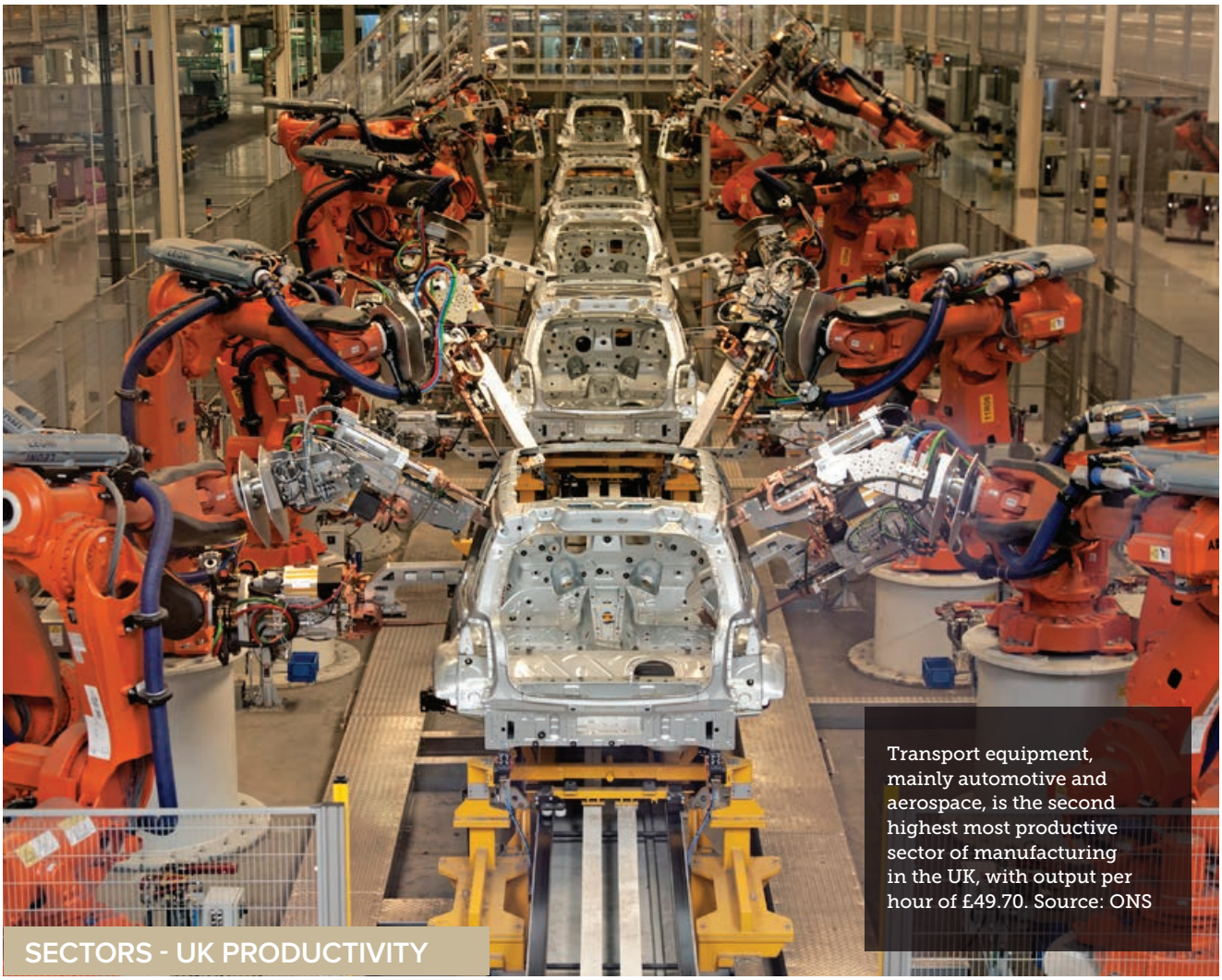
As the Trade Association for the manufacturing technologies sector it is important to us and our members that we help facilitate business abroad. The Manufacturing Technologies Association represents its members, at some of the largest manufacturing technology trade exhibitions across the world. A key part of the role is supporting SMEs to participate including through the hosting of UK Pavilions where appropriate. The last year has seen us active in Germany, Turkey, China, the USA and Japan as well as the pan-European EMO show held in 2015 as part of the World Expo programme in Milan. An Accredited Trade Organisation, the MTA works with UK Trade & Investment (UKTI) to deliver inward and outward missions with activity in India and Russia in the pipeline for 2016. As well as the assistance we provide at Trade Shows the MTA also supports UK SMEs in key markets through its offices and representatives in China and Russia.

These bases have proved huge assets when breaking down barriers to doing business overseas making companies more fully aware of the potential benefits of exporting and helping them where they lack the necessary knowledge, or capability, to successfully exploit overseas opportunities. The MTA is also a Member of the Institute of Export, giving Members further support when looking to trade overseas.

Robert Johnson, Managing Director of Craftsman Tools, a Yorkshire based SME manufacturer, said of the MTA's support at CIMT 2015 in China "As first time exhibitors at the show we appreciated the support of MTA and the UK pavilion has provided us with a good platform to introduce our products to a new market. The show has been a great opportunity to meet other exhibitors who otherwise we wouldn't have access to. The show has also given us the chance to meet visitors and exhibitors from a number of different countries, not just the Chinese market, at this truly international show".

The other more practical issues, such as significant international differences in culture, language, and regulatory frameworks, can also provide a challenge. The MTA has extensive experience of the markets exporters are accessing and a wide network of contacts around the world that can help mitigate problems when they arise.

MTA chief exectuive James Selka DL, said "Supporting exporters is an integral part of what the MTA is. The UK has a wealth of expertise in manufacturing technologies and there is a real demand for British manufacturing knowhow and quality products. We can help our members fulfil that demand". UKMR-15



Transport equipment, mainly automotive and aerospace, is the second highest most productive sector of manufacturing in the UK, with output per hour of £49.70. Source: ONS

Image © MINI UK/ BMW

SECTORS - UK PRODUCTIVITY

PUZZLING OVER PRODUCTIVITY

BY PETER MARSH

Productivity in the UK lags way behind other countries, representing a drag on the economy. Moves are afoot to change this dynamic as both businesses and government grapple with closing the UK's great productivity gap

Oliver Geoffroy has firm views about what is important in business. "We are not interested in anything other than productivity," he says. "Everything unfolds from this."

Geoffroy is founder and managing director of Unto This Last, a London-based firm which makes effective use of new digital tools to build hand-crafted furniture. In doing so, the company is addressing what the UK's chancellor of the exchequer George Osborne regards as a big challenge. The UK has a long-standing record of under-performance when it comes to productivity. To address this, the Conservative administration unveiled an eight-point plan in 2015 based around closing the hefty productivity gap between the UK and comparable countries – normally defined, either for a company or a business sector, as annual value-added output per employee.

Osborne reckons his programme – ranging from measures to boost innovation to ways to cut delays in the planning system for homes and infrastructure – can "fix the foundations of the British economy".

Unto This Last

While employee skills and overall levels of creativity and capability are other important factors, productivity cannot be divorced from products.

Oliver Geoffroy, owner of Unto This Last, believes everything in business unfolds from productivity

The political rhetoric and economic jargon surrounding productivity can obscure its importance.

Productivity depicts how people within any economic entity from a corner shop to a country can use their skills, together with inputs such as raw materials or bought-in services, to create goods or new thinking that others find valuable.

High-productivity businesses or countries generally have higher incomes per person – and are regarded as being more successful – than their low-productivity counterparts.

THE PRODUCTIVITY-PRODUCT FACTOR

Why is productivity in some businesses or sectors higher than in others? One element is investment in new equipment that can lead to faster output or the ability to make higher-value goods.

While employee skills and overall levels of creativity and capability are other important factors, productivity cannot be divorced from products.

Businesses with innovative products that are regarded favourably by customers tend to outsell their peers. Often they can charge higher prices – giving them an automatic boost in the productivity stakes.

Colin Shaw, leader of the UK operations practice at McKinsey, the strategy consultancy, says the reason manufacturers fall short on productivity is often to do with top management.

"The leaders of companies frequently fail to build the need to do better on [productivity] into the way they manage their businesses. There's often a preoccupation towards channelling resources into solving short-term problems through measures such as cutting employment or offshoring, rather than setting out a clear direction for reducing inefficiencies over the longer term," Shaw says.

But Shaw says that for all the UK's long-standing problems, the position is far from hopeless.

"It can be surprisingly easy to effect an improvement. Often it's done by replacing key managers with people with a better understanding of what the problems are and who have the commitment to change things," he says.

Value added – not gross revenues – is a key part of measuring productivity. For a company, value added is loosely defined as revenues minus purchases of materials and services.

While value-added output per worker gives a reasonable measure of productivity, economists normally consider a better measure is output per hour worked.

However, gaining the relevant data for this metric – especially at the level of companies – can sometimes be difficult.

Productivity in manufacturing – whatever the country – is generally higher than in other large sectors such as retail or transport services.

This is partly because manufacturing tends to be associated with higher capital investment. The trend towards automation boosts productivity through reducing the need for employees.

Manufacturing's high inherent productivity means it contains some of the keys to increasing countries' overall output per person.

And while the UK's recent performance on manufacturing productivity has been less than encouraging – at least by the standards of some other countries – companies such as Geoffroy's have shown the way forward.

Over the past two years, Unto This Last has spent around £200,000 to devise a set of software routines to allow workers to make wood-based products in different sizes using computer-controlled machines.

The products range from tables to light fittings and are made in 250 basic types.

The software cuts waste and increases efficiency. As a result, says Geoffroy, his 12-person company has increased output per employee by 30% in the past two years.

However, the UK's productivity challenges are not just about methodology and tools, as Geoffroy recognises. "We've put a lot of effort into technology – now we have to fix the people issue," he says.

Unto This Last is struggling to find employees skilled and motivated enough to use the company's innovative new software to its maximum potential while also having the necessary craft capabilities to make quality furniture.

THE GREAT PRODUCTIVITY GAP

An analysis of UK productivity makes for sobering reading.

According to a 2015 evaluation of the UK's productivity by the Institute of Public Policy Research (IPPR), the UK has an overall productivity gap of between 23% and 32% with other comparable European countries such France, Germany and the Netherlands.

While these figures apply to the average of all industries, the UK has a comparably poor performance for specific economic sectors including manufacturing.

The average worker in manufacturing in the UK is 27% less productive than the equivalent in France, 33% lower than in Germany and 35% lower than in the Netherlands.

But within the context of the poor showing for manufacturing productivity in the UK, there are glimmers of hope.

Even though in the past few years UK manufacturing productivity has performed weakly compared with other nations, it has risen faster in this sector in the UK than in other domestic industries.

The IPPR's analysis points to UK manufacturing output per hour of work increasing by 5% between 2007 and 2014. While nothing to shout about, this is well above the level for other sectors such as construction, agriculture and utilities – all of which showed a contraction over the period.

Another point is that in the UK – as in most comparable nations – manufacturing productively is significantly higher than in most other parts of the economy.

According to the IPPR, average UK manufacturing output per hour worked in 2013 was $44.4 (about £28), 26% higher than in construction, 32% above business services and 40% ahead of distribution industries.

Of the UK's main economic sectors, manufacturing has the highest productivity on this measure apart from energy/utilities and finance.

Unto This Last

Furniture maker Unto This Last struggles to hire staff with both the ability to embrace new technology and a natural skill with wood

Unto This Last

Unto This Last uses software which enables workers to hand-craft wood-based products using computer-controlled machines

TABLE 1: PERFORMANCE OF MANUFACTURING VS. OTHER ECONOMIC SECTORS IN THE UK ON VALUE-ADDED OUTPUT PER HOUR WORKED

	Percentage change 2007 to 2014
Professional services	14
Manufacturing	5
Information and communications	5
Retail/distribution	2
Construction	1
Agriculture	-7
Finance	-10
Mining/utilities	-40

Source: IPPR

Within UK manufacturing, some sectors score better on productivity. According to the Office for National Statistics (ONS), the chemicals sector is by far the most productive manufacturing sector, registering an output per hour of £72.6 in the first quarter of 2015.

The next highest scorer on this measure is transport equipment – mainly automotive and aerospace – with output per hour of £49.7. Computers and electronics, and machinery, are among the relative laggards, showing output per hour of £32 and £25.7 respectively.

Between 2011 and 2015, according to the ONS figures, transport equipment increased productivity by easily the largest amount of any sector, showing an increase of 11.4% in this measure. The next best performing sector was wood and related products, which showed an 8.5% increase. Most other sectors showed falls.

Izzy Hatfield, an IPPR researcher, reckons that manufacturing could play a key role in any effort to boost UK productivity.

"Britain has some competitive strengths in niche fields of manufacturing which also tend to have high productivity. This

TABLE 2: PERFORMANCE OF KEY UK MANUFACTURING SECTORS ON VALUE-ADDED PER HOUR WORKED

	Value-added/hour worked (£) 2011	Value-added/hour worked (£) 2015*	Change (%)
Food/drink	27.9	27.4	-1.6
Textiles	26.7	20.6	-22.8
Wood products	21.6	23.4	8.5
Chemicals	75.0	72.6	-3.2
Metals	22.5	22.3	-0.6
Computers/electronics	32.6	32.0	-1.8
Machinery	30.1	25.7	-14.6
Transport equipment	43.5	49.7	14.4

* = 1st quarter

ONS, 2015

provides a platform from which it might be possible to develop."

UNLOCKING THE PRODUCTIVITY PUZZLE

Some sense of how this could be done comes from the findings of Industry Forum, a consultancy owned by the Society of Motor Manufacturers and Traders that examines companies in many areas of manufacturing.

"We find there are five reasons why companies struggle to improve productivity: a failure to set a clear strategy for company objectives; lack of leadership on efforts to improve productivity; supply chain problems; inefficient manufacturing; and failures in introducing new products," says Chris Owen, chief executive of Industry Forum.

"Making sure employees in key roles have the correct skills for their jobs is one way for companies to try to tackle [productivity failings]. Often we find when working with manufacturing organisations that they struggle to recruit people with the right skills."

Reinforcing this message is one of the regular Manufacturing Barometer snapshots of industry opinions produced in 2015 for the government's Business Growth Service. This said that 71% of small to medium-sized manufacturers were planning to increase spending on employees' training and skills in a bid to unlock the productivity puzzle.

Adding to overall employee capability – and with this the propensity to be innovative – can often be done through stepping up apprentice recruitment, says Damon De Laszlo, chairman of Harwin, a Hampshire-based maker of specialist electronic connectors.

"They are my company's brains," says De Laszlo of his 23-strong cadre of young apprentices who comprise about a sixth of his company's workforce.

"If I speak to my older engineers about how to do things like using 3D printing to boost automation or increase our ability to make new products, they scratch their heads. The kids [apprentices] lap it up [the new thinking]. They have been responsible for some important advances [in productivity]."

Stuart Calvert, managing director of MGB, a Plymouth-based company that manufactures control systems for the railway industry, tells a similar story.

"We started taking in significant numbers of apprentices three years ago and now these people account for 15 of our 87 employees. They are enthusiastic and look at problems differently to older people. As a result they are often able to use some of the new tools in manufacturing more efficiently. They have made a big contribution to improving our productivity performance," he says.

THE HOLISTIC APPROACH

Other manufacturers point out that it makes little sense to discuss productivity other than in a holistic way.

That means regarding output per person as a means to monitor the overall performance of the business, taking in key points such as introductions of new products, capital investment and formulating the correct blend of using manual skills and automation in production processes.

Christopher Nieper, managing director of David Nieper, which makes clothing in Alfreton, Derbyshire, says: "Productivity is easily misunderstood as being only about people. But we can become more productive in a number of ways, such as better methods, better machinery, better use of space, better use of materials, better use of working capital and [of course] more motivated people."

Charles Baughan, managing director of Westaways Sausages, a food manufacturer in Devon, takes a similar view. Baughan says his firm has boosted productivity through a number of measures, including "tweaking" production lines between different sausage types of pack sizes, adding manual labour where necessary and in other instances bringing in more sophisticated machinery.

John Goodwin, chairman of Goodwin Group in Stoke on Trent, a producer of large castings such as valves, says his company aims at increasing productivity through a number of techniques.

One of these is an intense cost-cutting programme that has led to big price reductions for many key products over the past 30 years. Its initiatives have included everything from redesigning components to using fewer materials to buying parts from low cost nations.

Since the mid-1980s the company has more than doubled its number of UK employees from just over 300 to 800 while increasing global sales to more than £120 million, and boosting pre-tax profit per UK employee – one measure of productivity – more than 30 times.

Goodwin says it's hard to discuss productivity without considering a number of factors.

"We invest in productivity aimed at the efficient economic supply of technically advanced products to growth markets. This has resulted in innovative design and systematic manufacturing improvements. We have managed to save our customers money on products year on year. An essential feature has been to have passionate apprentices enthusiastic to succeed."

Achieving high productivity – and increasing it – means excelling at many things, as Goodwin points out. It is a lesson that should carry weight with other businesses as they strive to improve on a measure hugely important to the future of UK industry. UKMR-15

"Adding to overall employee capability – and with this the propensity to be innovative – can often be done through stepping up apprentice recruitment."

Damon De Laszlo, chairman of Harwin

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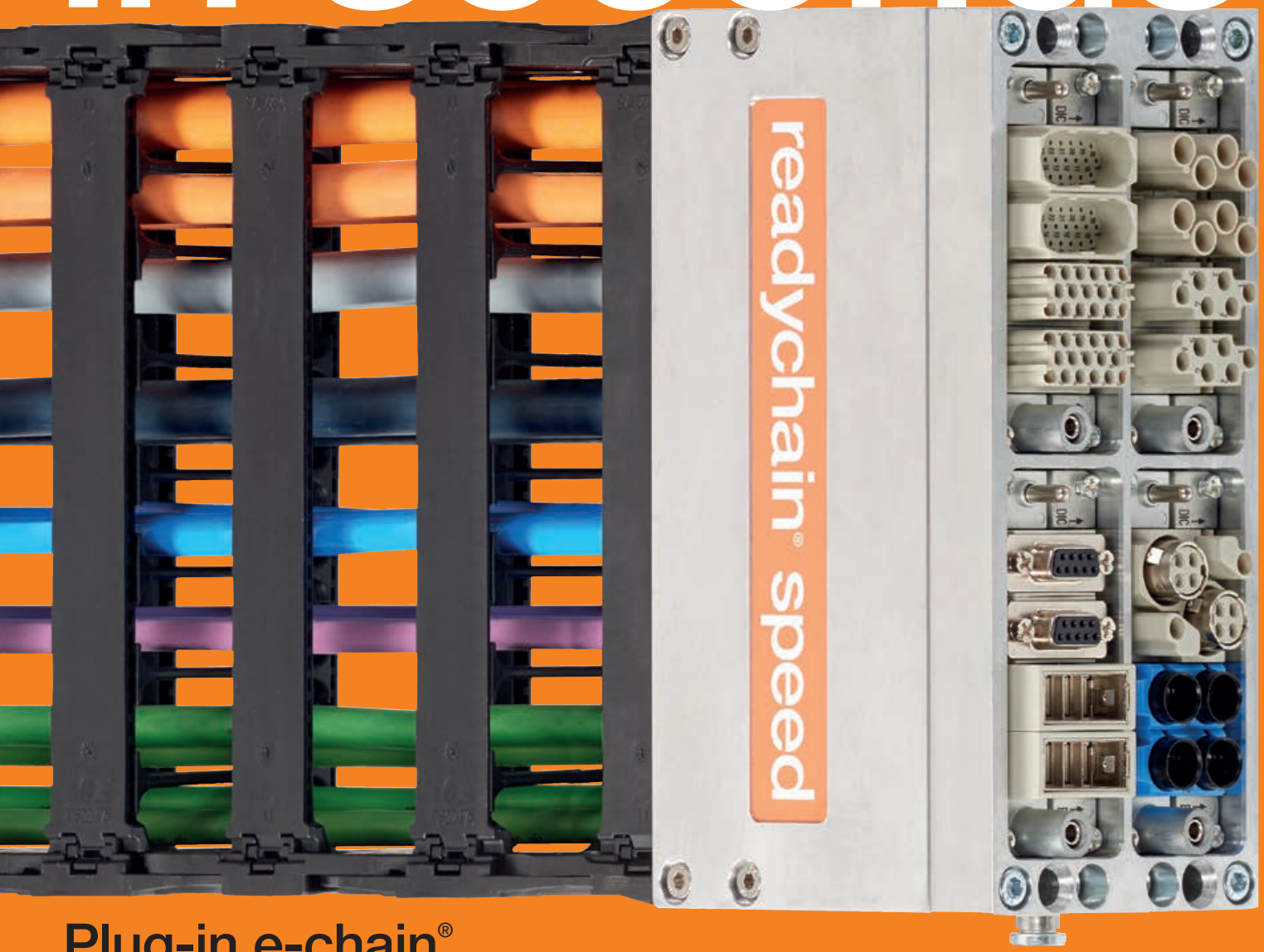

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YOUR CORE STRENGTHS CAN SOLVE THE PRODUCTIVITY PUZZLE

BY MATTHEW ALDRIDGE, MANAGING DIRECTOR, IGUS

For the UK's manufacturing industries to become more competitive globally, it is imperative that our productivity improves. There are many possible solutions but one of the most practical and immediate ways to improve productivity is to ensure you are devoting resources to do what you do best. Ask yourself honestly: 'Are we concentrating all our efforts on the areas of business where we can truly add value?'

In the answer to this question lies a pathway to greater productivity for many firms in the UK. We have unique talents and experience in the UK that simply have to be harnessed in order for our manufacturing sector to thrive.

If you are spending time and money on functions that could be performed better and more cost-effectively elsewhere by an outsourced supplier, then you may well be compromising your productivity. Imagine an automotive manufacturer, for example, diverting resources away from engine development and instead pouring investment into making its own seats and fabrics. It simply doesn't make sense to steer resources away from the core skills upon which the company's reputation depends.

The good news is that there are indications of a changing mindset. In its 2014 report on The Changing Shape of UK Manufacturing, the Office for National Statistics noted that cumulative reductions in manufacturing employment could be partly explained by the flow of jobs into support services such as wholesale and transport. The report went on to say: "If some manufacturing support services have been outsourced elsewhere in the economy, then this may have a positive impact on manufacturing productivity."

At igus, we are experiencing growing demand from the makers of advanced machines for customised sub-assemblies that can be quickly installed on site.

These customers recognise that ordering multiple components individually in order to construct a working piece of equipment on site does not typically represent an efficient use of available resources.

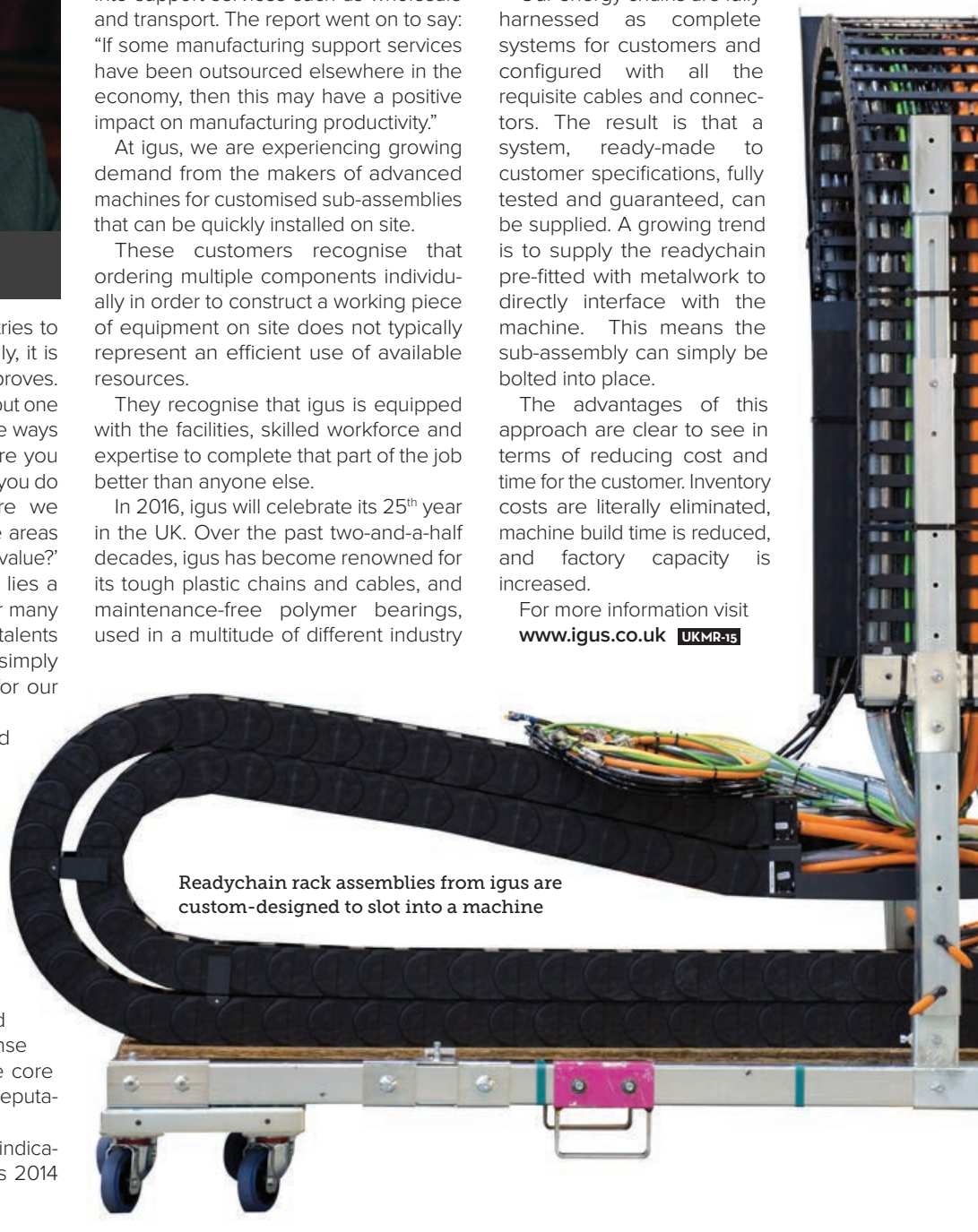
They recognise that igus is equipped with the facilities, skilled workforce and expertise to complete that part of the job better than anyone else.

In 2016, igus will celebrate its 25th year in the UK. Over the past two-and-a-half decades, igus has become renowned for its tough plastic chains and cables, and maintenance-free polymer bearings, used in a multitude of different industry applications, from agricultural machinery to medical technology. However, the emergence of our dedicated readychain assembly service has brought us closer than ever to our customers.

Our energy chains are fully harnessed as complete systems for customers and configured with all the requisite cables and connectors. The result is that a system, ready-made to customer specifications, fully tested and guaranteed, can be supplied. A growing trend is to supply the readychain pre-fitted with metalwork to directly interface with the machine. This means the sub-assembly can simply be bolted into place.

The advantages of this approach are clear to see in terms of reducing cost and time for the customer. Inventory costs are literally eliminated, machine build time is reduced, and factory capacity is increased.

For more information visit **www.igus.co.uk** UKMR-15



Readychain rack assemblies from igus are custom-designed to slot into a machine

The Made in Sheffield Productivity Roundtable

In association with the Sheffield Chamber of Commerce

Back row left to right: Jon Stewart, John Hancock, Mark Tomlinson, Craig Burton, Keith Jackson, Gordon Macrae, Barry Cunliffe, Sebastian Herrera, Richard Wright
Front row left to right: Charles Turner, Matthew Chenery, Nick Henderson, Martin Wood, Matthew Aldridge, Anne Wilson

Richard Wright (chair), Executive Director, Sheffield Chamber of Commerce

Keith Jackson, CEO, JRI Orthopaedics

Martin Wood, European Regional Director, AESSEAL

Gordon Macrae, Special Projects Director, Gripple

Barry Cunliffe, Finance Director, Tinsley Bridge Group

Sebastian Herrera, Managing Director, Pyronix

Anne Wilson, Managing Director, Numill and Freeman of the Company of Cutlers in Hallamshire

Jon Stewart, Director, Primetals Technologies

Matthew Chenery, Regional Manager, Barclays

Craig Burton, Partner, BDO LLP

John Hancock, Managing Director, Thos C Wild

Mark Tomlinson, Development Director, Sheffield Forgemasters

Charles Turner, Managing Director, Durham-Duplex

Matthew Aldridge, Managing Director, Igus UK

Nick Henderson, Account Director, Technical Publicity

Will Stirling, Director, Stirling Media

Richard Wright, the chair, set the stage by proposing that productivity is measured in GVA per person or GVA per hour worked.

"The UK has a national debt of £1.5 trillion. In perspective, a trillion seconds is 32,000 years, so if we paid back the debt £1 every second, we might repay two thirds of the debt in 32,000 years," he said.

"The government's austerity programme won't get this back – it might stop it getting bigger but won't repay it. We need to make money from trade, reverse the deficit and that means we need to be competitive. A core part of this is productivity. Also, while energy costs are high and controversially so, that is not expected to change quickly."

There is abundant evidence that the productivity gap is widening and this problem is starting to gain prominence and come to the attention of business commentators.

Wright noted that the *Daily Telegraph* earlier this year

described UK productivity is a national disgrace. *The Guardian* said in 2014 the productivity gap between the UK and its rivals was at its widest in 20-years.

He also pointed out that the ONS in 2014 showed the UK was 20% below the G7 for productivity. The Bank of England has also said that productivity is the biggest threat to the recovery of the UK economy and it would increase interest rates sooner if it was higher. "We are not in a very good situation. The job of the private sector is to create wealth and the solution could be in this room," Wright said.

He added: "The Sheffield City Region is 15th in the LEP table by size of GVA, but we are 38th in GVA per person out of 39 LEPs. Employment in the core sectors of the SCR economy is stagnant, and employment really works against productivity. Businesses tend to say 'how can I do what I'm doing with fewer people?' But things have started to improve in the regional economy in the last year, and we have world-class businesses in this region that compete in world markets – we just don't have enough."


Richard Wright, Sheffield Chamber


Gordon Macrae


Jon Stewart

What are the fundamental problems and how do you fix them?

Charles Turner (CT): If you are making one identical thing many times, it is easy to see your productivity change. But if you're making one-off or two-off castings it is a more difficult to measure.

We have been encouraged to take on more people, to train up young people. But every time you employ that person you are probably reducing your productivity because you are getting less work out of them for a period. The benefit will come in 10-15 years time. Is GVA per hour a "Noddy" way of doing it? With industrial blades I might run one million parts with one operator, but another product could take 14 guys several hours.

John Hancock (JH): In my sector all the competition is foreign-owned. Tata runs the local steel mills, Alcoa runs Firth Rixson, Dubai Capital Partners runs Doncasters. If I sit in corporate HQ in New York, where does the UK sit in my priority list for deploying money? The UK management team has to compete internationally for investment; is the UK a great place to make steel? Probably not (Ed's note: *this event was recorded before the UK steel industry suffered large scale redundancies in October*).

Also, aerospace is buoyant and Rolls-Royce is having a good year – but they've had three profit warnings this year. Business is very tough. With high energy costs, I can't see that turning around. If it doesn't turnaround in the next 12-months I can see a lot more shake-out.

Jon Stewart (JS): There has to be an appreciation *throughout* an organisation of the impact of productivity on company performance. It's fine coming from the top but to have a real effect, the whole company has to have that understanding and that is then a question of culture. The right messaging, transparency, visibility and ownership, amongst others, all play a part. I've first hand experience of companies that perform fantastically; they have a culture within them and a greater awareness of the impact of productivity on their business. This translates into a desire to improve and drives the organisational performance upwards. Weaker companies have the opposite, limited awareness of the benefits of productivity improvements and a low motivation to improve.

Gordon Macrae (GM): I'm fortunate to work for Gripple, a unique business. We have grown from £33m to £50m this year. If you take a direct measure, the UK workforce has increased from 200 to 250 so just 50 people have generated about £17m.

How? For us it's quite simple: flexibility, automation and employee engagement. People talk about engagement but very few people do it effectively. We have adopted an employee ownership model where people buy-in and everybody has to own £1,000 of shares. We hosted a factory tour with some printers recently and the MD said to a staff member: "I'm really impressed by your attitude; it's almost as if you own the company." She said "I do". It is about real engagement.

Anne Wilson (AW): I joined the company (Numill) as the bookkeeper. It is nine years since I became 100% shareholder and sole director. It has been a rocky road but I want to employ more people in this region, it's one of my drivers. But look at productivity with automation; if you increase productivity it does not increase jobs. If I buy a new CNC machine we could increase productivity if the guys we have know how to run the machine; productivity rises but not employment. How do you balance automation and be more efficient and then employ more people in your operation?

GRANTS AND INCENTIVES

Craig Burton (CB): It's interesting to look at the incentives to invest. Whether you look at grants previously or RGF loans, many of them are tied to jobs predicated rather than productivity. Is it the wrong way round?


Craig Burton, BDO

CT: New jobs do not have to be on the shop floor. If you have not got people selling, you will never grow. Some of the smaller Sheffield companies are terrified to step outside the UK. They have a product they could sell to the world, but won't engage internationally. But if you have another 20 orders your productivity will rise because you've got the capacity to work.

RW: Pubic sector grants are awarded on jobs created and protected and not linked to profit. An example is international trade. For example UKTI is driven by metrics like number of visits made, OMIS's and people doing Passport to Export courses. The real measure if the number of enquiries won and how many turn into profitable orders. The balance has been too far towards the grant culture.

Sebastian Herrera (SH): We made a decision in 2003/4 to transfer about 60% of our production to China. We were then the second independent alarm system company left in the UK and were struggling to compete. Had we not done that we would probably not have survived. It worked well for us and helped sharpen our minds. We had to source the raw material from China for both factories. But now we have done a U-turn. About two years ago we invested heavily in a new plant here, and a state-of-the-art production facility. Out turnover now is £24m/£25m a year, three to four years ago we were half that. The logistics of bringing from China was having an impact on business with long lead times, even with flexible arrangements. The new factory has made a big impact on our business – now my challenge is to bring more production back from China. The proportion of 65:35 made in China and here has reversed.

INNOVATION AND PEOPLE POWER

RW: Does anyone know what their competitors' productivity is?

Keith Jackson (KJ): The short answer is no, it is buried in their numbers. EEF published a report in October that showed output per hour had risen 0.9%. That's the right direction but I believe productivity is not about being busy. Whether in a business or in the UK economy we can never get the economic boost we need from continuous improvement and process efficiencies. It comes down to a core competence of the UK which is innovation.

We talk about gross value added, the value is a better designed, better functioning product in a world market. That plays to the skills agenda, so you can invent, and to a culture agenda, where people feel at ease experimenting.

A third aspect is agility – SME businesses need to be agile and able to respond to customer needs better and quicker than multinational competitors.

RW: Tinsley Bridge has continued to invest in new materials and products?

Barry Cunliffe (BC): Yes, across all three businesses. In terms of productivity, the three sectors we are in are still pretty depressed. Some 80% of our product is exported. The two key markets are still at the bottom; steel prices in the US in the scrap sector are at rock bottom, the HGV truck market in Europe has not picked up. But Tinsley Bridge has retained its staff. There is a core set of skills in there they needed to retain. If the markets picked up it would problematic because they would not be able to ship the product. We've had some RGF assistance in the redevelopment of the site.

You are right in that productivity improvements and the reduction of unemployment just do not go together. We have beaten the target we were given as part of the funding.

But it is about people ultimately and culture. If you want to implement lean, continuous improvement and incremental changes, there has to be a willingness to be measured. That is not too common in South Yorkshire.

It all comes back to people: you can order a brand new machine, have it commissioned and it can be best in class but if the person who operates it is not well-educated, trained and of the right character to do the job – is it worth investing in the machine?


Barry Cunliffe, Tinsley Bridge


Sebastian Herrera, Pyronix

TECHNOLOGY AND PRODUCTIVITY

SH: The problem we have is education. I have permanent job offers open. South Yorkshire is a bit of a back hole for electronics. I employ people from Spain, Corfu, China in the past, Bracknell and


Martin Wood, AESSEAL
Matthew Aldridge, igus


Mark Tomlinson


Anne Wilson

the M4 corridor. That is a real challenge in terms of productivity. Software developers are scattered around all over, but not here and it's a long term problem. This country is just not geared up to supply the electronics sector. This will take 15-20 years to fix. We used to have more choice in terms of electronic and software recruitment. It affects time to market.

My sector is also transforming. Ten years ago I would say we were in the design and manufacture of burglar alarms. All the big guys in the IoT (Internet of Things) world are looking at this sector wanting a piece of the pie. I have to broaden my scope of what I offer now, and must automate. We need to more to be competitive.

Martin Wood (MW): At AESSEAL we have a strong investment culture in our core competence of machining. We have just put an 11-axis machine tool on the shop floor that is rare in the region and country. The output of that is four times that of the 9-axis machine.

My view of the general investment culture of the UK though is that it could definitely be improved and this is fundamental to UK productivity, the support for investment is very different in Germany for example.

From a design perspective as a relatively new entrant to a mature market we have designed in productivity opportunities. Many of our designs are of course more modern and have been conceived as platform products with a clear focus on flexibility and customisation. I am confident that we would have better productivity from that base than our competition, because they have a legacy of old products.

We benchmark against products that are similar, and can benchmark against the competition by financial results. Productivity comparison is virtually impossible to measure. For me investment in equipment, product design and developing the mindset of people is core to the topic.

Mark Tomlinson (MT): Productivity measures are not always related to how busy or hard-working or expert those individuals are. At Redcar [the steel mill], for example, no-one is suggesting that they got into trouble because they were not an efficient steelmaker. So GVA is useful in some areas, but it has many more components than how much added value we can create on the shop floor.

RW: The Bank of England and others quote GVA per man and per hour as productivity. But we know it's more complex.

CT: They don't distinguish between engineering, administration and hospital workers.

MT: If you interrogate those figures, manufacturing provides the solutions not where the problem comes from. So GVA per person is increasing and is much higher in the mfg sector than other sectors - the ONS says it contributes 15.4% of GVA from 14% of labour costs. So to improve the productivity of the country let's do some unfashionable rebalancing and have more manufacturing.

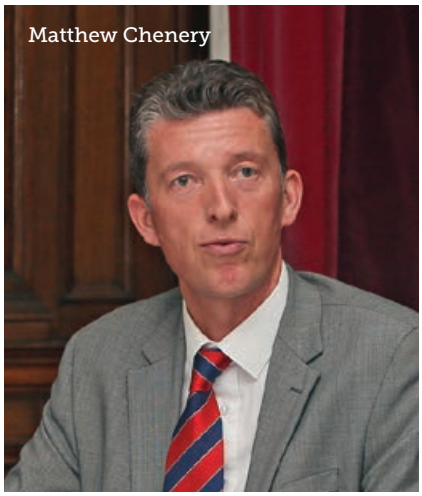
SUPPORTING SUPPLY CHAINS

AW: Other countries tend to support their industry from within. If we had more bigger projects, you would support supply chains, increase manufacturing and productivity naturally – I saw recently that larger companies want to shorten supply chains due to the cost of running them. But if you do that your SMEs with those specialist skills will get lost somewhere because big procurement teams will favour the big boys.

RW: A hard-nosed view would say if the skills on offer are not required then why is money invested in them, especially if those skills are not driving competitiveness in our economy now. Skills requirements move on, and are we quick enough to respond to that?

Matthew Chenery (MC): Culture is key. The companies that have grown successfully are those that have been most receptive to change and that challenge staff at all levels. I've seen companies that have reconfigured the whole shop floor so one operator can work on 3 to 4 machines, where he/she was willing to change. Also a desire to feedback from all levels in the organisation is important as well as good integration with universities that have challenged work practices.

GM: We don't believe in supply chains. The stuff we do is quite simple; we have


Matthew Chenery

brought almost all manufacturing in-house. It has impacted SME suppliers but some of these guys now work for us. It means that we have the profit that came from those companies. What we are focused on solving customer problems. At Gripple we want 25% of turnover to come from products that we had not invented four years ago. That means that we are employing more people. We can tighten the supply chain, and be more advanced.

But the fundamental reason why Gripple is successful is because we have invested in selling our product. The number of people we have under our direct control is where we have the ability to sell – we do not rely on distributors, we have closed that loop. I see with many businesses in the UK that rely on third parties but there is always some excuse for poor delivery. Our product is simple and it's an easier sell but the missing link I see is investment in international operations and selling.

DO WHAT YOU ARE GOOD AT

Matthew Aldridge (MA): As Charles said, it depends on what you are making. If you are making a product it can be worth bringing your manufacturing in house. But if you are making a machine, that does not usually make sense. It's how car companies used to work 80 years ago when they forged their own nuts and bolts, but then started to outsource these parts. Companies should focus on what they are good at. If that is making a packaging machine then do just that.

My company, igus, supplies assemblies into machine builders and machine users. We manufacture components but we tend to build those parts into sub-assemblies that the customer can directly fit into their product. I think we are an important part of that supply chain and that allows customers to increase their capacity, to make more machines, to increase productivity. The answer to the productivity conundrum is that it depends on what is being made.

A second point, if you are using machines they must be more automated. Richard said at the start that wealth creation is the job of the private sector – automation drives this.

RW: I deliberately quoted UK productivity stats at the start not those for UK manufacturing. I expected someone to challenge this. In fact, the figures are the same. Productivity applies to every sector, and it's not about being busy fools. I agree with Keith that we must not confuse productivity with "busy-ness".


Charles Turner, Durham-Duplex and chair of Made in Sheffield


Matthew Aldridge, igus

CB: Returning to the theme of concentrating on what you are good at, where we as a nation of manufacturers are is about that innovation and creating added value. If we just concentrated on what you are good at you could compromise that ability to innovate.

But it will depend on what you do. Innovation is not just about the product but about how you innovate.

MT: We run the risk of being at the mercy of economists here. Look at traditionally cyclical markets like steel and automotive, its fine to have this relentless drive for productivity if you can have a Blairite future where there is continual growth. If you are in a cyclical industry it's hard to grow productivity if you simply have fewer things to manufacture.

RW: With sales and people I was really inferring if you double sales, try to do it with a 50% increase in people, rather than reduce headcount.

Does everyone believe that productivity is important?

All: Yes. But it is not the only important thing.

SH: As far as I am concerned manufacturing is not the core activity of our business. We employ c. 200 people in the UK, if they were all software developers I can guarantee our revenues of £50m to £200m turnover as opposed to £25m. If I reached that revenue, I couldn't care less where I make the product. I know I am a manufacturer, but we have to have flexibility.

CT: But that is the business quoted cycle: you generate IP, profits, you grow and when profits reach here and your margin starts to fall, that's the time to do it somewhere else so costs fall, you keep your profit margin and bring a new product through.

SH: But my point is where you employ these people in the business. It doesn't have to be on the shop floor.

MEASURING PRODUCTIVITY

RW: Charles said while you are training people productivity falls. That should mean that while you are training them it is worth investing because you will end up better in the end than if you did not invest.

How many people here have a productivity programme? It's not the same as continuous improvement which is more about taking cost out. Pyronix measures productivity – does anyone else?

JH: Yes, we use GVA per man-hour. But a lot of the drivers are outside your control – when steel prices and scrap prices halve, what we you do? You can only control what you can control. We do add value to the raw material. (RW) And accounting for energy prices?

MT: If you are going to measure something like that the number at the end must mean something to the

operators/staff. You should really measure productivity in different areas of the company in different ways.

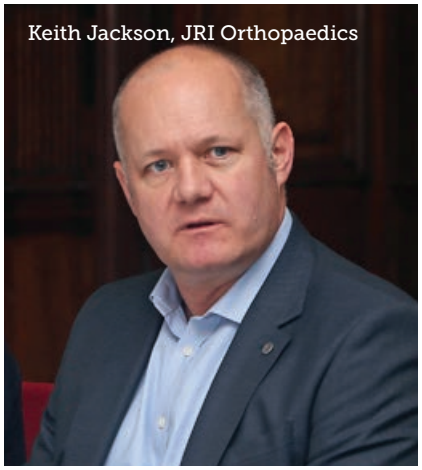
RW: Is your advice that companies need to implement formal productivity improvement programmes?

MA: You will be forced to with the increase in wages that is going to happen, with the Living Wage programme. That will directly affect shop floor staff and all our customers.

LABOUR COSTS AND TRAINING

RW: How many people here pay the minimum wage and will have to go to the Living Wage?

BC: The issue is not the difference between these markers, but the differentials higher up the scale. Our staff will not stand by and watch the minimum wage rise to £9 – they will expect to get that differential.


Keith Jackson, JRI Orthopaedics

KJ: The bigger driver for labour cost increase is the huge shortage of STEM graduates and STEM qualified people in the market. It will be a much bigger influence than adjustment at the bottom end. The demand is going to outstrip supply big time.

SH: We started a programme 3-4 years ago to get certain staff above the minimum wage. We told them we wanted to give them higher living standards.

RW: You've got to pay them more so they have to produce more. The deal with any employee is you pay them money but they earn more than that for your business.

JH: I have 11 out of 60 at the moment in training, eight apprentices and three graduates. It is all about management succession – trying to find people with metallurgical knowledge in this city is incredibly difficult.

RW: The government is suggesting giving employers training grants and not colleges. Is that good?

AW: You can't rely on grants, has to be a strategic decision for the business. I have an ageing workforce; I've got two people who have been at Numill for nearly 46-years. I have had to bring new people through and now, at one point, 33% of our engineering staff were apprentices.

CT: Should there be a compulsory retirement age? I have had highly skilled 70-year olds who are in effect bed-blocking jobs unless they are willing to train their successor.

JH: You hire for succession but you can't plan when you can do the succession.

MT: Our average age in the company was 51-years. We started an apprentice programme 10-years ago, at last count we've put 110 people through that programme. But they are all taken on with identifiable roles to go into because you see that demographic problem looming. None of us can afford to train people we don't need.

LEADERSHIP AND TAX INCENTIVES

CT: We have doubled turnover in the past 10-years and recently took over as the European Distributor for a US business and taken on their order book so we have doubled again and my staff numbers are the same – so productivity is definitely up at Durham-Duplex.

RW: Is leadership (in this region) a problem?

JH: Yes. If you are a family business owner you may want a lifestyle business; do you want to put in a whizz kid manager who wants to treble the size of the business and maybe bust it? The temptation is to think – why would I do that?

My colleagues tell mw that internationally our taxation system is competitive but I've got guys now who are


John Hancock, TC Wild

tripping into high rate tax, and it's a disincentive for them to work overtime. When you have blue collar workers tripping into £45k, £50k jobs – which I'm delighted about – they look at it and say I might as well not work Saturday.

CB: R&D tax credit is used by many companies and its one of the tax reliefs that government likes to give away. As long as you are doing something that is research and development related it is seen as a good investment.

CT: The R&D tax credit really works hand-in-glove with capital allowances, because often the R&D leads to a need for new kit. This way money will stay in the business. The Uncle Toms, the lifestyle business owners, the money leaves the business, in golf clubs and a big house in Derbyshire. It doesn't get reinvested in machine tools.

MT: But if you incentivise risk too much, it plays into short termism that doesn't play well with manufacturing. The R&D tax credits and the ways to incentivise longer term activity is probably better than trying to fox that on short term gains and risk.

JH: Maybe there needs to be a link between the capital release for investment in equipment, and how that manifests itself through productivity in your business – a tax break linked to productivity.

With thanks to Made in Sheffield, the Sheffield Chamber of Commerce for moderating the event and the guests for taking part in this roundtable debate. UKMR-15

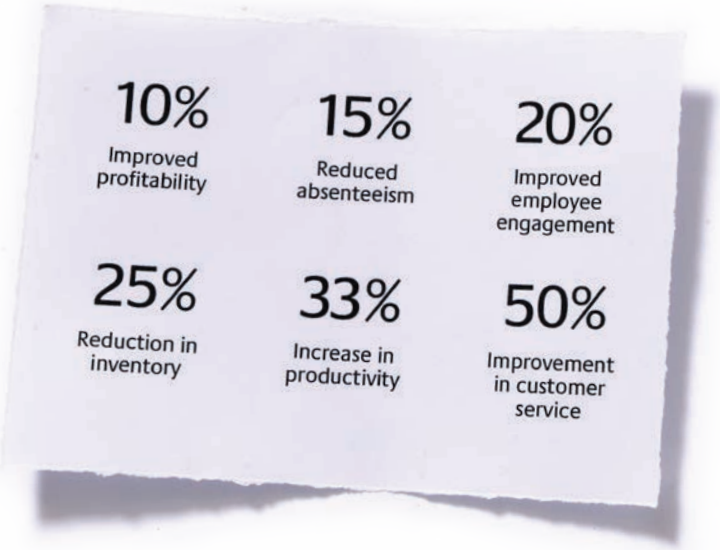
Lottery

When you win the lottery, you win big. Mostly, of course, you don't win at all. The lottery is not a business model. Business needs certainty. The certain knowledge that an action will result in a predictable improvement in that most basic fundamental: productivity.

Certainty

Over thirty years Unipart has developed a system that engineers certainty into every process of our business. By making productivity the focus of every activity. By engaging everyone who works for us to interrogate what they do. By permitting them to make it better. Daily, incremental improvements add up, creating consistent gain. Over time, the benefits of this scientific approach are considerable. We call it The Unipart Way. It works. Of that you can be certain.

Find out more at unipart.com



UNIPART GROUP

The Science of Productivity

Unipart has set up a web based information hub to show how to improve productivity at www.productivitypuzzle.com

Employee engagement is an essential part of improving productivity

Unipart's mission to solve the productivity puzzle

According to official data the average French worker could take Friday off and still be more productive than his/her UK counterpart. In October Unipart launched a campaign to help companies become more productive.

Unipart, Europe's leading logistics, manufacturing and consultancy group, is launching a new campaign promoting productivity improvement in Britain.

According to the company headquartered in Oxford, productivity is Britain's biggest issue when it comes to economic growth.

Over the past months, the media has regularly reported on the UK's 'productivity puzzle', a situation in which our economy is growing while the productivity rates are declining when compared to our global competitors. The situation is so significant that during the last budget announcement, the Chancellor of the Exchequer, George Osborne, identified productivity as the government's number one priority.

Now, Unipart is setting out to raise awareness of the issue by engaging business leaders who are interested in learning how to improve their organisations and in sharing best practice.

Unipart chairman and group chief executive John Neill explained:

"Productivity is at the heart of our nation's quality of life and yet Britain is lagging behind our global competitors. Economists talk about this as a puzzle, but we believe that Unipart has the solution.

"The Government has made productivity improvement a major priority, and Unipart is pleased to be able to play our part in helping to unlock the potential that exists amongst millions of people in the UK to not only be more productive, but to do so by becoming more engaged with their organisations," he said.

"Over the past 25 years, Unipart has invested in creating a comprehensive ecosystem called The Unipart Way which continuously improves productivity in any organisation.

"We have implemented The Unipart Way in all of our own operating companies and in our clients around the world. We know it works because it consistently delivers strong results. It is not a lottery that relies on the breakthrough ideas of a small number of people. The Unipart Way is a complete ecosystem that engages everyone in the organisation in the science of improvement.

Unipart is setting out to raise awareness of how to improve productivity through a major national media campaign and a web based information hub that can be found at www.productivitypuzzle.com.

A key part of the hub will be a new series of video documentaries called "Solving the Productivity Puzzle" in which business journalist Juliet Mann investigates why productivity is so essential to the economy and, most importantly, what can be done about it.

She interviews a wide range of senior industry leaders including CBI Director General John Cridland, McLaren Automotive CEO Mike Flewitt, Unipart Chairman and CEO John Neill, Institute of Directors Chief Economist James Sproule, and many others.

The hub also features a wide range of resources and reports including a new white paper by Steve New, Associate Professor in Operations Management at Oxford University's Saïd Business School, who presents a better way of addressing the productivity issue.

Highly creative new print ads will raise awareness of the productivity challenge and signpost the solution to the productivity puzzle. The ads will appear in the business sections of major publications like The Times, Sunday Times and The Telegraph. They will explain that certainty of productivity improvement comes from adopting The Unipart Way.

The new ads focus on how The Unipart Way can bring productivity benefits to customers across all sectors of the economy. Unipart's productivity campaign begins on November 9 with the premiere of the "Solving the Productivity Puzzle" on www.productivitypuzzle.com

UNIPART LOGISTICS

CREATE A MANUFACTURING POWERHOUSE THAT WILL DRIVE THE ECONOMY

In order to build a robust and strong economy it is essential that greater balance is achieved to allow prosperity to flow around the country and not just be concentrated in London and the South East.

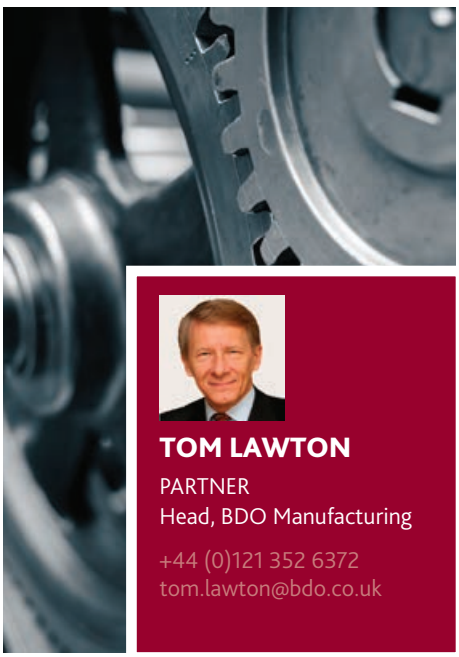
Britain's historic strengths in manufacturing, innovation, design and service, as well as the significant potential that the move to more automated manufacturing offers, should be supported and developed as key foundations for a successful and well-balanced UK economy. However, firms cannot do this alone. Government has a role to play in supporting the sector in an increasingly competitive world and we believe that some of the initiatives below will help to do this.

Manufacturing is a long-term game – most businesses in the sector rely on large capital investments which pay off over years or even decades. Businesses need stability and certainty in government policy if they are to commit to the investment that the country needs to grow. The Government should, therefore, match manufacturers' long-term outlook by looking 15-20 years ahead to plan an industrial policy, avoiding the disruptions of the political cycle. This should include setting a formal target for manufacturing growth over the next five, ten and 20 years to provide the background to a sustainable industrial policy. The programme must be steered by a dedicated manufacturing minister, able to focus on firms' needs in a way that will benefit us all.

Employers' NI is also a barrier to businesses taking on new workers. The government has sought to tinker with National Insurance reliefs over the past few years but the impact of these measures has so far proven negligible. To back up the Government's rhetoric on targeting a doubling in exports, a bold step is required. A temporary reduction in Employers' NI, for UK businesses that take on all new employees involved in manufacturing production processes, would be a targeted relief aimed at those businesses that are most likely to be exporters or that supply exporters.

Productive manufacturing needs investment and the Government must encourage this in every way possible. We strongly support the steps taken in this direction by increasing the annual investment allowance to £200,000, (and a temporary increase to £500,000), but this step is not yet the game-changer we need to unleash manufacturing might. Government should take the leap and increase the annual investment allowance for expenditure on plant and machinery to £5 million for five years. This increase would provide a significant incentive for mid-market businesses to invest in the capital assets that will drive future growth, and give businesses the confidence to plan ahead.

And finally, high quality apprenticeships are needed to bridge the skills gap in the sector. Underinvestment in skills is harming our regional productivity and economies. Improving the skills of the UK workforce is a long-term challenge but must be addressed in an ever globalising world. An increase in the number of high quality apprenticeships on the scale needed is unlikely to be wholly publically funded and the government's current plans for an Apprenticeship Levy are under consultation. However, there are a number of simple steps that can be taken to improve the awareness of apprenticeship programmes. Reform is required in the Ofsted assessment system for schools to give some weight to the number and quality of apprenticeship places secured by schools for their pupils and focus incentives in areas where there are acknowledged skills gaps such as manufacturing and technology.



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The importance of manufacturing to our economy is more than a romantic attachment to our industrial heritage, says **Terry Scuoler**

Manufacturing businesses are part of communities right across the country, employing 2.6 million men and women, with many more jobs dependent on the sector.

In recent years the public profile of manufacturing has increased as we've taken more pride in our successful sectors, and manufacturers are playing a big part in helping to ensure we achieve sustainable growth.

As an outward-looking sector, manufacturers are innovative and inventive, being more than twice as likely to export than firms in other sectors. Exposure to global competition provides a further spur to improve productivity.

Industry also has a strong track record of improving productivity, with growth over the past five years around four times faster than the rest of the economy and on a par with major developed-world competitors. Higher skilled employment in manufacturing has undoubtedly contributed to this stronger productivity performance.

EDUCATION, FOR MASSES

Over the past decade, the share of hours worked by employees with a degree qualification has grown by almost three-fifths. With this comes better jobs and higher pay.

Our manufacturing industry is reflecting this and becoming faster, more responsive and closer to customers. Companies are capable of mass production and will become capable of mass customisation of low-cost products on demand.

This will reshape the factories of the future with a mix of large super-factories and smaller reconfigurable enterprises making a range of products for different market sectors.

From technical textiles and personalised medicines to low carbon vehicles and nuclear supply chains, we have the companies and the capabilities to compete and grow in global markets.

And many manufacturers have been making the complementary investments in technology, people and business processes that will drive our industry forward.

> "As an outward-looking sector, manufacturers are innovative and inventive, being more than twice as likely to export than firms in **other** sectors. Exposure to global competition provides a further spur to improve productivity"
>
> *Terry Scuoler, chief executive, the EEF*

Developments such as the Internet of Things and cyber-physical systems, such as sensors and wearable technology, will enable machines and computers to have a greater active role in manufacturing production processes. Big Data and powerful analytics will allow these systems to process huge data sets and translate that information into smart strategies. Innovation cycles will shorten, but the manufacturing value chain will be more complex.

IN IT TO WIN IT

These changes are coming, and the UK must be in the race. Nine in ten manufacturers believe that the UK should be taking a leading role in this 4th industrial revolution, and two-thirds say that UK manufacturing's ability to compete globally will depend on keeping up with advances in these technologies.

There is clearly everything to play for. But manufacturers don't and won't succeed by operating in isolation. Embracing future opportunities will be extremely resource-intensive, and UK manufacturers will only be able to fully exploit them through collaboration – with customers and suppliers, with the research base and with government.

There are three steps on the journey that we can start to take today – manufacturers need to build their strategies for this technological revolution, government must commit to a well-resourced future for the UK's innovation infrastructure and, collectively, we must get a handle on our longstanding skills problem. UKMR-15

Energy Market Needs Reform As Industry Suffers

THE UK ENERGY MARKET

Hinkley Point C nuclear power station in Somerset (artists impression): The completion date for the 3,200 MWe power station has been extended

Image: EDF

The viability of renewable power will face a stern examination in 2016

2015 began under the looming cloud of a general election which could have had dire consequences for the UK energy sector had Labour not been routed against all expectations.

With a potential energy price freeze in the balance, energy company executives largely heaved a thinly veiled sigh of relief, when a Conservative majority stole the show in May and supply chain organisations optimistically anticipated a flurry of contracts from a sector which is estimated to require £200bn of infrastructure investment within the decade.

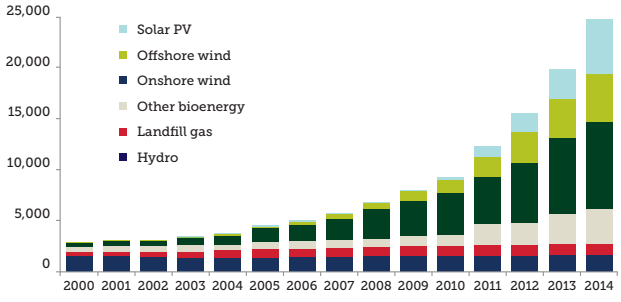
On the whole, such hopes have been widely disappointed however. David Mooney, managing director of SME Drallim Industries which supplies specialist engineering equipment to the utilities sector observed that despite the reassurance of a Conservative majority the energy industry "continues to be slow to launch new investment and projects remain in limbo."

This sluggishness is perhaps indicative of wider continuing upheaval in the energy sector's regulatory frameworks. The year opened, for example, with the results of the UK's first capacity market and contracts for difference auctions in in January and February respectively.

These fundamental elements of the drawn out process of Electricity Market Reform (EMR) were long awaited. The former secured 49 gigawatts of generating capacity for the winter of 2018-2019 and the latter committed £315m of government money to support renewable energy projects while also taking a big step toward making renewable energy a competitive market player. Assuming they go forward to completion, these projects will add significantly to the UK's installed renewable capacity of 24.6GW, an asset base which generated 64.7 TWh in 2014 according to the 2015 Digest of UK Energy Statistics.

While the UK's EMR process jolted forward, more definitive

ELECTRICAL GENERATING CAPACITY OF RENEWABLE ENERGY PLANT SINCE 2000



(1) All waste combustion plant is included because both biodegradable and non-biodegradable wastes are burned together in the same plant.

(2) Hydro includes both large scale and small scale, andshoreline wave and tidal (8.7 MW in 2014).

Source: Digest of United Kingdom Energy Statistics 2015

events were unfolding in the global energy environment. In late 2014, assumptions about the inevitable upward trajectory of energy prices came crashing down in tandem with the global oil and gas markets. Prices continued to decline in the first part of 2015 before broadly stabilising in February.

The ramifications of low oil and gas continue to animate investors in fossil-fuel-fired assets. But the main impact of the oil and gas price crash which will have been visible to energy end users in early 2015 was renewed pressure on suppliers to reduce prices.

Despite reluctance to cut tariffs prior to the general election over January and February, the UK's largest energy suppliers (the Big Six) caved to expectation. One after another, they announced a string of tariff cuts, primarily to gas tariffs, most closely linked to the commodity wholesale price. A range of independent suppliers also joined the action.

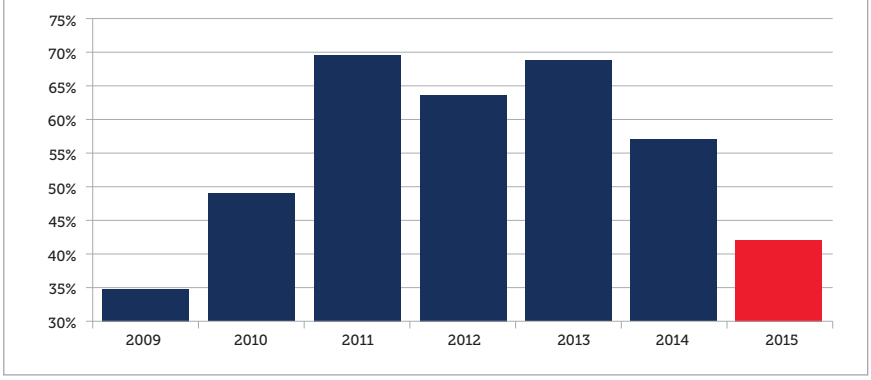
In spite of these cuts, however, pressure on energy suppliers to reduce the burden of energy costs on UK households continued to form a central thread in the energy sector narrative throughout 2015.

On being appointed energy secretary in May, for instance, Amber Rudd wrote a public letter to Big Six bosses demanding that they take action to cut tariff's further. By November, even chief regulator Dermot Nolan had joined the chorus of voices demanding price cuts, pointing out that, as the nation headed into winter, wholesale gas prices were at their lowest for six years (see chart, above).

But while pressure on suppliers to reduce bills mounted, it was, for once, another energy topic which dominated the early days of the new government's administration - renewable energy subsidies. In a bonfire of tax-payer funded mechanisms, Rudd slashed support first for onshore wind, which the Conservatives made a manifesto pledge to curtail. Further cuts then forged a swathe through the solar industry and biomass generation as officials at the Department for Energy and Climate Change (Decc) discovered massive overspends in the Levy Control Framework (LCF) – which limits the amount consumers pay for the advance of renewable energy – under the previous government.

Decc's attempts to counterbalance the £1.5bm LCF overspend came in tandem with a surprise announcement from chancellor George Osborne that he would remove climate change levy exemption certificates (LECs) from renewable energy within 24 days.

CLOSING WINTER AHEAD: NBP GAS PRICE (P/THERM)



Source: Icis Energy

Drax Power Station, a large coal-fired power station in North Yorkshire

The combined impact of these events caused outrage in the renewable energy industry with spokespeople decrying the "body blow" they had been dealt, complaints which were more than idle talk. In three hours following the chancellor's announcement, the share price of Drax – the UK's largest power station which is in the process of converting three of its coal-fired generation units to biomass – dropped a staggering 30%. Drax estimated that the sudden withdrawal of exemption certificates would cost it £90m over 2015-2016 and, in early September, it launched a legal battle with Treasury on the basis that the timescale for its policy move was "inappropriate".

The subsidies ruckus fixated low carbon energy generators for a significant time, only losing headlines to the new nuclear industry in autumn. In October, in the first Chinese state visit to the UK in over a decade a momentous and controversial £30 billion deal was struck between the UK and Chinese governments to form a nuclear alliance. Among other things, this agreement secured support for the build of Hinkley Point C, a 3.2 GW new nuclear project in Dorset.

In the first Chinese state visit to the UK in over a decade, a momentous and controversial £30 billion deal was struck between the UK and Chinese governments to form a new nuclear alliance.

Owned by French energy company EDF, the plant has been beset by delays and political wrangling over the cost of the power it will generate. Though massively expensive, at a total cost of £24.5bn, advocates of Hinkley say it will secure essential low carbon baseload as old plants - like Eggborough and Longannet which are both set to close in March 2016 - succumb to the pressures of transmission costs, carbon taxes and the inevitable impact of shifts towards a low carbon economy.

Opponents to Hinkley were horrified by the deal. They say government is backing the wrong technology to address the UK's decarbonisation and security of supply challenges, favouring instead support for demand side

Image courtesy of RenewableUK

On being appointed energy secretary in May, Amber Rudd wrote a public letter to Big Six bosses demanding that they take action to cut tariffs further

response, electricity storage and bridging investment in new gas-fired plant while these distributed technologies mature. Peter Atherton, an analyst for Jeffries, said that for the cost of Hinkley "the UK could build 270,000MW of gas-fired power stations, solving the 'energy crunch' for a generation."

Peter Atherton, an analyst for Jeffries, said that for the cost of Hinkley "the UK could build 270,000MW of gas-fired power stations, solving the "energy crunch" for a generation.

Further upstream, 2015 will be remembered by suppliers and distributors as a year of intense scrutiny from the Competition and Markets Authority (CMA).

While this was expected for suppliers, who sat at the centre of an 18 month investigation launched in July 2014, the investigation into the Distribution Network Operator's (DNO's) regulatory regime came as more of a surprise. It was sparked in March 2015 when Centrica-owned British Gas, a dual fuel supplier, referred the eight year price settlements awarded to the UK's DNOs to the CMA for being too generous and allowing unsustainably high network costs to be passed on to consumers.

The step was unprecedented and end badly for British Gas when, in late September, the CMA threw out four of the five charges of ineffectiveness that the supplier had levelled at Ofgem's regulatory settlement for the networks. The only adjustment the CMA allowed was to revenues DNOs are allowed to recover through charges. British Gas, meanwhile, was ordered to pay the costs for the investigation it had incurred.

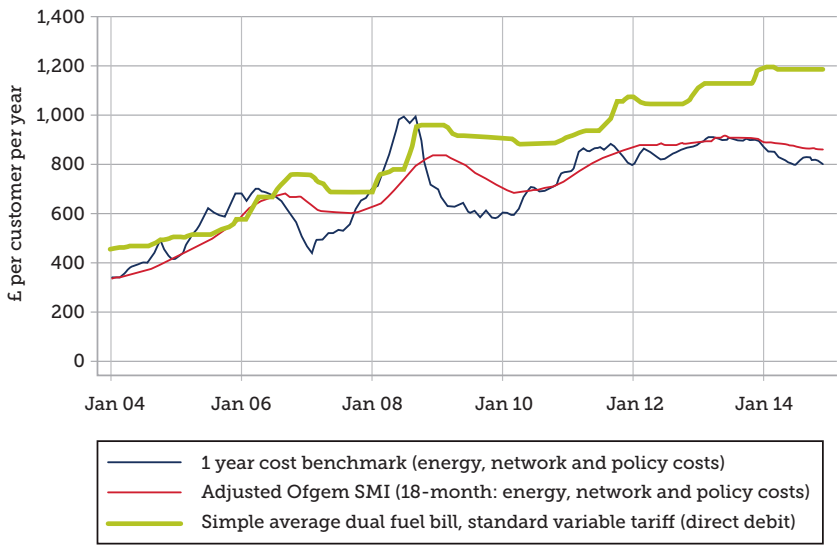
The CMA's investigation into the energy market rumbles on. It was due to report in December but announced in later September that it will take the option of a six-month extension, meaning continued uncertainty in the measures to be taken to reinstate transparency and trust in the energy retail market.

Some indication of the CMA's intentions for the energy market were made apparent in July when it published provisional findings and recommendations. One suggested remedy for sluggish switching caused consternation in the market. This advocated the introduction of a "safeguard tariff" for "sticky" domestic customers on standard variable tariffs – which are thought to be "cash cows" for the Big Six. Critics said this was overly interventionist. Stephen Littlechild, a former energy sector regulator wrote to the CMA to say that a safeguard tariff would "restrict competition and militate against the CMA's other remedies to increase customer involvement. It will increase regulatory uncertainty and hence the cost of capital, and hence prices to customers."

In addition to its remedies for the domestic energy market, the CMA also put forward recommendations for problems experienced by non-domestic customers, especially SMEs and micro-businesses. It found this market lacks transparency – often due to third party intermediaries – and raised concerns about the significantly higher margins earned by the Big Six from their SME customers compared to the domestic market (8.4% compared with 3.3%).

While these findings did not draw main stream press attention, experts at professional services firm PwC warned that they could have a "profound" impact on the market place. Stuart Cook, head of utility strategy and regulation said: "Ultimately, we expect the CMA to introduce remedies which will see the six largest energy companies lose further market share in the SME sector... Greater

EVOLUTION OF AVERAGE SVT BILL AGAINST EXPECTED DIRECT COSTS



Bill is an average across regions and six large energy firms, for a typical consumer. Direct costs are not those actually incurred by firms, but forward-looking expectations. Indirect costs are not shown.

Source: Digest of United Kingdom Energy Statistics 2015

competition will have a significant impact on the profits the largest suppliers make from this segment of the market."

LOOKING TO 2016

Despite having a majority government in place, energy sector hopes for a period of policy certainty over the next five years have not yet been fulfilled.

It remains unclear how far the Conservatives will go in scrapping renewables subsidies in order to redress the affordability element of the energy trilemma and, meanwhile, there is new risk from opposition energy policy following Jeremy Corbyn's succession to the role of Labour party leader.

The implications of a newly influential SNP in Westminster are yet to fully manifest, but it is likely that the party will push for for further devolved powers in 2016, adding to powers already ceded in the areas of energy efficiency and fuel poverty policy.

Meanwhile, the SNP's Angus MacNeil who took on the chairmanship of the Environment and Climate Change Committee in 2016 made an assertive start in his role, setting out an agenda to investigate: home energy efficiency and demand reduction, investor confidence in the UK energy system and low carbon network infrastructure in the coming year. There will also be shorter term projects to explore the severity of the UK's winter supply margin and the outcomes of the UN Climate Change Conference in Paris in December 2015.

Alongside the outcomes of the CMA investigation into the energy market, expected in April 2016, the Paris talks will set the tone for debate in the energy sector over the course of the coming year. Most commentators are sceptical about the likelihood of a unilateral and legally binding commitment to tackle climate change. Nevertheless, the event may catalyse action for European energy union and cause the emphasis of policy making to shift once again in favour sustainability, rather than affordability or security. Finally, according to Jeremy Nicholson, director of the Energy Intensive Users Group at EEF, the talks could necessitate retrospective amendments to the UK's fifth carbon budget, also due in December 2015.

Jeremy Nicholson, director of the Energy Intensive Users Group at EEF: talks may lead to retrospective amendments

2016 will see the continuation organisational transformation in the energy sector. Eon is due to complete the carving of its business in two in the spring – putting a dividing line between the growth areas of renewables and energy services and declining "dirty" generation activities.

Another big energy sector concern for 2016 will be the official start of the national smart meter implementation programme. This aims to see 53 million smart energy and gas meters installed in UK homes and businesses by 2020 and has so far been beset by criticism, technical challenges and delays.

More broadly, 2016 will see the continuation organisational transformation in the energy sector. Eon is due to complete the carving of its business in two in the spring – putting a dividing line between the growth areas of renewables and energy services and declining "dirty" generation activities. Meanwhile, Centrica will take steps to implement its new strategy, announced in July, to focus on energy services, the connected home and energy trading while divesting its generation and exploration and production business units.

Eon and Centrica are at the vanguard of such change, and it is expected that other traditional energy suppliers will follow suit, restructuring for a world with more competition from independent players (who now hold 13.4% of dual fuel supply in the UK) and new entrants. Network operators meanwhile, will focus on developing responses to new regulatory requirements for customer-centricity while grappling with the technical challenges of incorporating a growing volume of renewable and decentralised generation. UKMR-15

Innovation is key to global warming solution

The Earth's atmosphere is warming due to the increase in greenhouse gases emitted. Buildings account for 40% of global energy demand, with business energy costs set to rise 30% by 2020 and few tools available to help them mitigate this rise and cut carbon.

The Earth's atmosphere is warming – and it's the greenhouse gases emitted by human activity that are primarily to blame. The world needs to reduce carbon-based energy consumption. In the face of mounting global pressure to reduce emissions of CO_2 and other greenhouse gases, industry must play its part.

The Intergovernmental Panel on Climate Change (IPCC) elected Hoesung Lee of the Republic of Korea as its chair in October 2015. Mr Lee says the IPCC remains deeply committed to providing policymakers with the highest quality scientific assessment of climate change, but that "we can do more".

The IPCC believes that the use of advanced technologies to improve energy efficiency could stabilise or even reduce energy consumption by 2050.

It is an area where German engineering company Bosch already has a lot to offer. "If we approach the challenge of climate change in the right way, we can turn it to our advantage," said the company's CEO, Dr Volkmar Denner, in October 2014. "If done in the right way, products that protect our environment are innovative advances that combat climate change, and increase comfort. "They will also save users money."

Dr. Denner, a physicist, believes energy efficiency must be prioritised far higher if a target of limiting global warming to two degrees Celsius is to be achieved.

"We need to know how the energy consumption of everything from manufacturing operations to private vehicles will impact tomorrow's environment – even if that impact is on the other side of the world. "Wherever we can establish this sort of transparency, we have the chance to make the right choice."

Bosch is responding with a whole range of innovations. Factories can be heated with the waste heat from production processes; Bosch technology for the internal combustion engine, contributes to fuel savings of 15%; Bosch makes the most energy-efficient tumble dryer in the world, which knocks another 10% off even the most energy-efficient A+++ class of domestic machines.

Bosch has a voluntary commitment to cut CO_2 emissions by 20% by 2020. The company is well on its way, since value-added CO_2 emissions are already over 16% lower compared to 2007 levels.

Following detailed analysis it was decided that a strategy was required across all sites. In the UK, the Bosch Rexroth site in Glenrothes, Scotland manufactures hydraulic motors for fork lift trucks, mini excavators and other mobile plant for household names such as JCB and Caterpillar. The Glenrothes site was a significant consumer of both gas and electricity with a large number of machines and test rigs in both the main manufacturing area as well as the R&D facility. Additionally, the shop floor was heated by a number of large gas-fired radiant heaters, which were over 20 years old. Whilst the office space was heated by multiple gas boilers, some of which were in excess of 25 years old.

It was quickly realised that a site-wide solution was required and, following detailed analysis, it was determined that a combined heat and power (CHP) technology offered the best plan. The theory behind CHP is that a gas-fuelled piston engine drives a generator to produce three-phase electrical power, which feeds into the mains low voltage distribution system where it can be used locally or exported to the National Grid.

Heat, which is produced as a by-product of the electricity generating process, is used to generate hot water for space heating of offices or during an industrial process such as the large number of process wash machines at Glenrothes.

Bosch Rexroth contacted Worcester Bosch, one of the UK's leading manufacturers of heating and hot water technologies. After an extensive analysis, it was concluded that the Glenrothes site had the potential to produce one third of its total electricity requirement with the installation of three 140 kilowatt Loganova CHP units. The units work 24 hours a day, seven days per week, with four of the most powerful Worcester, Bosch Group 100kW GB162 Greenstar boilers as heating back up during planned maintenance cycles.

In addition, hot water is stored in three 10,000 litre buffer tanks which can hold hot water at 90o Celsius. The entire system is controlled by a full building management system, which controls and measures all inputs and outputs from the CHP units and can be adjusted on PCs located around the site.

"This all goes to show that we don't just set climate protection priorities at Bosch, we implement them too," Dr. Denner emphasises. Bosch is also an industry and research partner for the Technical University of Darmstadt's 'energy-efficient factory for interdisciplinary technology and application research' – a project that aims to further reduce the amount of energy consumed in industrial production.

KNOWLEDGE EXCHANGE

Steffen Hoffmann, who became boss of the company's UK business in April 2015, explains that Bosch uses its innovative technology across divisions. "We have a new domestic oven with an oxygen sensor inside. this is a technology that comes from the automotive industry, from exhaust gas treatment. It feeds back to the engine control unit,so you can make the engine more efficient." In the new series 8 oven, it measures the humidity level, preventing it from becoming too low preventing the food in the oven from being burnt.

Bosch expects energy efficiency to be one of the major success factors for their business and already generate more than 40 percent of sales with technologies and products that protect the environment and conserve resources. To maximise synergies Bosch established the company Bosch Energy and Building Solutions who offer services for commercial and industrial customers to help them save energy. For example Bosch supported a college in Bracknell, improving the energy efficiency of the ventilation system in their sportshall, reducing energy demand by 82%.

The hydraulic drives that are made in Glenrothes are energy efficient too. Although they are generally used in the construction industry, the London Eye uses them as well. "Our UK operations cover the complete spectrum of Bosch products." says Hoffmann.

Some of Bosch engineers' ideas for improved energy efficiency are award-winning. For example, the company has implemented, on an industrial scale, a new technology that uses ultra-short laser pulses to drill micro-scale holes.

> The CHP solution at Glenrothes meets in excess of one third of electrical needs and also provides 100 per cent of our office and shop floor heating and process needs.

This method is able to bore out petrol injection nozzles so precisely that the fuel distribution within the combustion chamber can be optimised, contributing to a fuel saving of up to 15% for petrol direct injection systems. In 2013, the team of Bosch researchers and partners responsible for developing the idea won the German Future Prize, awarded by Germany's Angela Merkel.

"Protecting the environment and doing business sustainably are central tenets of our corporate strategy. Bosch focuses almost half of its research and development spending on the development of eco-friendly products," says Dr Denner.

For example, Bosch also provides innovative solutions for decentralised energy systems. Smart connectivity for electrical and thermal energy using a photovoltaic system, combined with the latest in heat pump technology, can be implemented. This allows users to consume the lion's share of the electricity they generate from solar power in their own homes – which dramatically reduces electricity costs – while also powering the heat pump, so it can extract heat from air, water, or the ground – and convert it into energy that can be used for heat or hot water.

Dr Steffen Hoffmann, President of Bosch UK

The Bosch system features an energy management system that knows when the heat pump requires electricity and, provided there has been enough sunshine, answers that demand with solar-generated power. Another clever innovation is a WiFi-enabled Remote Room Controller with a touch screen and a corresponding app, which allows users to control their heating systems remotely via a smartphone, while providing information on consumption.

Energy efficiency is also best of class at Bosch UK. Each of Worcester Bosch's Greenstar i, Si and CDi Compact combi boilers already have A-rated status, with guaranteed efficiency levels of 94%. Greenstar i combi-boiler is a model introduced in 2015 for small and medium-sized homes

By adding a Wave Internet-connected Smart Controller with its combined weather and load compensation feature, it takes this to an impressive 98% efficiency. Bosch's Wave thermostat fills the role of a modern programmable control but, through a free clever App on your smart device. It also gives many more useful and easy-to-use functions puting people in control of their comfort whether they are home or away.

For instance, you can switch your heating or hot water on or off remotely using the app on a smart device via an internet connection. However, it is the load and weather compensating features which provide the extra savings. Unlike many other models on the market, the Wave takes into account the current room temperature and only fires the boiler at the necessary level.

Bosch Lawn & Garden bases in Stowmarket, Suffolk, produces Bosch's next generation of hi-tech, high value, garden tools. They have already launched the Indego robotic lawnmower, which 'learns' the shape of a lawn. It has also just launched a new PRO range of cordless garden tools, giving equivalent performance to petrol tools whilst significantly reducing vibration and noise with zero emissions. UKMR-15

Recycling: companies such as Marks & Spencer, as well as the EPSRC Centre for Innovative Manufacturing in Industrial Sustainability, are pushing methods to eliminate sights like this

Photo: Katja Novitkova ®

DECISIVE ACTION DEMANDS CLEAR DIRECTION

BY ISABELLA KAMINSKI

Although the manufacturing sector has taken big strides in cutting its waste and energy use, there is still a lot of work to do in the wider areas of sustainability. Strong government environmental policy will help set a level playing field and also enable the sector to stay competitive

By its nature, the manufacturing sector makes big impacts on the environment, both locally and globally, and is in turn threatened by climate change and resource limits. But the sector is taking big steps to improve its performance, spurred to a great extent by regulatory compliance and cost-cutting but also by wider corporate responsibility goals.

The most influential laws governing sustainability stem from the European Union, including the EU Emissions Trading Scheme and the Industrial Emissions Directive. The latter, which sets strict air pollution rules for 31 industrial sectors across the EU bloc, has started to bite over the past year. The directive was a key factor in the announcement that three UK coal plants would close by March 2016. And it will force operators in other sectors, from glass-making to paper production to intensive pig farming, to make big technical changes to their sites over the next few years.

In August, DECC announced a review of the energy efficiency landscape, including possibly scrapping the CRC, mandatory greenhouse gas reporting and the Climate Change Levy.

Domestic regulations have also had an effect on business sustainability, primarily when it comes to energy use and efficiency. A notable example is the Carbon Reduction Commitment (CRC), which was intended to encourage cost-effective energy efficiency. Earlier this year, the

Department of Energy and Climate Change (DECC) published a study showing that it had succeeded in doing this for many companies, helping them slash their carbon emissions[1].

The Department for Environment, Food and Rural Affairs' (DEFRA) latest figures show that the UK's business and industrial process sectors combined emitted 103 million tonnes of CO_2 equivalent in 2013, a 21.3% improvement on a decade earlier (see table below). Industrial energy intensity (energy consumption per unit of production) has also improved markedly over the past 35 years, although the chemical and food sectors have done much better than iron and steel.

EMISSIONS AND ENERGY BY NUMBERS

UK BUSINESS AND INDUSTRIAL PROCESS GREENHOUSE GAS EMISSIONS 2003-13

Year	MtCO2e*
2003	131.32
2004	130.63
2005	129.57
2006	125.66
2007	125.96
2008	121.52
2009	102.01
2010	106.56
2011	99.31
2012	98.54
2013	103.38

* Million metric tonnes of carbon dioxide equivalent

Above: Source: DEFRA/ National Air Emissions Inventory

UK INDUSTRIAL ENERGY INTENSITY 1980 TO 2014

Year	Energy intensity (Index (2000=100))
2000	100.0
2001	101.4
2002	98.3
2003	99.9
2004	95.7
2005	94.6
2006	91.5
2007	88.6
2008	86.6
2009	79.7
2010	82.8
2011	77.8
2012	78.4
2013	80.0
2014	78.7

Source: DECC

However, the second half of 2015 saw significant changes to government policy following the Conservative Party's win at the general election, with big implications for manufacturers.

Renewable energy subsidies and incentives were slashed and some dismantled altogether, making fuel sources such as biomass and solar a much less attractive option financially for companies hoping to be energy self-sufficient.

And in August, DECC announced a major review of the whole energy efficiency landscape, including possibly scrapping the CRC, mandatory greenhouse gas reporting and the Climate Change Levy.

One promising piece of work completed earlier this year by DECC and the Department for Business, Innovation & Skills (BIS) was a series of roadmaps for decarbonising UK's most carbon-intensive industrial sectors – including cement, ceramics, chemicals, food and drink, glass, iron and steel, oil refining, and paper and pulp – by 2050[2]. James Wyse, national sustainability lead for manufacturers' association EEF says this was "definitely the right approach". However, the project now appears to have been kicked into the long grass.

This policy uncertainty has caused serious concern, delaying investment in important upgrades and making it difficult for manufacturers to prepare for the future. Wyse points out that sustainability strategies need to be planned over at least a five to 10-year timescale, which is difficult for governments at the best of times.

But the turbulence has shone a spotlight on the companies going beyond compliance, either to give themselves a competitive edge or because they believe it is the only way to guarantee their long-term profitability.

Professor Steve Evans, director of research in industrial sustainability at the University of Cambridge's Institute for Manufacturing, says there has been a noticeable increase in the number of companies setting new sustainability initiatives over the past 18-months and announcing they have met their commitments. "The leading companies are not just talking or setting targets for many years in the future – they're busy doing things," he says.

Ikea is one of the front-runners on energy consumption. The home furnishings company has already spent Eu1.5 billion on renewable energy projects such as wind and solar since 2009, and in June promised another Eu600 million more. It says it is

"The companies that have the most interest in this at the moment are the ones who are concerned directly about the materials they use from outside the UK. Rolls-Royce is an example"

Professor Steve Evans, CIS Centre, University of Cambridge.

Working smarter: Toyota is working ard to reduce emissions and save energy

Image courtesy of Toyota UK

Håkan Dahlström CC BY 2.0

Front-runner: Ikea now has a 100% LED lighting range and has invested heavily in sustainable wind and solar projects

Pre-loved: secondhand clothing is well accepted by many consumers on ethical grounds

on track to become energy independent by 2020, producing as much renewable energy as it consumes in its buildings.

An Ikea spokesperson says this made good business sense because energy is the second largest cost in its stores. Investing in renewables has therefore helped it wrest control over rising energy costs. "In some cases sustainability imposes short-term costs. However, we also see that in most cases it creates efficiencies thus saving money and creating new business opportunities."

John Malpas, environment section manager for Toyota's UK manufacturing plant, says his facility's biggest achievements over the past year have been reducing energy use by using a new paint booth climate control technology. This eliminates the need for centralised steam generation for temperature and humidity control.

> Unilever met its target to obtain all its palm oil from sustainable sources by mid-2015 – three years ahead of schedule.

The plant also introduced a new nitrogen spray to cut down on paint consumption and overspray waste, and to reduce solvent air emissions.

In the vacuum caused by weak carbon markets, a growing number of companies are applying their own figure to each tonne of CO_2 produced, to help manage their emissions. A September report from the Carbon Disclosure Project showed that the number of organisations globally setting internal carbon prices had tripled over the past year; in the UK, these now include communications specialist WPP Group, hospitality giant Whitbread and retailer Morrisons[3].

In terms of resource use, Nestlé, Mars and Birds Eye, for example, are all on track to meet zero waste to landfill targets by the end of 2015. "Announcing zero waste to landfill ambitions has become commonplace," says Evans.

But while simple waste reduction is now a basic part of sustainability strategies, there are much wider resource issues at stake, particularly scarcity.

Evans notes: "The companies that have the most interest in this at the moment are the ones who are concerned directly about the materials they use from outside the UK." Rolls-Royce, for example, is "incredibly aware of material efficiency", he says.

Another notable example is Coca-Cola, which has been particularly vocal about its water risk strategy. This is, of course, unsurprising given that it is one of the company's key raw materials. In August, Coca-Cola announced that it was about to meet its 2020 target to replenish all of the water used by it and its bottling partners by the end of the year.

For Dr Steffen Hoffman, managing director of Bosch UK, sustainability is a much less dramatic concept. The company's seven UK manufacturing plants have a programme of continuous improvement to reduce their energy input and carbon. This is agreed with senior management teams, which then implement action points. "This is simply part of our business," says Hoffman.

But Evans says awareness of resource risks is still not widespread: "The leading companies have a larger view. Most normal companies are absolutely blind to it."

EEF's Wyse adds that there has been significantly more emphasis on reducing the amount of material used than on reducing the impact of the materials themselves – either during production or through a product's lifecycle. "For most their drive is still linked to cost savings which takes them down the route of resource reductions."

WHAT IS BEST PRACTICE SUSTAINABILITY?

While awareness of the importance of corporate sustainability is growing, it is doing so at a faster pace at companies that manufacture upstream, consumer-facing products.

Wyse says: "Carbon and water savings aren't really about brand differentiation. People expect businesses to be saving water and energy, because it will save them money. The real differentiation is about how you are adapting in your business practices."

He cites consumer goods giant Unilever as a good example. The company met its target to obtain all its palm oil from sustainable sources in mid-2015 – three years ahead of schedule. It also fast-tracked its target to sustainably source all its wood-based packaging by the end of the year – five years ahead of schedule.

The most forward-thinking companies are looking beyond their own immediate manufacturing processes and examining the full life-cycles of the products they make. Ikea, for example, now has a 100% LED lighting range.

But Wyse says Ikea can do these kinds of things because of its size, noting most manufacturers are still focused on compliance rather than the future. "The reason why some companies stand out is because they are the exceptions to the rule. There is still so much that they can do to improve their performance in terms of energy and resources that they haven't seen the necessity to look forward yet."

Evans agrees, saying that the gap between the leaders and the laggards is "enormous".

Image © Oxfam

The UK's business and industrial process sectors combined emitted 103 million tonnes of CO_2 equivalent in 2013, a 21.3% improvement on a decade earlier.

Source: DEFRA

Return to source: Marks & Spencer's 'Plan A' sustainability programme has been a commercial success

REMANUFACTURING

With the circular economy concept still at a nascent stage, set back by the European Commission restarting its legislative discussions, remanufacturing became one of the big sustainability buzzwords of 2015. Scotland really has been one of the leading regions for this, launching a £100,000 remanufacturing fund for businesses and financing a £1.3 million remanufacturing research centre at the University of Strathclyde which opened in January.

Evans has noticed an increasing trend for corporate experimentation. "People are trying to do things in one plant or one part of a plant with the specific idea of seeing how far they can get. Then if successful they roll it out across the rest of their factories, or the supply chain."

He cites one project with Marks & Spencer, which is experimenting with its business model to try to return 50% of the clothing it sells back into the company. Evans says this will take "a combination of technical change and logistical and management practices". It is an extension of M&S' "Plan A" sustainability strategy, which the company credits for its recent financial successes and which has also been positively received publicly.

But retaining a competitive edge relies largely on consumer confidence, which was shaken by the recent revelation that VW had been fiddling its emission data. As well as putting a serious dent in the company's credibility, the scandal is likely to have repercussions on the way that regulation is framed and monitored, and the way companies approach corporate social responsibilities strategies.

What else will 2016 bring in this field? It's hard to tell, with UK government policy so uncertain. On energy efficiency, though, the Energy Savings Opportunity Scheme (ESOS) could drive improvement. ESOS, which has similar elements to the CRC, required companies to undertake an energy audit by December.

But it has been plagued by low awareness and a lack of appreciation about its advantages. This is partly because companies are under no obligation to act on the findings of the audit, so it remains to be seen if manufacturers really grasp the opportunity next year or just see it as a compliance exercise.

One big certainty for 2016 is a major revision of environmental management standard ISO 14001, which was published in September. For the first time, it requires companies to examine their supply chains and the full life-cycles of the products they make. It also requires engagement from senior management. This is likely to be a big cultural shock for some firms but could also increase corporate recognition of the value of sustainability and drive better practices.

Toyota, for example, will start to evaluate any new requirements that need to be implemented. Malpas expects the new standard to increase focus on risk management at the company's manufacturing plant.

Next year could be a game-changer in terms of industrial sustainability, particularly following the United Nations climate change talks in December. These will present huge challenges for government to set a strong and equitable regulatory framework and for the energy-intensive manufacturing sectors to move beyond compliance on their own terms. Some have even pointed to the Northern Powerhouse concept as an ideal opportunity to build sustainability into the heart of manufacturing, right from the start.

"Long-term strategy needs clear direction from government," says Wyse. "Once we have that we can get together as a group of businesses and see what we can do to collaborate."

Evans hopes that next year will bring better corporate information and good practice sharing. He says even the most advanced companies can gain from this and that it all boosts resilience in both the environment and national industry.

However, the dark shadow caused by the steel crisis cannot be ignored, raising hard questions about how to balance environmental concerns with the need to retain a domestic industry. Wyse warns that, if these challenges are not embraced, we not only risk environmental and climate damage, "we risk losing parts of our manufacturing sector altogether".

FOOTNOTES

1. DECC: CRC Energy Efficiency Scheme Evaluation – Final Synthesis Report

2. DECC/BIS: Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050

3. Carbon Disclosure Project: Putting a price on risk - Carbon pricing in the corporate world **UKMR-15**

Small is beautiful

"By adopting the new guidelines and potentially investing in foundries using these new approaches we will be able to reduce energy usage in aluminium casting by one-third."

Cranfield University's Sustainable Manufacturing Systems Centre provides tailored solutions to issues around manufacturing processes for industrial clients, through using a systems approach to identifying the root causes of problems and recommending evidence-based solutions.

The centre runs the Small is Beautiful project, which researches the introduction of design for reduced energy in manufacture. One of their projects is looking at how to make light metals casting more energy and material efficient, and has introduced a technique which could reduce the energy costs of light metal/aluminium foundries by at least 50%.

This new approach, called CRIMSON, enables foundries to heat only enough material needed to fill a single mould rather than the whole batches of metal melted in the current approach.

The layers of oxide which develop on liquid metal during the traditional method's pouring process are minimised using CRIMSON (which relies on a counter-gravity casting method), leading to improved yield and well as a better quality material.

A different mind-set towards the scale of metal casting activities accompanies the new processes. Rather than an 'economies of scale' approach, CRIMSON advocates one of '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 of a higher quality than under previous techniques, leading to a reduced scrap rate and decreased re-melting costs. The savings this technique could bring are significant. Last available figures (2012 world census) suggested the equivalent of 1 400 800 tonnes of oil is used every year in British foundry manufacturing processes.

The UK is at the forefront of the light metal casting, and investment casting, technologies vital to the global aerospace and automotive industries. Fifty per cent of the European Investment Casting Sector is based in the UK, about 400 foundries.

Mark Jolly, Professor of Sustainable Manufacturing at Cranfield University and of the "Small is Beautiful" project summed up the potential savings from this new technique: "At the moment in the UK we use the equivalent of every woman, man and child boiling a kettle twice a day, every day of the year, just to melt the aluminium for casting. It is hoped that by adopting the new guidelines and potentially investing in foundries using these new approaches we will be able to reduce energy usage by one-third.

"Any understanding of the relationship between processing and energy usage is of benefit to both the process engineer and designer in today's climate of sustainability". UKMR-15

Wyke Farms, Somerset
Richard Clothier, MD, Wyke Farms Ltd
Colin James, Relationship Director, Barclays

As Britians largest independent farmhouse cheese maker, Wyke Farms wanted to become self -sufficient in energy production. Barclays supported them by providing £3.5m of finance to build a biogas plant to recycle waste and generate green electricity. As MD, Richard Clothier, says "It's people that make things happen. Barclays' knowledge, enthusiasm and commitment are crucial to making our business sustainable and competitive".

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BARCLAYS

SECTORS - INNOVATION AND GOVERNMENT

RDM Automotive had no exposure to autonomous vehicles until they responded to a Transport Systems Catapult tender. The tier-one automotive supplier is now manufacturing driverless pods

Image © Transport Systems Catapult

BY MALCOLM WHEATLEY

Seeking the mother of invention

UK manufacturers are regularly at the forefront of innovation often supported by a myriad of government bodies dedicated to stimulating the sector. But with the UK's expenditure on R&D decreasing, the sector cannot rest on its laurels

Half-airship, half-aircraft: hybrid air vehicles that combine lighter-than-air aerostatic lift with a body shape that produces aerodynamic lift, like an aircraft wing. Lobes in the hull reduce drag, permitting them to carry heavier loads than conventional airships, while vectored thrust from directional ducted propellers allows them to hover precisely in position, as well as take off and land on ultra-short strips.

The world's first such vehicle finally floated for the first time on Saturday, 31 October 2015 at 10pm, having been built by Hybrid Air Vehicles of Cardington, Bedfordshire. Dubbed Airlander, it is also the world's largest aircraft, and should be ready for its first full flight during the first quarter of 2016.

Capable of carrying up to 10 tonnes of cargo, and flying halfway around the world on a single tank of fuel, Airlanders have ultra-long endurance, and a point-to-point cargo carrying capacity. Moreover, they can take off and land vertically and operate in a range of remote environments including water, desert, ice and fields, requiring only minimal infrastructure.

"Seeing the Airlander come to life and floating was simply breathtaking," says Mike Durham, technical director of Hybrid Air Vehicles. "This is a key moment for the UK's aerospace industry in getting this unique aircraft ready for flight."

Just as fascinating as the aircraft itself is the funding model behind the company that built Airlander. With many obvious potential applications in markets such as coastguard duties, military and civil surveillance, cargo carrying and oil, gas and mining exploration, Airlander has already secured more than £60 million of customer funding, more than £6 million of government grants of one form or another, and over £12 million of equity funding. An Initial Public Offering on the London Stock Exchange's Alternative Investment Market is the eventual plan.

Put another way, Hybrid Air Vehicles has joined many other UK manufacturers – small, medium-sized and large – in developing and bringing to market commercially exploitable innovation in partnership with government. From friction-free gearboxes to nanoceramics, to the redesign of aircraft wings' winglets to make them more suitable for automated production to high-tolerance composite cutting in the aerospace sector, the public purse has helped fund significant numbers of innovation projects.

INNOVATORS LARGE AND SMALL

Sometimes, the manufacturers involved are large, well-established businesses already regarded as technology leaders. It was GKN Aerospace, for instance, which worked with two High Value Manufacturing Catapult centres – the National Composites Centre and the Advanced Manufacturing Research Centre – to redesign those aircraft wings' winglets, one of a number of collaborative R&D projects funded under the £12 million Structures Technology Maturity (STeM) programme launched by government innovation agency Innovate UK (formerly the Technology Strategy Board) and the relevant academic research councils in 2012.

"Our target was to produce a winglet that performed just the same, but more quickly and at a lower cost. We achieved 20% cost savings, reduced production times, and improved the consistency and quality of manufacturing," says John Cornforth, GKN's head of airframe technology for European special products. "We learned a lot that can be applied to other aerostructure projects."

At the other end of the scale, a grant of just £10,800 – again through Innovate UK – helped Bolton-based Bindatex, founded in 2004, diversify from cutting materials for book binding to cutting composite and laminate materials for manufacturers of other products, in particular in the aerospace sector. Almost instantly successful, the move saw sales revenues at Bindatex jump to a projected £540,000 in 2015 from £70,000 in 2012. A further grant of £3,500 – a sum of remarkably modest proportions – provided coaching and mentoring to help to develop a three-year business plan.

But why is such government backing for innovation necessary? In the country which began the Industrial Revolution, and which invented and commercialised innovations as diverse as the railway locomotive and the jet engine, why do present-day manufacturers require such assistance?

"Innovate 2015" run by UKTI had 2,512 unique visitors & over 3,000 visits over two days in November, a rise on 2014

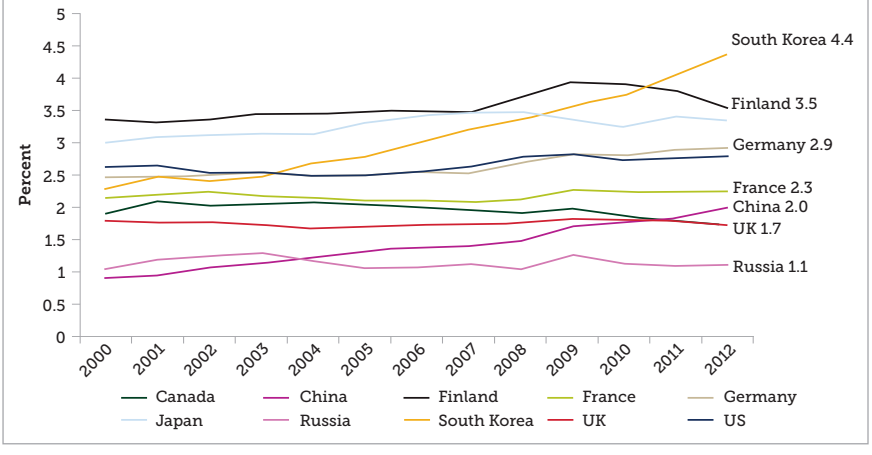
There is, it seems, no simple, single answer. The UK's R&D abilities are undoubted: as the Department for Business Innovation and Skills biennial publication *Innovation Report 2014* points out, the UK has a world class research base, which punches above its weight.

With just 4% of the world's researchers, for instance, the UK accounts for 6% world research articles, 12% of citations (a key measure of research excellence), and 16% of the most highly cited articles. Moreover, the country is an attractive R&D destination, leading most of the world in terms of inward foreign investment into its innovation and research system. Expenditure on R&D by foreign owned companies now exceeds that of domestically owned firms.

On the other hand, the report points out, UK expenditure on R&D as a percentage of GDP is significantly lower than that of a number of international competitors – including France, Germany, China and the US – and also declining.

And a further Department for Business Innovation and Skills report, *International Comparative Performance of the UK Research Base – 2013* shows just how wide the gap is. Making use of OECD data, adjusted for constant prices and purchasing power parity, it estimates that Germany spends more than twice as much on R&D as the UK, China spends five times as much, and the US 10 times as much. With innovation reckoned to account for up to 70% of long-term economic growth, such discrepancies are undeniably troubling.

As a proportion of GDP, leading international competitors spend more on R&D



INNOVATING TOWARDS GROWTH

So perhaps it is no surprise that David Willetts, the former minister for Universities and Science, was so forthright in expressing the government's commitment to encouraging innovation in his foreword to the Innovation Report 2014. With the 2013 Spending Review placing particular emphasis on support for business led innovation as a priority for additional investment, in order to drive economic growth, he emphasised that Innovate UK had been specifically tasked – and appropriately funded – with the job of helping businesses, large and small, to develop new ideas into commercial success in key UK economic sectors.

That help comprises two very distinct forms of assistance, explains Zoë Webster, head of high value manufacturing within the innovation programmes directorate at Innovate UK.

"Over 90% of manufacturers are already innovating, so there's only a small proportion that needs help in starting to innovate," she says. "Where we help most is in helping manufacturers accelerate their innovations, and so get to market earlier; and also innovate more broadly, and so develop a broader product or service offering around the original core concept than would otherwise have been the case."

That said, despite the extensively-published case studies showing the results of Innovate UK's assistance to manufac-

turers, Webster acknowledges that it can be difficult to measure the success – or economic impact – of such interventions.

Carl Perrin believes in a collaborative approach to innovation

"We're obviously required to demonstrate to the Treasury how successful we are, but the time lags can be considerable," she points out. "There can be seven years between us working with a manufacturer and the results showing up in increased sales and profits. In the meantime, though, there are interim benefits showing up in the form of increased employment, safeguarded jobs, increased skills, and improved process knowledge."

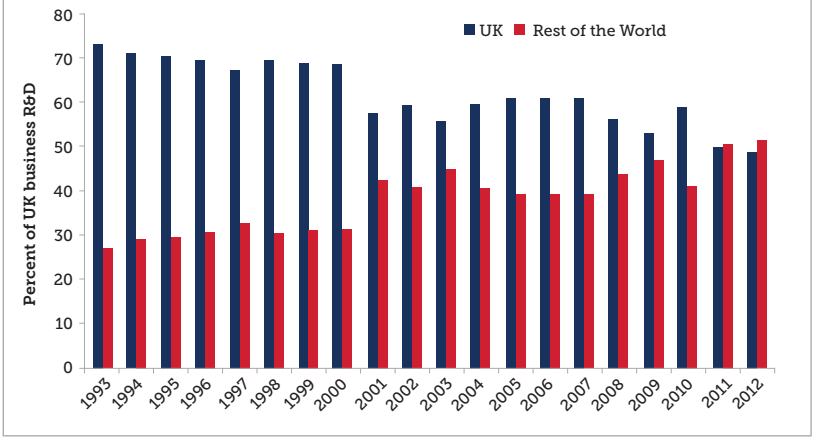
And by design, explains Webster, the nature of Innovate UK's assistance is predisposed towards hard, practical help – starting with the insistence that every collaborative research partnership is business-led, not university-led, and focused on commercialisation, not simply academic publication.

"Often, innovation is competing with capital equipment spend, and – particularly in smaller companies – it can be difficult to make internal funding available in the right timescale and quantity," she says. "We represent an alternative source of funding, and also help to provide access to specialist hi-tech manufacturing equipment via the various Catapults, key technical skills, and of course manufacturing and entrepreneurial advice."

That said, Innovate UK – together with its Catapults and associated organisations such as the Manufacturing Technology Centre – isn't the only game in town when it comes to practical help for innovation. The Department for Business Innovation and Skills' Business Growth Service, for example, also provides 'hands on' advice to those manufacturers, especially at the smaller end of the size spectrum, who are seeking assistance in bringing new products to market.

"There's typically a lack of structured process thinking among SMEs when it comes to innovation and new product development," says Roy Pulley, an adviser with the service. "They don't know what they don't know, in other words. Our approach is to explain where the banana skins are, and put in place metrics and checklists to help businesses understand where they are in the innovation process, and what they ought to be doing. In essence, learn fast, fail fast, and kill the losers early."

FOREIGN-FINANCED R&D IN THE UK NOW EXCEEDS DOMESTICALLY-FINANCED R&D



Source: Innovation Report 2014

COLLABORATIVE INNOVATION

Meanwhile, the Institute for Advanced Manufacturing and Engineering is an example of another form of innovation assistance, explains its director, Carl Perrin, a former head of technology at a Rolls Royce joint venture developing and manufacturing turbine coatings for a range of Trent aeroengines.

Established in 2014 as a collaboration between automotive manufacturer Unipart and Coventry University, the Institute is part-funded by the Higher Education Funding Council for England, and is already building a reputation for combining university-level manufacturing engineering education with pioneering work in powertrain applications.

"Look at companies such as Rolls-Royce and Jaguar Land Rover and what you see is them accessing a massive network of suppliers, institutions and partners to take innovations forward," says Perrin. "Smaller manufacturers can lack the contacts and supply chain partners to fully exploit an innovation, or even develop the expertise to access funding. In some ways, it can take collaboration with a larger manufacturer or institution to actually get things moving."

Even so, it would be a mistake to characterise Innovate UK's approach as purely reactive, dispensing funding in response to manufacturers' requests. There is also a very strategic, proactive aspect to its work – picking promising-looking technology ideas, and putting together consortia to develop them further, hopefully to the point of full commercialisation.

Autonomous vehicles, known as 'pods', which are being trialled in Milton Keynes, represent one such example. Manufacturer RDM Group originally had no prior exposure to the concept of autonomous vehicles, beyond a level of general awareness from its business as a tier-1 and tier-2 supplier of components and advanced engineering solutions to automotive manufacturers, explains Miles Garner, director of sales and marketing for the group.

"And then, about a year and half ago, a tender came out from Innovate UK and the Transport Systems Catapult, to design an autonomous vehicle from the ground up," he explains. "We quoted, alongside consortium partners Oxford University, and were successful – investing our own money in the project, alongside European Union funding and money from Innovate UK.

"With the pods delivered, we've discovered that we're now having meaningful conversations with large companies who want to partner with us, because of the expertise we've now acquired. Without the initial external funding to kick-start the project would never have happened."

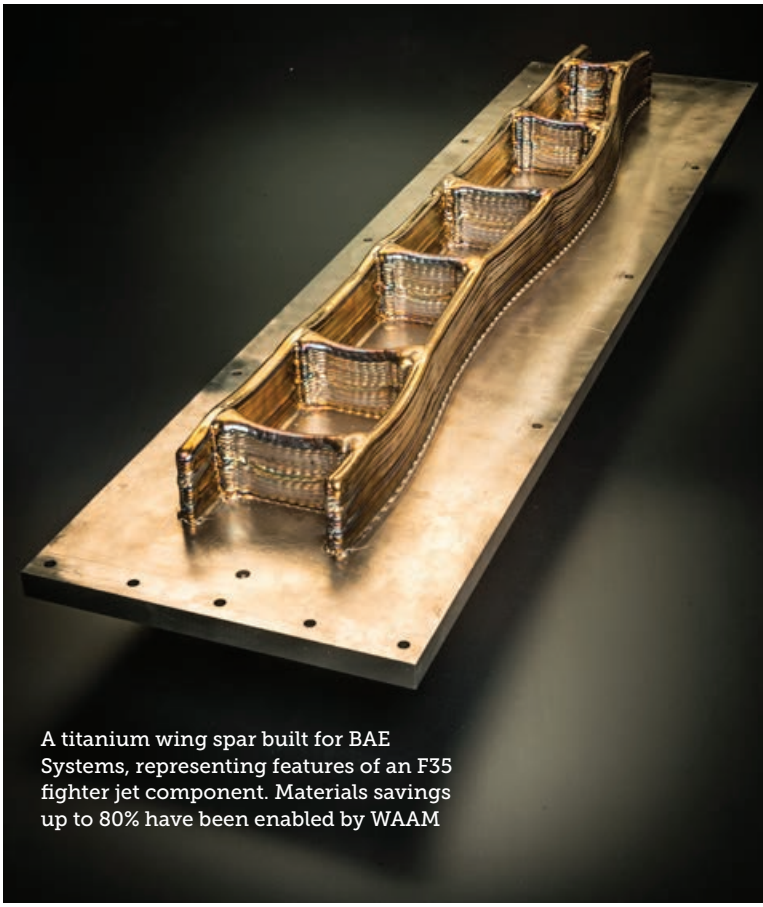
That said, it's worth keeping the importance of government funding in perspective. Intriguingly, recently-published research from Lancaster University Management School shows no significant connection between businesses' resource constraints – especially in the form of raw knowledge – and the resulting level of innovation. If the idea is a good one, suggests lead researcher Dr Rebecca Liu, businesses often find a way of bringing it into being.

"One effect seems to be that firms focus and concentrate even more," she sums up. "There's something of a paranoia at work, where businesses over-compensate."

So necessity, it seems, can be the mother of invention. UKMR-15

Printing the future

Hundreds of millions of pounds are spent on medium to large scale components by the aerospace industry each year. There is an enormous potential for huge cost savings in terms of waste and production efficiency if the manufacture of these parts could be transformed



A titanium wing spar built for BAE Systems, representing features of an F35 fighter jet component. Materials savings up to 80% have been enabled by WAAM

With the increasing use of carbon fibre reinforced polymers, aircraft designers are forced to shift from aluminium to titanium due to aluminium being electro-chemically incompatible with carbon. This means the demand for titanium parts is increasing and is likely to remain high with the current and forecast aircraft market expansion rate.

Titanium is a very expensive material to source and machine. So, in the aerospace industry, there is a pressing need for the development of a manufacturing process for large structures such as stiffened panels and wing ribs to replaces the current method of machining from billets or large forgings. Wire + Arc Additive Manufacture (WAAM) is a new 3D printing process enabling the production of large structural parts such as these with significantly reduced time and cost constraints

POSSIBLE AND AFFORDABLE

WAAM, the combination of an electric arc as heat source and wire as feedstock (raw material), has been investigated at Cranfield University for AM purposes since the 1990s. WAAM hardware currently uses standard, off-the-shelf welding equipment – welding power source, torches and wire feeding systems.

Cranfield University is developing both hardware and software for commercialising WAAM to enable it to be applied to the manufacture of these components. Depositing large components (in excess of 100kg) in titanium, as well as aluminium, steel and other metals, is now possible and affordable using WAAM.

One of the largest 3D metal titanium parts in the UK, measuring 1.2m in length, has now been produced as a result of the research. The part forms a main structural element of an aircraft wing structure and took just 37 hours to build from a digital model, where previously this process would have taken weeks. Furthermore an even larger aluminium wing part measuring over 2.5m in size has also been produced in less than one day.

Professor Stewart Williams leads the Welding Engineering and Laser Processing Centre (WELPC) at Cranfield University and is conducting the WAAMMat research programme. This multi project multi-client programme has been put in place, with the aim to mature the technology so that it can be exploited by industry. The research is tackling problems such as automation, mechanical properties, residual stress and distortion and how to build complex structures. The programme comprises more than 35 activities including student projects, industry contracts and government funded projects. UKMR-15

WHAT IS WAAM?

"Among the different AM processes, WAAM seems suited to the manufacturing of medium to large scale components and substantial reductions in manufacturing costs and lead times are its main business drivers, as well as the complementary advantage of increased design freedom. Now that the business case has been built, we are supporting major players such as Airbus and BAE Systems along the road towards qualification of WAAM for the manufacture of Class 1 structural components."

Professor Stewart Williams, Cranfield University

Another dimension, a world of possibilities

BY RACHEL PARK

SECTORS - ADDITIVE MANUFACTURING

Consumers may be getting excited about 3D printing – aka Additive Manufacturing – but its biggest impact will be felt in industry. Some sectors, however, will take longer than others to employ it for mass manufacture

The practical uses of 3D printing may still be a source of some confusion among the general public, but that is certainly not the case in UK industry – where it is more commonly known as Additive Manufacturing (AM).

Within the sector, there is an ever-increasing understanding of the technologies and processes available – and their application for development and production. Today, the industry is worth $4 billion (£2.65 billion).

The leading application for AM technologies remains prototyping, courtesy of the benefits it brings in terms of producing accurate, functional prototypes in a speedy and cost-effective way. However, direct production applications, particularly with metal materials, are becoming more common and have the potential to revolutionise industrial design.

The maturation of the ecosystem around AM hardware platforms has also gone a long way to drive uptake of additive technologies, specifically more powerful system software, as well as design and scanning input capabilities, together with a much wider palette of materials that can be more reliably used on the machines.

Most notably, the proposition of more capable and all-encompassing file formats such as the AMF and the formation of a consortium of leading global software and 3D printing companies to develop an open 3MF (3D Manufacturing Format) are driving an increasing emphasis on end-to-end manufacturing solutions with AM – solutions that include 3D data generation, materials and finishing requirements as well as production hardware.

Despite tremendous progress, there are still numerous limitations on the technology and there are trade-offs between speed, resolution and repeatability.

HOW 3D PRINTING INTENDS TO MAKE IT BIG

Renishaw is the only UK company that develops and manufactures metal AM systems and has invested heavily in R&D for its laser melting process. This year has seen particular focus placed on control issues and new optical systems as well as developing an end-to-end manufacturing solution.

According to the company, 2015 has been a year of consolidation and solid growth on the AM front – the core technology development group has moved into new premises at the company's headquarters in Gloucestershire, while the AM division has expanded into a new and significantly larger facility in Stone that will focus on AM application development and operate as a technology centre for current and potential clients.

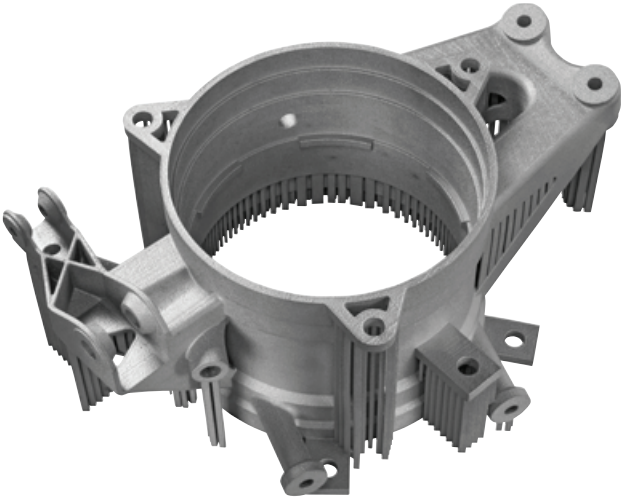


Photo courtesy of Renishaw

Laser melting: UK company Renishaw is developing end-to-end manufacturing

Birmingham-based Cooksongold is a jewellery company that has seen its strategic partnership with German metal AM system manufacturer EOS come to fruition this year. After four years of development, Cooksongold launched the M080 platform, an AM system that can produce parts in 18 carat gold, based on EOS's DMLS process.

The M080 is presented as an end-to-end manufacturing system that processes precious metals and was officially launched at the huge Basel World jewellery event in Switzerland in March 2015. By autumn, the company had sold two

machines and was receiving enquiries for more. It is working on processing other precious metals.

Ion Core, a UK-based manufacturer of mid-range, desktop additive machines, reports that it has penetrated into key industrial vertical markets this year. With clients in the automotive, aerospace, architecture and medical sectors, Ion Core has continued to scale up production in response to tremendous growth and is set to introduce two new platforms, together with a significant broadening of its material offering.

Arburg, the German machine manufacturer, well known in the injection moulding sector, launched its new Freeformer AM platform on the UK and Ireland markets earlier this year.

The machine, first introduced in Germany in 2013, uses the patented Arburg Plastic Freeforming (APF) process. It stands out among its peers due to its ability to process plastic materials in standard granular form, an economically favourable proposition compared with filament or powdered materials.

"The introduction of the Freeformer is a huge technological step for [Arburg]," Colin Tirel, managing director, Arburg says. "We have always considered ourselves a technology innovator, not a technology adopter, and our new system for AM is a superb example of this philosophy."

Two other new 3D printing platforms to emerge from Britain are the 5axismaker from 5axisworks, and a new resin 3D printer from Photocentric. The 5axismaker was introduced following a crowdfunding campaign. It is an accessible, multi-functional desktop tool for industrial applications that offers 5-axis CNC machining, 5-axis probe scanning, and 5-axis extrusion 3D printing capabilities courtesy of an interchangeable tool-head set-up.

Photocentric, meanwhile is a specialist manufacturer of high performance 3D photopolymer resins. As an extension of its core business, the company has developed and just introduced a new LCD desktop resin printer that processes a unique daylight polymer resin, also made by the company.

IF CANON CAN...

R&D activities into AM are continuing in Britain. The AM/3DP Research Group at the University of Nottingham, led by Professor Richard Hague, is conducting a series of independent and collaborative research projects.

Key areas include the development of multi-functional platforms and materials and a new metal jetting process in collaboration with Canon company Océ.

The first concept machine for jetting metal materials was installed in the research group's lab earlier this year. While still in the embryonic stages, this is a significant development that points to the exciting future potential of metal applications of additive technologies.

"We are now beginning to realise the real potential of AM and comprehend – and therefore overcome – the technical challenges," Hague comments. "We are way beyond where I thought we would be five years ago. It is a very exciting time."

The University of Sheffield, which is home to the Additive Manufacturing Research Centre (AMRC) and the Centre for Advanced Additive Manufacturing, is another hotbed of AM research and development.

Professor Neil Hopkinson is developing a new high-speed sintering AM process that is nearing commercial reality. Spanning 12 years, the concept was conceived while Hopkinson was a lecturer at Loughborough University, and the initial patents were filed in 2003.

The central premise of the process is that it can produce high volumes of AM parts at a speed that competes with or improves on traditional manufacturing techniques – while also improving part functionality and aesthetics. Hopkinson says: "It is an economically viable, high production rate system."

Cooksongold

Exciting developments: Cooksongold of Birmingham

With a number of major breakthroughs this year, Neil says that he expects volumes for a single platform to reach one million parts per day. "The vision for this technology is that it is available to platform manufacturers under non-exclusive licences, thus opening up supply chains for the equipment market in a similar way to how the injection moulding sector works."

The project already has key industrial partners, including BAE Systems, Unilever and Xaar. There are numerous further research projects being conducted into AM inks, applications and process developments. The universities of Liverpool, Cambridge, Heriot-Watt, Bath, Southampton, Warwick and Reading are all carrying out research activities that will keep Britain at the forefront of AM technological developments.

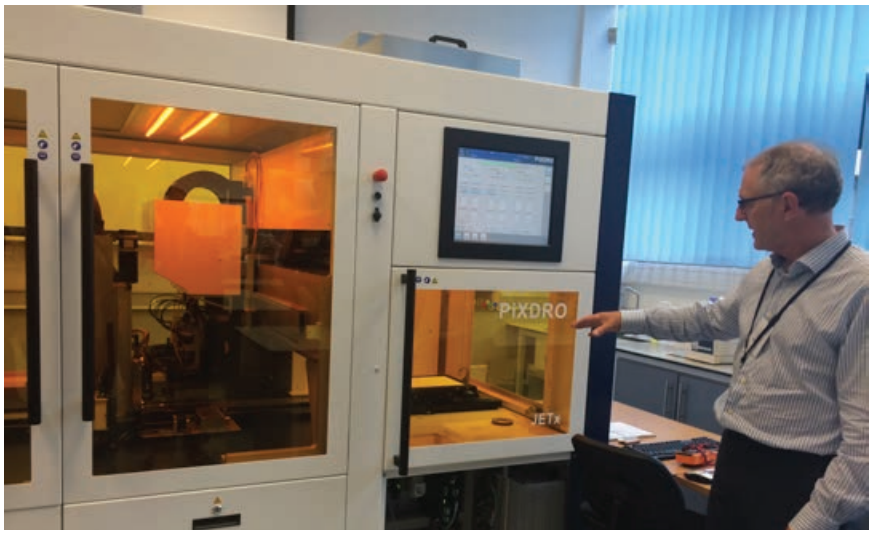
Another development close to commercialisation is the new Picsima AM process for real silicone materials. Developed by Sheffield's industrial and product design consultancy Fripp Design and Research, the Picsima process produces parts from room temperature vulcanising medical grade silicone. Its technology its regarded as novel by the European Patent Office, but Fripp says it is being constrained by a lack of funding for its exploitation.

FROM AERO TO ARCHITECTURE

When it comes to applying Additive Manufacturing technologies across industry in Britain, a number of sectors stand out in terms of adoption and continued uptake – aerospace, automotive, medical and architecture. The aerospace industry

has been at the forefront of driving applications for additive tech for prototyping and, more recently, final production. This year, Airbus, which has a solid track record when it comes to 3D printing and Additive Manufacturing parts across its entire enterprise, revealed that it had produced more than 1,000 in-flight parts for the A350 XWB aircraft from AM.

Apart from highlighting Airbus's engagement with additive technology, in this case supplied by Stratasys, it also provided some solid evidence of the penetration AM has made in the aerospace sector, but with higher volumes of final production parts. There is also evidence that BAE, Rolls-Royce, Boeing and GE have similar AM strategies. UKMR-15



University of Nottingham

Big challenges, huge potential: exploring applications at Nottingham university

Ones to watch

Croft Additive Manufacturing, based in Warrington, was set up to offer specific metal AM services.

The company has been developing and manufacturing original parts for a number of key applications on its in-house Realizer metal AM platform and has been conducting dedicated research into finishing operations for metal parts – an overlooked part of the process – to further maximise the potential of metal AM.

3D Print Bureau, meanwhile, is an independent service provider of a wide range of additive processes. Led by industry veteran Gary Miller, the company is set to be the first in the UK to acquire and run a new Carbon3D platform, which uses a proprietary continuous liquid interface production (CLIP) process and produces parts in real thermoplastic materials – an unprecedented offering that is cited by many as a "game changer".

Although this type of rhetoric is not uncommon in the AM industry, beta testers of CLIP, including Ford, are reporting unprecedented applications and results.

A spin-out from the Centre for Fine Print Research at the University of the West of England centres on the long-standing research into 3D printing of ceramics by Stephen Hoskins. Called Argillasys, the company is positioned as both an online boutique featuring a curated range of designer ceramic items for sale and a bureau service.

One initiative that seeks to create a unified strategy for AM in the UK was launched in 2015 at Coventry's Manufacturing Technologies Centre and hopes to ultimately be integrated into British industrial strategy.

While recognising the progress of AM in the UK it is also important to view it within a global context. The US, Germany, China and Singapore are notable geographic regions for extensive AM activity. In particular, the US is home to a number of companies pushing the boundaries and introducing new technology platforms and materials that are set to change the sector's landscape.

Developments at MIT point to accessible, multi-material 3D printing. Voxel8, a spin-out commercial company, has developed a multi-functional 3D printer that promises the ability to print conductive materials in-situ, alongside traditional plastic materials.

The Carbon3D platform is perhaps most anticipated as it nears commercial launch and promises the greatest impact in 2016, along with the highly anticipated new industrial 3D printer from HP. This company has been busy consolidating in 2015 and split into two separate divisions.

This saw Dion Weisler, previously head of HP's PC and printing division, become chief executive of an independent publicly traded company. Steve Nigro was named as the head of HP's new business devoted specifically to 3D printing. The new machine is at least a year out from commercialisation, with the earliest launch date scheduled for the back end of 2016.

The two dominant AM/3DP companies – Stratasys and 3D Systems – are headquartered in the US and continue to serve global markets via regional subsidiaries and extensive reseller networks.

3D Systems is closely aligned with corporate giant Canon as plans to extend its reseller relationship further across the globe have been revealed, together with Canon's own internal developments – via Dutch firm Océ and other means.

3D Systems and Stratasys have always competed strongly and invite comparison from the very start. Looking ahead, it is not hard to envision a new leadership dynamic emerging within the AM sector in the coming years as both HP and Canon push further into the field by way of technology development, collaboration, and, potentially, acquisition.

The road to smarter, lighter, greener

BY PROFESSOR LORD BHATTACHARYYA, KT, CBE, FRENG, FRS

This year and next, successful British manufacturers and popular British products will need to be greener, lighter and smarter.

The reason is straightforward. Britain is recovering well and European economic growth is at last picking up, but the real drivers of global growth are in India and China, where growth of 5% a year is seen as a failure and domestic consumer and business demand is expanding.

Success in these markets can transform an industry. British automotive exports outside the EU have grown six fold in fifteen years, achieving £15 billion of new orders. Exports to the EU grew just £3 billion over the same period.

This kind of opportunity means British manufacturers must develop innovative products and processes for these markets, while dealing with regulatory and competitive pressures to reduce resource demands and lower costs - making it possible to offer customers good value even when exchange rates are unfavourable.

Such a long-term focus takes significant technology investment. UK automotive R&D has doubled since the recession and is now nearly £2 billion a year. Automotive innovation is now over a tenth of all UK R&D, a change driven by Britain's biggest investor in manufacturing innovation, Jaguar Land Rover.

Yet even successful innovators must not relax. Consider the scale of China's new technology strategy. Copycat products and commodity prices may be today's frustrations, but China-designed products will soon change THE whole sector fundamentally. More than a hundred of the top thousand global R&D companies are now Chinese owned, and China's domestic innovation spending jumped 46% in 2014 alone.

Given the scale of investment elsewhere, British manufacturers will need to build enduring innovation partnerships to maximise their returns from research invest-ment in green, light and smart technologies.

£150M NATIONAL AUTOMOTIVE INNOVATION CENTRE

At WMG we're supporting our manufacturing partners' green innovation plans with a £14 million battery pack manufacturing research centre. The project will help develop the next generation of traction batteries for electric and hybrid vehicles.

We're also working to help firms meet the lightweight challenge by investing in two major new research institutes in advanced materials, so reducing weights, energy consumption and production costs. One will focus on advanced steel, another on plastics.

Our biggest new research hub, the £150 million National Automotive Innovation Centre (NAIC), will back UK and global manufacturers and suppliers who are proven smart innovators. It will create a world class innovation cluster which links battery, engine and materials advances, developing real world applications for new products, and by integrating the physical and the digital through new design, testing and production systems all the way to developing , connected and driverless vehicles as part of a co-ordinated transport networks.

> "By 2020, Britain could fall to 28th out of 33 OECD countries for immediate skills if we don't act. That will not be good enough."

WMG is supporting its partners' green innovation plans with a £14 million battery pack manufacturing research centre

That's one way manufacturing will get smarter, but there's another just as important. By 2020, Britain could fall to 28th out of 33 OECD countries for immediate skills if we don't act. That will not be good enough.

At WMG, we're only not thinking of next year's University students. We're backing the skills and the engineers in the next decade. When our second Academy for Young Engineers opens in Solihull next year, we'll be on the way to giving a thousand youngsters a chance to be world class engineers.

These young pupils will join over three thousand WMG students, engineers, researchers, teachers, entrepreneurs and technicians, all working with businesses to make Britain's manufacturing greener, lighter and smarter for many years to come. It's a good time to be making in Britain. It's a great time to be innovating. UKMR-15

Renishaw is working with the Bristol-based BLOODHOUND SSC supersonic car team to additively manufacture the vehicle's nose cone and also the titanium steering wheel which has contours that are precisely designed to match the hands of driver Andy Green.

PUSHING THE LIMITS OF WHAT ADDITIVE MANUFACTURING CAN DO

ROBIN WESTON, RENISHAW

Robin Weston, Marketing Manager for the Additive Manufacturing Products Division at Renishaw, says that like any new technology, the more engineers use AM, the more "we stretch it and find out where the limits are".
The Solutions Centres will "allow customers to gain a deeper understanding of the capabilities of AM technologies".

That will enable companies to address all the unknowns that go with deploying new technologies. The Centres will mean more customer-facing work, but also free up some of Renishaw's engineering team to go further in "really understanding the performance envelope of the technology", Weston explains.

The technology needs to be stretched, he adds. Its limitations need to be assessed and fed into future product development.
"The Centres are a representation of the voice of the customer, and that guides our product development."

He adds that Renishaw does a lot of machining and is a big consumer of machine tools.

"People understand that additive manufacturing has a part to play, but it doesn't take you the whole way. You will certainly need to integrate it with other processes.

"That is certainly a message we are starting to push."

Weston explains that companies in the supply chain that do not understand the complexities of design and manufacture with AM are having to learn how to successfully position it in a production environment.
They need to understand the supply chain for raw materials, and how to apply techniques such as non-destructive testing to AM parts.

"The Solutions Centres will go some way to answering those questions, but they will also help us spend some more time working on the really difficult ones."

It all adds up WHEN YOU KNOW HOW

Renishaw is developing a global network of Solutions Centres to help companies learn how to use additive manufacturing (AM) techniques.

The Centres, which will be based in the UK, US, Europe, and Asia, are intended to provide cost-effective access to machinery, facilities and AM expertise.

Additive manufacturing in series production is still relatively rare, but otherwise there are varying levels of deployment of AM out there, explains Marc Saunders, Director – Global Solutions Centres, Renishaw.

"The further up the levels you go, the more commitment you need to the technology, and the greater the potential benefit.

"The bottom level is rapid prototyping and tooling, where you're not really intending to put those parts to hard use, or sell them."

For prototyping, the payback is pretty quick and volumes are small, with the aim being to de-risk a project. The next step is using AM to make production parts, but where it's essentially a replacement for producing an existing component design.

Products for aerospace, medical and oil & gas applications have to be proven and tested to rigorous quality standards. Qualifying AM to produce such parts can be an expensive process that takes a number of years. Many companies are already on this journey; Renishaw itself produces customised dental implants using AM that are adapted to the individual patient.

Work that starts out niche can become mainstream, as in the example of high-performance metal heat exchangers designed originally for motorsport, which will migrate into high-performance car design.

Saunders explains that Renishaw is planning ten centres, including one at the home of its Additive Manufacturing Products Division in Stone, Staffordshire, and others in Shanghai, China; Pune, India; Dallas and Chicago in the USA; Toronto, Canada, and several in Europe.

The company makes its own line of AM machines at a plant in Miskin, just outside Cardiff. Saunders says: "Our business model is to sell machines, of course – we hope companies will choose our technology once they have tried it, rather than anyone else's."

The Solutions Centres will also provide post-processing, including bead blasting, metrology, machining and wire erosion, whilst titanium parts may need heat treating to reduce residual stresses. Firms using the Solutions Centres will be able to manage their risk before committing to investment in expensive new machinery, while discovering ways in which AM will work for them.

Companies interested in the technology can trial Renishaw's AM systems and fully evaluate the suitability of additive manufacturing in a dedicated 'incubator cell', before moving towards system ownership.

Renishaw's Additive Manufacturing Products Division works closely with other divisions of the company, including the firm's medical/dental team, LBC Engineering in Germany, the rapid manufacturing unit at Renishaw's New Mills HQ in Gloucestershire, and the Miskin site in Cardiff, the former Bosch automotive components plant where the additive manufacturing machines are built. UKMR-15

MARC SAUNDERS

In November Renishaw joined Land Rover BAR's Technical Innovation Group (TIG) as an official supplier and will contribute its expertise in metal 3D printing and position feedback encoding.

Complex mechanical structures such as this prosthetic hand can be produced by AM

Additive manufacturing: understanding the bigger picture

AM is very exciting but it will not turn manufacturing on its head. There are still many practical barriers to prevent it from displacing conventional, mass production techniques

BY DR TIM MINSHALL

Governments around the world have high hopes for additive manufacturing (AM) – also widely referred to as "3D printing". But if it is to have the economic impact they are looking for, there needs to be a better understanding of both the huge opportunities AM presents as well as the barriers that may prevent it realising its potential.

The University of Cambridge's Institute for Manufacturing is undertaking a multidisciplinary research project, jointly funded by the EPSRC and the ESRC, to understand how AM will affect the manufacturing landscape and how UK firms can become global leaders in it. The research team is also supporting the development of the UK's National Strategy for Additive Manufacturing.

AM technology and its potential is still characterised by uncertainty. While there is an ever increasing interest in AM, our research indicates that there is still a lack of awareness of what it can do and how it can translate into economically viable business models. Spare parts are an interesting example. They have been highlighted by some as an area in which AM could have a major impact on current manufacturing activities. However, when analysed from a business and technology perspective the model quickly breaks down.

While it makes perfect sense for the International Space Station – or a nuclear submarine - to be able to 'print' its spares in situ the model becomes less clear as you extend into less specialist environments. For example, repairing failures in container ships in the middle of the ocean might also seem to be an opportunity to apply this technology. However, once all the constraints of what can actually be printed on-board have been taken into account, it may prove more practical to get spares or do repairs via more traditional means. Extend the model even closer to home and it breaks down completely. If a local car dealership were to print its own spares, for example, the parent company would incur significant costs to train a franchisee and the risk of failure – and subsequent brand damage for the parent company could be just too great.

As well as this lack of clarity around viability, we see a range of other barriers relating to the technology itself. While in many respects extremely advanced, AM is still dependent on a surprising amount of 'craft' or low tech, manual interventions. And this has a number of implications for scaling up. With other manufacturing processes we have had hundreds of years to understand them and get them right. But we do not have complete data on these new processes, either because it does not exist or because individual companies have no reason to share it in this highly competitive environment.

What are we likely to see over the next few years? The hype around consumer applications will start to recede as we realise that we are not all going to have 3D printers in our own homes in the near future. But industrial applications will steadily advance and consolidate in areas such as life sciences and aerospace. We are also likely to see interesting international developments, such China using AM to help shift its manufacturing from high-volume to high-value add, Germany leading on the integration of AM into the broader 'Industrie 4.0' transformation, and many countries including the US and Singapore seeking to link AM adoption and entrepreneurship to create new opportunities for value capture. UKMR-15

ISSUE	SUMMARY OF COMMON PERCEIVED BARRIERS
MATERIALS	Understanding properties in different processes/machines/ applications, QA, costs, availability (IP constraints, independent suppliers), use of mixed materials, recyclability, biocompatibility.
DESIGN	Need for guides and education programmes on design for AM – better understanding of design for AM constraints, availability of AM-skilled designers, security of design data.
SKILLS/ EDUCATION	Lack of appropriate skills (design, production, materials, testing) preventing adoption, up-skilling current workforce vs. training of next generation, education of consumers, awareness in schools.
COST/ INVESTMENT/ FINANCING	Funding to increase awareness and reduce risk of adopting (testing, scale-up, machine purchase) – especially for SMEs, understanding of full costs (including post-processing, testing), cost of materials.
STANDARDS/ REGULATION	Perceived or actual lack of standards - all sectors/sector specific (especially aero/health/motorsport), for processes/materials/ software/products/applications.
MEASUREMENT/ INSPECTION/ TESTING	Need data labraries, standards or tests (general and sector specific), materials/in-process/final part, tests for higher volumes, non-destructive testing, QA through lock-in c.f. open access to data.
IP/PROTECTION/ SECRECY	Balancing need for openness to share knowledge with need for commercial protection to capture value from investments, enforcement of IP rights.

Dr Tim Minshall is a Reader in Technology and Innovation Management at the University of Cambridge

Alstom's latest 'Platform for Service Delivery

Image: Alstom UK

SECTORS - SERVITISATION

Why engineers must protect and serve

BY HOWARD LIGHTFOOT

The services manufacturers provide are becoming as crucial as the products they create in the first place

'Servitisation' is a manufacturing business model for the provision of services, to deliver value through the customer's use of the manufactured product.

As a term, 'servitisation' has been around since the late 1980s. It was coined by Sandra Vandermerwe and Juan Rada in their 1988 article 'Servitisation of Business: Adding Value by Adding Services', in the European Management Journal.

They defined servitisation as "the increased offering of fuller market packages or 'bundles' of customer focussed combinations of goods, services, support, self-service and knowledge in order to add value to core product offerings."

Servitisation is now big business. In 2014 – 2015 the support and service industry generated more than £11 billion of revenue in the UK, and more than £23 billion globally. The value of this sector is expected to grow annually at a compound rate of around 5%, according to the ONS data.

Many manufacturing companies made the switch to service-centric businesses from the mid-1990s to early 2000s, and for some companies, revenues from support and services account for between 50-60% of their revenue.

These organisations made a transformation: from the capabilities they need to move from selling products to providing product-centric services for their customer – a 'servitisation' journey.

BEYOND THE PRODUCT

In 2007, researchers at Cranfield University, following an extensive review of the relevant literature, defined servitisation as, 'The innovation of an organisation's capabilities and processes to better create mutual value through a shift from selling product to selling product service systems (PSSs)'.

Michael Hulme, MD Trains & Modernisation

A (PSS) can be thought of as a market proposition that extends the traditional functionality of a product by incorporating additional services. Here the emphasis is on the 'sale of use', rather than the 'sale of product'.

The customer pays for using an asset, rather than its purchase, and so benefits from a restructuring of the risks, responsibilities and costs traditionally associated with ownership.

For more than two decades, academic literature has encouraged manufacturers to 'go downstream' and move towards their customer's end of the supply chain, adding value by integrating services with their products.

Looking to the aftermarket, where for many products the installed base can be orders of magnitude greater than annual sales of products – cars 13/1; trains 21/1; tractors 30/1 and civil aircraft 150/1 – this presents a revenue generation opportunity, and a potential moderator of cyclical business downturns.

Today, more and more manufacturers are finding that their best means of competing in the market is to provide a portfolio of integrated products and services.

Offering services has now turned into a conscious and explicit strategy for manufacturers with the provision of product-centric services becoming a main differentiating factor. This has become known as the 'servitisation of manufacturing'.

However, this type of competitive strategy brings with it significant cultural and corporate challenges for traditional manufacturing organisations.

Companies who decide on a product-centric service strategy must transform their organisational structures and processes in order to become successful.

It is essential to understand what customer values and competencies are needed in the organisation to deliver the service offering, what the service delivery system will need to look like, and the business model will be that that will ensure effective and efficient delivery of the service offering.

Manufacturers are moving from selling products to their customers, to providing solutions or outcomes where the product itself can become the platform for service delivery.

SERVITISATION: A BRIEF HISTORY

Interestingly, this is not a new phenomenon. In the 1800s in the US, the International Harvester Corporation used services to help establish their new reaping equipment among farmers in the American Midwest.

In the 1960s, the origins of 'power by the hour' can be traced back to the the practices of Bristol Siddeley, when it offered this model to encourage the US military to buy jet engines.

So what's new? It appears that manufacturers are recognising that manufacturing is not just about product innovation, process technologies, and production. They are abandoning a production-centric world view to embrace a broader view of manufacturing.

Iconic examples of the implementation of servitised manufacturing business models in the UK are Rolls-Royce Civil Aerospace, and Alstom Transport (TrainLife Services). Rolls-Royce, through its 'TotalCare' service offering, no longer sells engines to all airline operators but provide the majority on a 'power by the hour' basis on a long-term contract.

Here the operator pays an agreed $/hour rate when the engine is in use. The rate is based on a pre-determined pattern of use for the aircraft, such as short or long haul; and dependent on environment – for example, the Asia-Pacific, or

HIGHLIGHTS 2015

- In October, the Cambridge Service Alliance hosted the 2015 Cambridge Service Week with speakers from Rolls-Royce, ABB and Zoetis
- The EPSRC Centre for Through-life Engineering Services (TES) launched a National Strategy for TES in Parliament on September 10, 2015
- The Aston Centre for Servitization Research and Practice hosted the Spring Servitization Conference on May 18-19. Details here: http://www.aston-servitization.com/publication

THE UK: A FORCE IN PRODUCT SERVICE SYSTEMS RESEARCH

There are a number of academic institutions in the UK that are collaborating with major industrial organisation to better understand this new, servitised world of manufacturing. Those with a clear focus and significant activities addressing the associated technologies and business models are: **Cranfield University, through the Through-Life Engineering Services Centre**. This is a national research centre hosted by Cranfield (lead) and Durham Universities. Industrial partners include Rolls-Royce, Bombardier Transportation, BAE Systems, Babcock International and the UK MoD.

The centre's aim is to improve the availability, predictability and reliability of complex engineering products to deliver the lowest possible whole life cycle cost by developing technologies and processes to improve the design and manufacture of such systems – a key driver in the effective and efficient delivery of a servitized business model.

Andrew Gill, Prof Raj Roy of the EPSRC TES Centre and Dick Elsy of the HVM Catapult launch a new national strategy in through-life engineering services in Parliament on September 10.

There is also the **Cambridge Service Alliance, IfM, Cambridge University**. In 2010, the Institute for Manufacturing joined with Cambridge's Judge Business School, BAE Systems and IBM to launch the Cambridge Service Alliance. The alliance brings together some of the world's best firms and researchers devoted to delivering today the insights, education and approaches needed for the complex service solutions of tomorrow. Finally, the

Aston Centre for Servitization Research and Practice – at Aston University Business School – is a centre dedicated entirely to understanding and promoting servitisation within the global market, and incorporates researchers, practitioners and industry leaders who have a depth of knowledge and experience of the models, frameworks and practical requirements of this business model transformation for manufacturers.

HMS Daring, the first Type 45, is a flagship of the Royal Navy's next generation of Area Air Defence Destroyers. Through-life engineering services is an engineering discipline practiced by BAE Systems Naval Ships, the builder

Image © BAE Systems

desert areas. The operator benefits from knowing a fixed cost of operation and Rolls-Royce adopts the risk and responsibility for delivering this service effectively and efficiently. This involves the use of technology to monitor the engines in use and requires implementing design for service, reliability and maintainability in product design and engineering.

Meanwhile Alstom provides Virgin Trains with an availability contract to provide 52 of 56 Pendolino high-speed trains every day, operating to full specification. For this Alstom receives an agreed fee but should there be less than 52 trains, or trains not able to perform to specification, or with faulty lighting, toilets or heating, or failure causing delays to passengers – 'lost passenger hours' – then the fee paid is reduced.

As in the case of Rolls-Royce, Alstom uses integrated communication technologies and on-board monitoring technology to assess the condition of every train in real time. Through control centres, this information is evaluated by technicians and decisions made as to actions needed to ensure that problems can be resolved in a timely manner to ensure train availability in line with the contract.

"Innovation is key to ensure a culture of continuous improvement within the service environment, and by the very nature the contract being long term and output related, the supplier is incentivised to develop a culture of innovation, and adoption of new technologies to deliver continued added value to the end customer," says Mike Hulme, vice president Train Life Services UK & Ireland, Alstom.

CLUB FLEET

Selling solutions rather than products can be seen in industries other than manufacturing. Zipcar is a car club – a large network currently operating in London, Bristol, Oxford, Cambridge and Maidstone, and another 50+ cities across Europe and the US.

It provides access to a car or van that the customer needs when they need it, but with none of the hassle or expense of ownership. Zipcar is far simpler and more convenient than conventional car hire. When a member needs a car, they can choose a make and model from the selection parked around their local area and get in and drive off. This business model has a positive environmental impact – Carplus Annual Survey of Car Clubs 2013/14 (London) comments that One Zipcar helps take 17 privately-owned vehicles off the road in the UK.

In healthcare, pharmaceutical firms are rethinking their business models – defining themselves as healthcare solutions providers. What does the patient really want? It's not the products that pharmaceutical firms provide – rather they would prefer not to be ill in the first place. So a healthcare solution, which reduces the likelihood of illness, serves the interests of both providers and customers alike.

Looking forward, increasingly the connected world includes physical objects. Machinery, infrastructure and devices are being equipped with networked sensors and actuators that enable them to monitor their environment, report their status, receive instructions, and even take action based on the information they receive.

Even people can be equipped with sensor-enabled devices – to track their health status, for example. This is what is meant by the term 'the Internet of Things' and this is growing rapidly. Internet of Things technology ranges from simple identification tags to complex sensors and actuators. The Internet of Things is still in early stages of adoption.

In manufacturing, Internet of Things technology can improve operational efficiency in a variety of ways. Sensors can be used to track machinery and provide real-time updates on equipment status, decreasing downtime.

All the pieces are not yet in place to guarantee that rising interest in servitisation will turn into widespread investment and adoption. Early adopters will need to prove that sensor-driven business models create superior value.

But for the first time, computers are now able to receive data from almost any kind of physical object, enabling us to monitor the well-being and performance of machines. UKMR-15

Understanding the customer:
New service-based business models

BY PROFESSOR ANDY NEELY

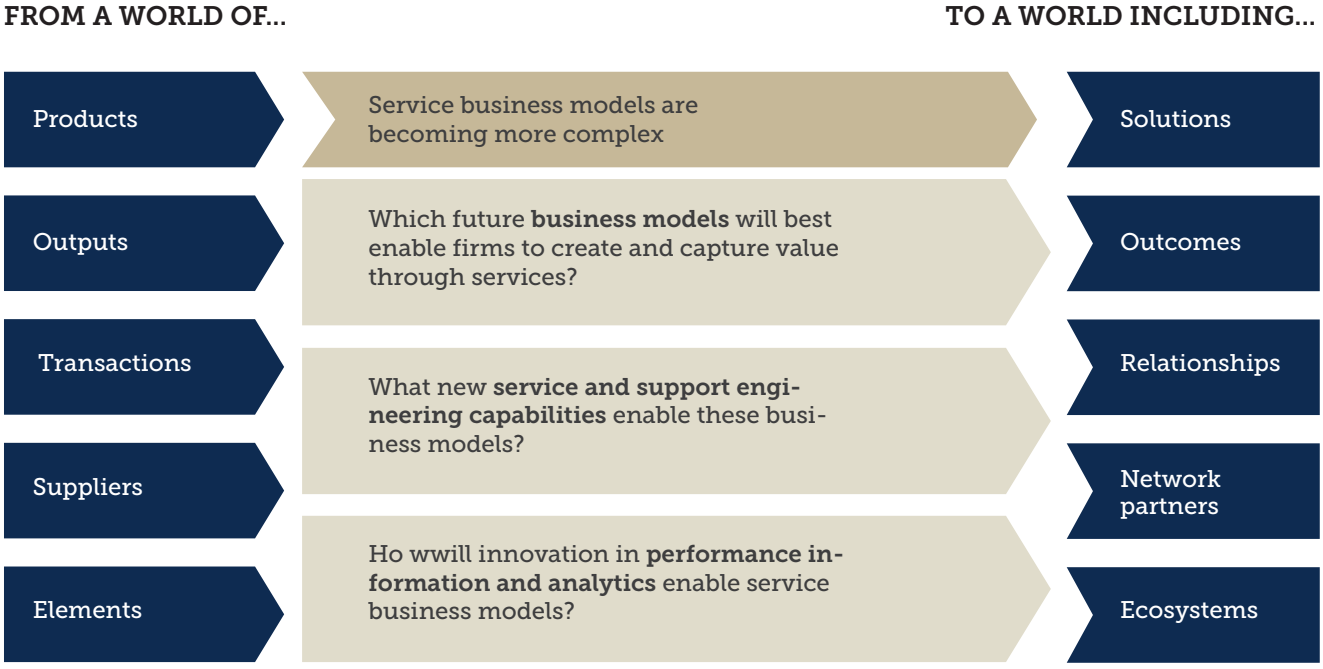
At the Cambridge Service Alliance we are exploring new service-based business models and, in particular, what the business-to-business (B2B) world needs to learn from consumer-focused companies. B2B firms are being put under increasing pressure by innovations in the business to consumer (B2C) arena. These innovations help us all carry out daily tasks simply and efficiently – even enjoyably – and, by doing so, they are raising our expectations of service levels in all areas of our lives. To help B2B companies better understand and adopt these new business models, we have identified five key aspects of B2C innovations: the user experience, augmented resources, platforms, multi-sided markets and ecosystems.

Airbnb, the accommodation website and Uber, the app that calls you a cab, are good examples of these five concepts. Both have created a seamless user experience. Take Uber. You come to the end of a meal in a restaurant. A couple of taps on your mobile and you are told a car will pick you up in two minutes. You leave the restaurant and the car is waiting for you. You know it's the right car because you have its description and registration number. When you get to your destination the fare is automatically charged to your credit card and you can rate the driver – and they can rate you. It's a seamless customer experience. Airbnb is similar. It has an intuitive interface which allows you to find and book accommodation quickly and easily. When your stay is over, you rate the accommodation and the landlord rates you.

One of the major challenges facing manufacturers and B2B service providers is how can they provide these kinds of user experiences to both their customers and to their employees who may be battling with unfriendly internal processes and systems. As expectations are raised by everyday consumer

PROFESSOR ANDY NEELY

Professor Andy Neely is Head of the Institute for Manufacturing (IfM) at the University of Cambridge and the Director of the Cambridge Service Alliance (CSA). Professor Neely recently succeeded Professor Sir Mike Gregory as head of the IfM. He is widely recognised for his work on the servitization of manufacturing, as well as his work on performance measurement and management.



experiences, so the level of frustration with poor internal IT systems and interfaces increases.

The second lesson that B2B companies can learn from their B2C counterparts is about leveraging and augmenting resources. Again, Uber and Airbnb are prime examples. They have persuaded other people to provide a resource they can leverage. Uber doesn't own its cars, and Airbnb doesn't own its properties. This is an exceptionally efficient operating model and means they can deliver their business with relatively low levels of capital investment. Uber does not need to invest in cars. Airbnb does not need to build hotels. Yet both can offer services using these resources because they have persuade others have invest the necessary capital and then granted Uber and Airbnb access to it. How can other organisations persuade people to engage in their businesses in a way that allows then to scale rapidly?

A third issue is the platform - which allows resources to be accessed and customers to be connected with providers. Platforms are key to many B-2-C business models and indeed Uber and Airbnb are only able to do what they do because of the platform they have created. In fact their manjor contribution is the platform - providing a user-friendly interface which connects the end-user with the service provider.

Creating multiple revenue streams from one business model is something else many of these innovators are doing. A company like Airbnb, for example, can charge consumers to book their accommodation through its site, landlords to promote their properties on its site and, potentially, other businesses to advertise on its site. We are seeing more and more business models which are not based on a 'bilateral' transaction, but where the business is finding ways of creating multi-sided markets which allow them to capture value in a variety of ways – and, if they choose to, charge individual customers lower prices because they are benefiting from multiple revenue streams. Threadless, a t-shirt manufacturer, for example, has created a platform which allows users to design their own t-shirts. Users can post these to the website and other people can 'like' them. When they get enough likes, Threadless manufactures their design. It then generates additional revenue by selling its consumer insights to retailers, who want data on the latest fashions so they can decide which clothes to stock in their stores.

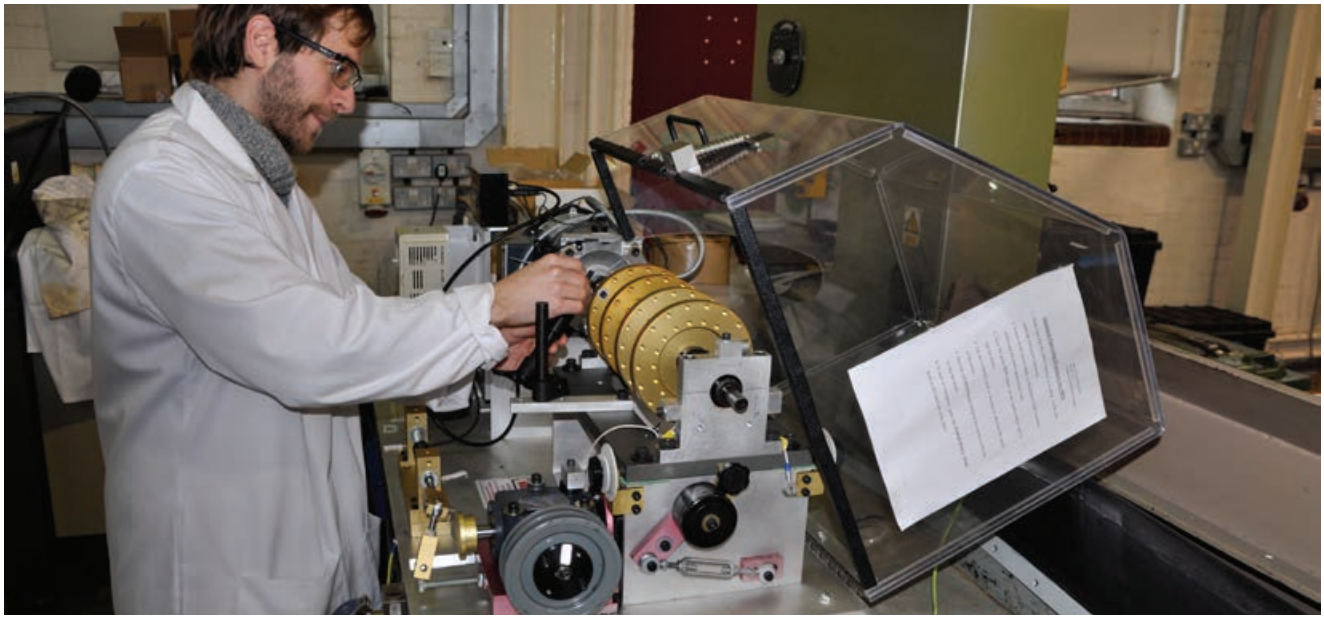
In order to develop and capitalise on multi-sided markets, companies need to understand their ecosystem. They need to think creatively about who else might be their customers – who can they provide value for, what is that value and what resources might those new customers be able to bring?

These are some of the questions we have been addressing at the Cambridge Service Alliance: how can you create a seamless user experience, how can you access and supplement your resource base, what role can platforms play in creating user experiences and in enabling users to access those augmented resources, how can you leverage all that in a multi-sided market and how is that encompassed within the broader ecosystem?

In 2016 and beyond, the pressure on firms will continue to grow particularly around the seamless customer experience because, as consumers, it is something we increasingly expect. Unless the core manufacturing businesses learn these lessons they are going to find their staff and customers becoming more and more frustrated.

But how do you change your current business model to meet the demands of this changing world? A Cambridge Service Alliance Report is about to be published describing the critical success factors that underpin business model transformation. The report, co-authored by Dr Veronica Martinez, Professor Andy Neely and their Cambridge Service Alliance partners, describes the lessons those partners have learnt as they have transformed their business models – often slowly and painfully – and will provide an invaluable 'roadmap' for other organisations embarking on this journey. The report will be available on the Cambridge Service Alliance Website: www.cambridgeservicealliance.eng.cam.ac.uk UKMR-15

A Centre of Excellence in Industrial Prognostics Cranfield's IVHM Centre



Launched in 2008 in partnership with Boeing - Cranfield University's Integrated Vehicle Health Management (IVHM) Centre has become a world recognized research centre, with Core Partners, Members and clients that include: Boeing, BAE Systems, Thales, Meggitt, Alstom Transport, DRS (Finmeccanica), MoD, Western Power Distribution, and MBD Safran. New Members are always welcome; the most recent Member to join is Novartis, a well-known global healthcare leader.

Since opening in 2008, the Cranfield IVHM Centre has developed a mature research programme – over 35 projects delivering capability up to Technology Readiness Level 6 – with a total research investment of over £11m giving a gearing of 10:1 against Core Partner investment. High impact projects that have delivered include: business case methodology, blade crack detection, architecture and standards (OSA-CBM), a design system for IVHM, and a health management development process. To complement these we have: published over 100 technical papers; edited 5 books on IVHM; co-authored one book (on No Fault Found); influenced international policy and standards (SAE, PHM Society, RAeS, HealthMap NTC) and run internationally recognised short courses.

While a major part of our activity is centred on Aerospace and Defence applications we have applied these technologies to an expanding range of other market sectors such as Energy, Agriculture, Health and Rail. Our funding comes from both commercial and public funding sources (UK & EU), with 3 current projects being funded through the EU. Centre projects range from the fundamental prognostics of relays, through IVHM and Safety, to industrial scale problems on Integrated Drive Generators (IDG) and Environmental Control Systems (ECS, Figure 1). Our future will continue with a mix of projects, but with a strong focus on industrial prognostics blended with sound engineering judgement, including research on Cranfield's recently acquired B737-400. UKMR-15

Since opening in 2008, the Cranfield IVHM Centre has developed a mature research programme – over 35 projects delivering capability up to Technology Readiness Level 6 – with a total research investment of over £11m giving a gearing of 10:1 against Core Partner investment

Web site: www.cranfield.ac.uk/ivhm

IVHM partners include

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ALSTOM
MINISTRY OF DEFENCE

THALES
MEGGITT
SAFRAN
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WESTERN POWER DISTRIBUTION

Manufacturing in Parliament 2014-2015

Manufacturing output is now growing at the fastest rate since April 2014. There are, however, still a number of issues which have presented challenges for business and government over the past several months. The steel industry, for example, has come under significant pressure recently but there are also some perennial challenges for the sector.

BY BARRY SHEERMAN MP AND CHRIS WHITE MP

Co-Chairs , All-Party Parliamentary Manufacturing Group

Chief among these is the skills shortage. Some positive initiatives have been put in place such as increasing the amount and quality of apprenticeships, with Employer National Insurance Contributions abolished for under-25s. The Government also created a new Careers and Enterprise Company to advise young people about entering the sector, expanded University Technical Colleges, and set up a new National College for Advanced Manufacturing.

The high cost of energy for UK companies has also long been high on the political agenda. This led to the recent industrial decarbonisation roadmaps for the Energy Intensive Industries led by BIS and DECC. On the innovation side, the extra £61 million for the High Value Manufacturing Catapult should help UK businesses successfully commercialise new technology, and academic research itself got a boost with over £3 billion of new funding.

A major announcement in the March 2015 budget was permanently setting the Annual Investment Allowance at £200,000. This is a reduced amount, but its permanence should inject some much needed stability into the sector, and is a step the All Party Manufacturing Group (APMG) has explicitly called for.

The APMG Summer Reception in July 2015

There are promising signs for the manufacturing sector and its significance to a rebalanced economy. We must ensure that the right policies and regulation are put in place to give businesses the best environment to innovate, expand and grow.

In October 2015, the Manufacturing Commission, another APMG initiative, published its inaugural report which focused on the long term sustainability of UK manufacturing. The report focuses on five key areas that the sector and the government need to focus on to achieve a more sustainable manufacturing industry. These include: leadership, resilience, innovation, collaboration and system redesign. Both the Commission and the parliamentary group will continue working with all parties to create better policy for the sector, to help it grow and become more resilient for the long-term. UKMR-15

A major announcement in the March 2015 budget was permanently setting the Annual Investment Allowance at £200,000, a step the All Party Manufacturing Group (APMG) has explicitly called for.

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Xtrac is leading the way as a mid-sized exporting company

SECTORS - MID-SIZED COMPANIES

Leading from the middle

Professor Stephen Roper of Warwick Business School reports on a bullish mid-market UK boardroom

Across the UK, there are around 30,000 firms with sales of between £10m and £500m. This is the UK's mid-market, accounting for around 2% of all UK firms but around a third of all private sector jobs and wealth creation. The UK mid-market includes some household names and many hidden champions generating wealth and jobs but with little recognition.

Over the past four years working with GE Capital, we have surveyed senior executives in around 1,000 UK mid-market companies each year to get the view from the boardroom. Our survey has not just covered the UK, however, but similar groups of companies in Germany, France and Italy (the EU4). So, how does the view from the UK boardroom differ from that in a similar company in Germany?

GROWING SALES, GROWING JOBS

Mid-market businesses are all very different between sectors and in terms of their level of ambition. There are some important contrasts, however, between the UK and its continental competitors. In the UK, around 18% of mid-market firms are family-owned, with the majority of these also being family-operated. In German, family ownership is more than twice as common, applying to 38% of firms, around half of which are family-owned and operated.

Many mid-market companies are mature businesses. Around a third of mid-market companies across the EU4 were established prior to 1980 with around 1:6 in the UK and 1:5 in Germany set up prior to 1945. Their markets vary, too. On average, export sales account for 34% UK firms' revenues compared with 40% in Germany and around 35% in France and Italy. So, typically, UK mid-market firms remain less export-oriented than their German and continental counterparts. This more domestic orientation has not hindered the growth of the UK mid-market, however, as Figure 1 shows. In each year of our survey, UK mid-market matched the sales growth of German mid-market firms from 2013 to 2015 and expect to grow more rapidly than their German counterparts in 2016. In each year, the UK mid-market has outpaced that in France and Italy.

The growth of the UK mid-market sector is also bringing new jobs. In 2015, 60% of mid-market firms increased the size of their workforce, and only 12% of firms reduced their head count. Overall, workforce growth was 2.5%, with the UK leading the other major European economies in mid-market job creation.

This jobs growth is taking place across all sectors of the UK mid-market. Workforce growth was strongest in the administration, construction, and hospitality sectors but, in 2015, no sector had employment growth below 1.2%. This marks an improvement over 2014, with the biggest acceleration in job creation occurring in the hospitality and administration sectors.

UK jobs growth in the mid-market is not just coming from new business and expansion. Re-shoring is also important in both manufacturing and a range of service sectors. Around a fifth of mid-market companies with offshore activities intend to re-shore some or all of this activity over the next three years. Through growth and re-shoring, the UK mid-market continues to make an important contribution to national employment growth after the recession and financial crisis.

THE GROWTH CHAMPIONS

Around 11% of UK mid-market firms are what we call Growth Champions (Germany 12%), increasing turnover by 10% or more

in the last year. Like the mid-market more generally, the Growth Champions are a diverse group but there are some common features. In terms of strategy, the Growth Champions often have super-niche strategies, focusing on a very narrow but global market segment. This is often accompanied by an obsessive attention to customer requirements and service and a deep understanding of related technologies.

RECOGNISING PERFORMANCE

Closer to home, the Growth Champions use high-performance work practices – teams, multi-skilling, incentives – to recognise performance and retain key talent. And, when we ask mid-market directors what the most important factors are in improving performance, they emphasise the management and structure of the business, skills and factors such as team-work and employee and managerial attitudes (see Figure 2). Notably, a lack of access to finance is rarely mentioned among these key performance improvers.

The strong record of growth means that UK mid-market business leaders are now, in 2015, more bullish about the growth prospects of their firms than in either 2013 or 2014. Figure 3 illustrates this as the difference between the percentage of directors anticipating growth and those envisaging contraction. Mid-market directors' views of the prospects for the UK market have also improved sharply since 2013. Views of the prospects of European growth remain muted, however, with mid-market directors seeing the main growth opportunities elsewhere.

INVESTING FOR THE FUTURE

Our 2015 boardroom survey suggests that UK mid-market firms have strong intentions when it comes to future investment. This follows a period of weaker investment sentiment. Key investment priorities are firms' IT capabilities but increased investment in sales and marketing, staff training and R&D and innovation were also anticipated.

In some areas – IT, marketing, R&D – investment levels in the UK mid-market are very similar to those elsewhere. In terms of training and skill development, however, UK firms' investments are very different, however, and this is reflected in whether firms provide apprenticeships and, more surprisingly, internships.

As Figure 4 shows, UK mid-market firms lag Germany in terms of both apprenticeships and internships and are also less likely than their French and Italian competitors to offer internships. UK firms match their continental competitors in terms of operating graduate recruitment schemes.

Lower levels of engagement with apprenticeships and internships in the UK mid-market are all the more surprising when we consider the key challenges to growth faced by mid-market firms.

Each year we ask mid-market firms about the key challenges to growth. In 2015 – as in 2014 - the top three challenges to growth were all skill related. 33% of mid-market firms said "finding talent in the local area" was a high challenge. Another 30% said retaining key and talented employees was difficult, and the same proportion said that the competition for talent against larger companies was particularly tough. This pressure on skills seems likely to increase in the future as mid-market firms seek to grow their sales and continue to re-shore their activities.

LOOKING FORWARD

UK mid-market firms remain bullish about future prospects for growth and exports through 2016. There are some sugges-

Figure 1: Growing mid-market sales set to continue

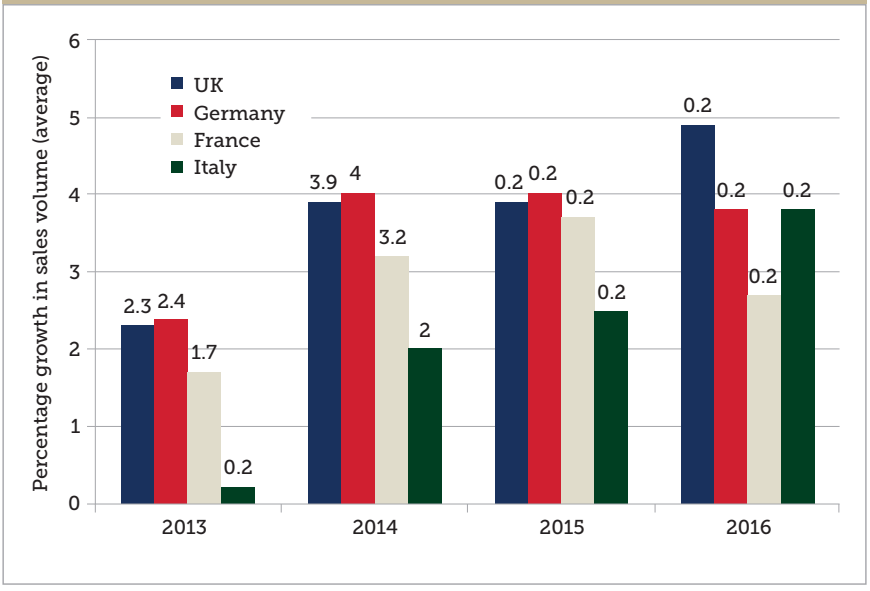


Figure 2: Key performance improvers in UK mid-market firms

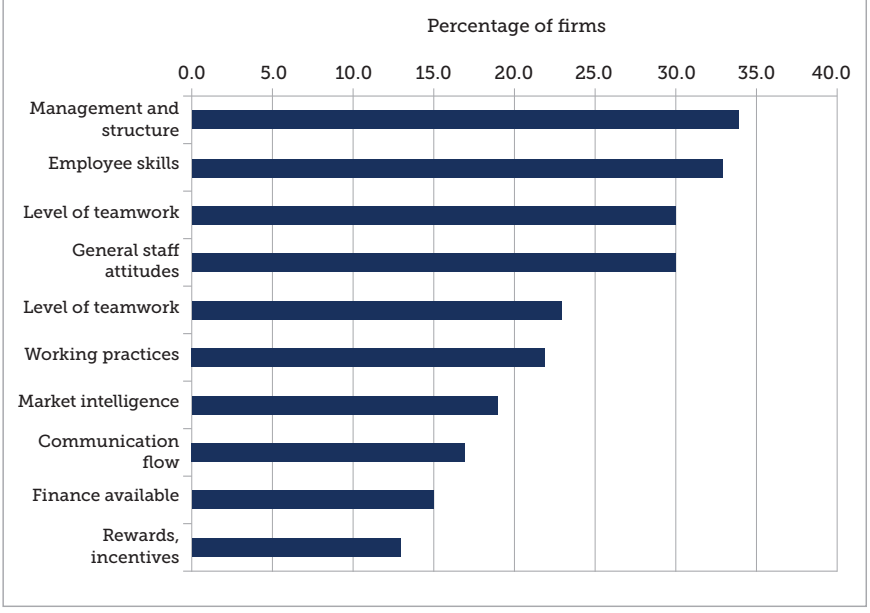


Figure 3: The balance of sentiment: growing and declining opportunities?

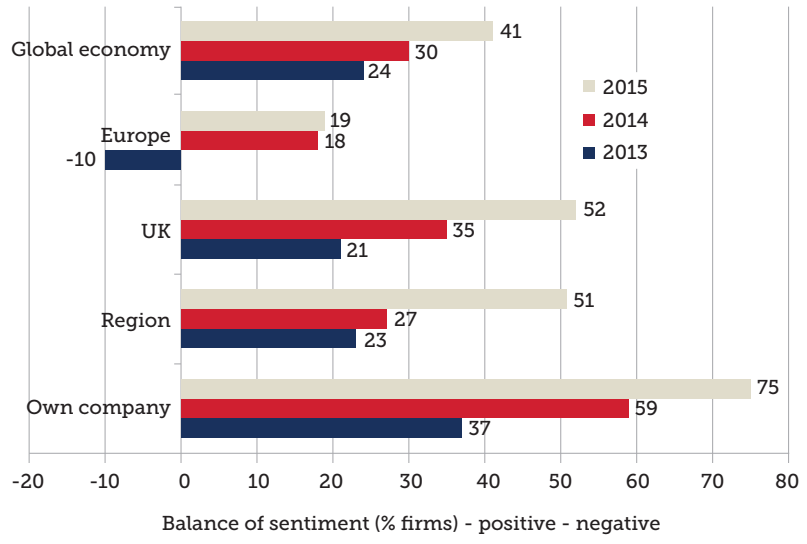
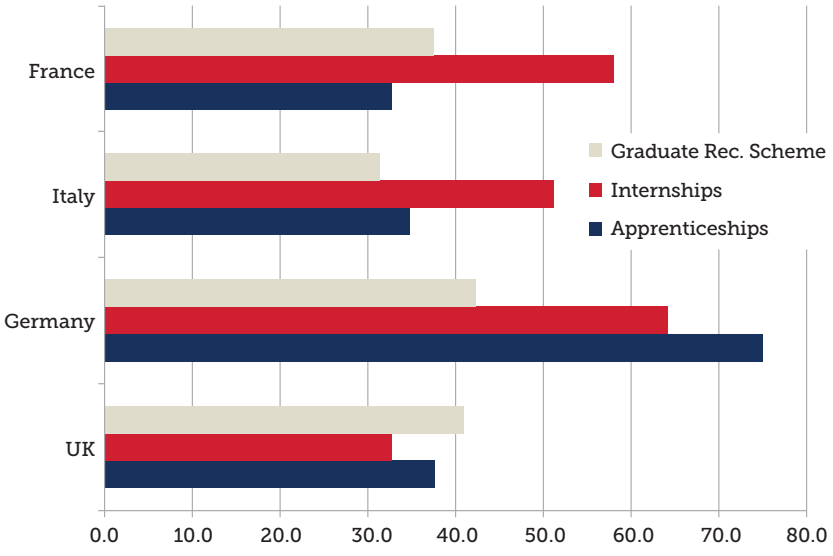


Figure 4: Investing in future skills



tions in the data of moderating future growth, however, and firms face continued challenges in terms of the continued need to invest and acquire and retain suitable employees.

SOURCES AND ACKNOWLEDGEMENTS

All data used in this article comes from the *Leading from the Middle* reports and surveys. The 2015 report is available at: www.gecapital.co.uk/en/docs/GE_LFTM_UK_mm_2015.pdf *The views in the article are those of the author alone.*

Adrian Moore became managing director of Xtrac in October. The company is an exemplar mid-sized UK manufacturing firm

How Xtrac stays in pole position

By Peter Digby, chairman, Xtrac – the world's largest manufacturer of motorsport transmissions

We have concentrated on the premium end of this niche global industry for over 30-years, building a customer base which includes teams and promoters from Formula 1, the World Rally Championship, IndyCar and an ever-increasing touring and sportscar market.

Nearly 80% of our annual turnover now comes from products produced for global export in our 90,000 sq ft factory near Newbury.

Staying ahead of the game and continually expanding into new markets takes a strong but cautious strategy. First, a consistent capital investment programme ensures that we have the very latest machinery. Our UK factory supports over £40 million worth of state-of-the-art machine tools with a strong focus on R&D, striving to make our own products obsolete as we push the technological and performance boundaries.

We also strongly believe in investing in people. Our apprentice and graduate schemes work with schools and colleges to recruit and train new team members, while personal development plans ensure we have a highly skilled workforce at every stage of the career journey.

By far the biggest business decision I ever made was the creation of a 100% employee-owned business. Employee share ownership definitely ensures a highly committed and more flexible workforce.

In-house capacity expansion has also allowed us to expand into the lower-priced, higher-volume market with extended service interval transmissions. This has proved immensely successful, but we remain mindful of over-leveraging against a backdrop of overly accessible finance options. Our export-led organic expansion strategy is primarily self-financed, thus reducing our exposure.

Finally, we have felt the positive effects of a business-friendly government, the easing of employment legislation and a strong trade association in the shape of the Motorsport Industry Association. **UKMR-15**

MAKING THE MOST OF THE UK MID-MARKET

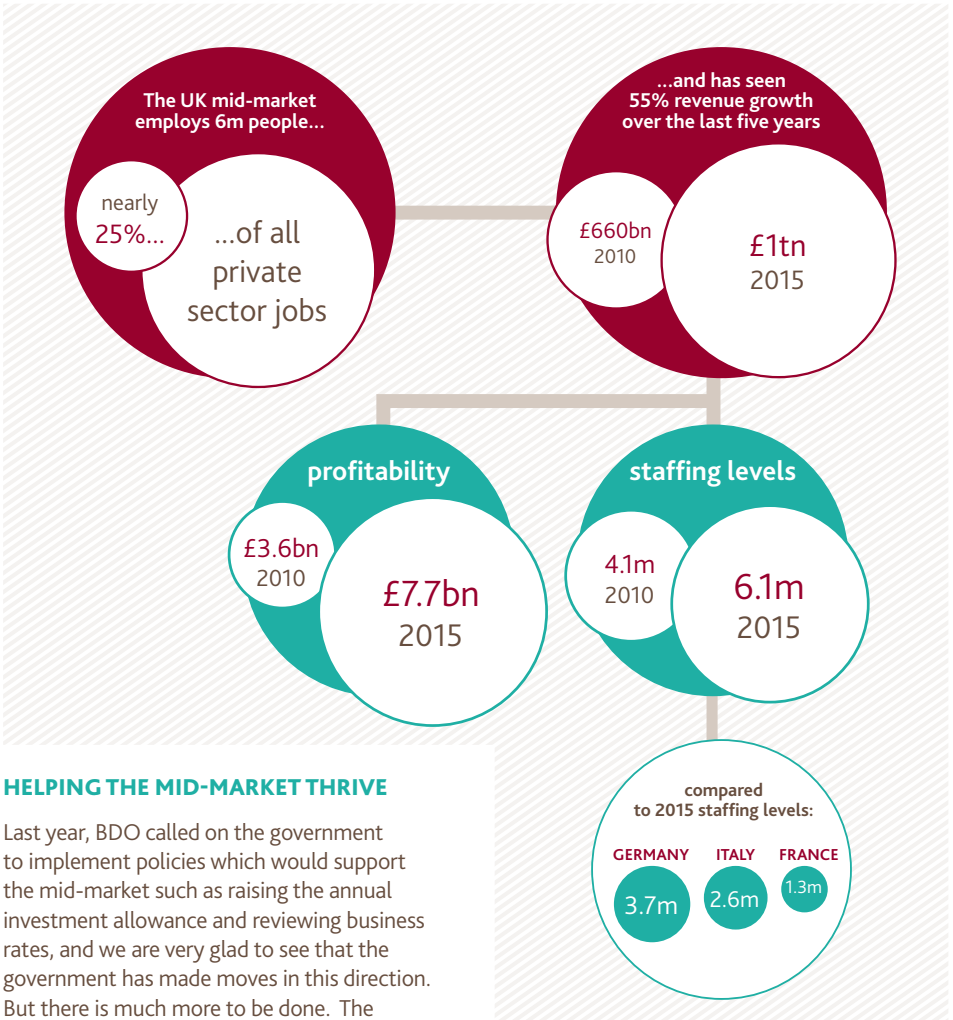
Mid-market companies are an essential and dynamic element of the UK economy. Innovative, ambitious and consistently developing new technologies, the UK's mid-market businesses are engines for growth – exploiting globalisation and employing millions of people.

The unprecedented shock of the financial crisis has focused minds and as the recovery takes hold, we have a chance, and a duty, to make sure that our economy's recovery is robust and is fit for the future. To create a truly 'new economy', we believe that policy makers must focus on making the most of the UK mid-market, particularly mid-market manufacturers.

These firms are large enough to take advantage of the opportunities offered by global growth, but sufficiently agile to adapt to the new economic realities. With the economy shifting once again to recognise the value of specialised, regional businesses, the mid-market is in prime position to take advantage of this.

Mid-market firms have thrived in these conditions. The 24,000 mid-market firms in the UK turn over a combined £1 trillion each year, a figure that has grown by over 50% in the last five years. Over six million people are employed in mid-market businesses – accounting for nearly a quarter of all private sector jobs.

But, the needs of mid-market firms and the power they could add to the new economy can be overlooked by policy makers. The sheer scale of the largest PLCs mean that they can grab attention; and the very smallest businesses are seen – not always correctly – as the most deserving and dynamic sector. Amidst this, the mid-market companies that largely drive the UK economy remain unknown, and their issues and opportunities are not often aired. Effectively, these firms fall into a policy and profile gap. Too small to make their voices heard amongst larger high-profile enterprises but too big to take advantage of the attention lavished on start-ups.



HELPING THE MID-MARKET THRIVE

Last year, BDO called on the government to implement policies which would support the mid-market such as raising the annual investment allowance and reviewing business rates, and we are very glad to see that the government has made moves in this direction. But there is much more to be done. The Government has a role to play in supporting the mid-market manufacturing companies in an increasingly competitive world and we believe that some of the initiatives below will help to do this:

- A minister for manufacturing to enable long-term thinking and planning for manufacturers
- Cut employers' national insurance for manufacturers to enable firms to bring on new staff
- Increase the annual investment allowance to help increase productivity.

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SECTORS - TAX LINKS TO INNOVATION

R&D TAX RELIEF IS WORKING – SO DON'T CANCEL IT

BY ELIZABETH ANDERSON

Is Britain's tax system making it easier for the 'march of the makers'?

There was a time when Britain led the world in innovation. But in recent decades Britain's track record has lagged, intensified by the decline of UK manufacturing, an increasing reliance on financial services, and the squeeze on funding brought on by the 2008/9 recession.

As a result, the UK's productivity record trails behind that of other developed nations and is only just showing signs of recovering from the recession. Low productivity is a problem for the economy, as it means flat wages as well as falling living standards and profits (see chart).

Recognising this, the government has increasingly put measures to boost innovation and productivity at the centre of its economic manifestos. Cuts to corporation tax, incentives for research and development, the Patent Box and infrastructure improvements to boost regional economies were all given prime slots in this year's summer Budget.

"It's definitely a good time to be in business at the moment," says David Brooks, tax partner at accountancy group BDO. "R&D tax relief in Britain is the best in Europe and this year there have also been surprise cuts to corporation tax, falling to 18% by 2020. It's good for the economy because lower business taxes mean more profit, which can be used to pay more staff and to buy new machinery."

Supporting the development of new products and ideas is crucial to Britain's long-term economic growth, adds Harry Swan, managing director of chemical manufacturing company Thomas Swan who also sits on the board of government body Innovate UK.

Consett-based Thomas Swan is currently focusing on the development of the atom-thick graphene, dubbed a wonder material that is extraordinarily strong and incredibly versatile. Around a sixth of the company's 150-strong workforce work in its R&D lab and the firm recently picked up three grants for realising the potential of graphene and helping to get the material into the supply chains of big league manufacturers.

"If I was running the UK as a company, I would invest heavily in R&D because it generates wealth, which is needed to balance the books."

Harry Swan, Thomas Swan

Swan says investing in R&D is critical to the company's survival, and companies that do not take risks or innovate face falling behind rival firms in the future.

STOP PRESS!

Companies have until June 2016 to apply for the Patent Box, when it will be closed to new entrants

"During the recession, the country cut back on R&D spend," Swan says. "Seven years on, there are not enough new products coming out and that's why the UK has low productivity. If I was running the UK as a company, I'd invest heavily in R&D because it generates wealth, which is needed to balance the books."

R&D TAX RELIEF A HIT

An extension of R&D tax relief, announced in the Autumn Statement in 2014, is viewed as one of the most attractive tax breaks for companies, particularly for those in manufacturing and product development.

The relief means small-to-medium-sized enterprises (SMEs) committed to R&D have enjoyed a reduction in their corporation tax bill by up to 230% this year. This equates to an additional £230 deduction on top of every £100 spent on qualifying R&D expenditure. For loss-making companies, they have the option to receive tax relief by way of credits, so they can essentially receive a cash refund from HMRC of up to £33.35 for every £100 spent on R&D.

"R&D tax relief (in the UK) is the highest in Europe and is a very generous subsidy for businesses that are testing new technology. It encourages them to embark on a project that may include inherent risks, which historically companies have been reluctant to do," says Mark Smout, business development manager at Forrestbrown, a Bristol-based accountancy firm specialising in R&D tax credits.

Yet the government still has a long way to go to raise awareness of the scheme; a survey of SMEs by financial services firm KPMG earlier this year found that only 5% had taken advantage of R&D tax credits, with many entrepreneurs unaware they could apply for the incentive.

TAX BREAKS ENCOURAGE START-UPS

SMEs are seen as the fuel to get the UK economy back on track, providing solutions to social and economic problems and creating jobs at a time when public sector resources continue to be squeezed. Recognising their importance, the government has also introduced tax breaks for investors, making it less risky for them to invest in start-ups, ultimately boosting the amount of finance on offer to small businesses.

For Mike Matthews, managing director of North East-based manufacturing business Nifco, the automotive manufacturing sector is benefiting from a wide range of grants, helping the UK to become a market leader in engine innovation.

Nifco, which supplies car parts to car manufacturers including Toyota and Jaguar Land Rover, has received £5m worth of funding in the past four years, bringing R&D production costs down by up to 8%.

"In the UK, we build twice as many engines as cars, so there are some fantastic opportunities for innovation and we've had an awful lot of support for R&D. We often hear that the UK isn't productive. Actually, the UK's automotive industry is one of the most productive in the world," says Matthews.

However, not all tax changes have been good for business owners. Investors who receive more than £5,000 from company dividends will pay more tax from April next year. Basic-rate taxpayers will pay 7.5% on earnings over £5,000, while those who pay the additional rate of 45% will face 38.1% tax.

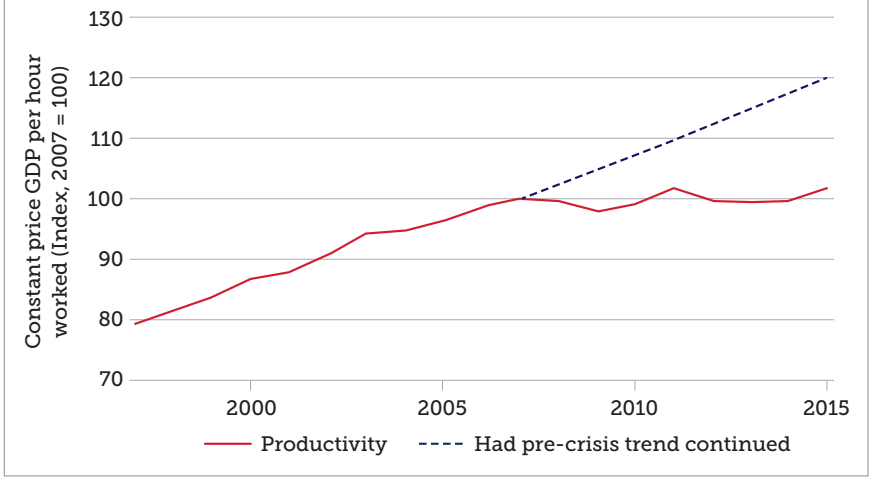
Meanwhile changes to the Patent Box, a generous tax incentive introduced in 2013 to help firms commercialise their creations, are due to come in next year.

As the regulation currently stands, the relief allows companies to reduce tax on profits from products developed through R&D to as little as 10%. However, the scheme will be closed to new entrants from June 2016, and existing participants will be able to enjoy the benefit for only a further five years.

The Patent Box is closing following a challenge from German politicians that the reduced tax rate makes it possible for multi-nationals to obtain a tax saving in the UK despite R&D being based elsewhere. Companies will therefore have to apply in the first half of next year if they want to benefit from the relief, and it is expected the Government will promote the tax regime again in the next Autumn Statement.

The government's Comprehensive Spending Review, due on the same day as the Autumn Statement, will reveal many more details of the chancellor's spending plans over the next year, and how the government will support high-growth industries at the same time as achieving a £10bn budget surplus by 2020. UKMR-15

UK productivity levels



Source: ONS

Nifco

"We've had a lot of support for R&D (from government). The UK's automotive industry is one of the most productive in the world." Mike Matthews, Nifco

Alternative funding
giving banks a run for their money

BY JAMES HURLEY

Blaze, a new laser light for cyclists, raised £55,000 from 782 backers on Kickstarter. There was a rise of alternative finance for enterprise manufacturers in 2015

With Kickstarter a proven funding source for manufacturing and challengers rising, banks now say that alternative finance is a complementary not competitive source of borrowing.

When Emily Brooke needed funding to manufacture her innovative design for a laser bike light, she didn't bother asking for a bank loan. Instead, she turned to crowdfunding website Kickstarter, securing £55,000 to fund production from 782 backers.

Many of these 'supporters' got early versions of the product in return. Ms Brooke says the approach has a number of advantages over traditional manufacturing finance. Since only projects that achieve their funding target get any money, it demonstrates whether or not there is demand for your product, and those early backers also provide vital feedback on product design. You don't usually get that from your bank manager.

Ms Brooke's company, Blaze, is returning to Kickstarter this year to fund manufacturing of another new product. The attraction of the approach to early stage businesses has been summed up by Eric Migicovsky, the co-founder of smartwatch maker Pebble, one of Kickstarter's most famous success stories. "We were able to produce a consumer electronics product with only 11 full-time employees. It's a lesson about the new state of manufacturing that you don't need a gigantic team in order to build a consumer product."

While the proportion of manufacturers that will turn to solutions like Kickstarter for funding compared to traditional sources remains very small, Ms Brooke's approach is merely one example that there's now an unprecedented array of funding options for companies looking for finance. The bank is no longer the only game in town.

Mike Rigby, head of manufacturing at Barclays, says mainstream lenders now view the rise of alternative finance as complementary rather than unwelcome competition. "We welcome alternative finance solutions that help business grow and prosper and in this sector there are a range of them that sit alongside the more traditional offerings. Some of the

options offered provide bespoke, niche solutions which some customers find useful."

Other non-bank finance solutions that are growing in popularity include peer-to-peer lending, through online platforms like Funding Circle, and more long-standing alternatives like asset-based lending, which is increasingly provided through non-bank lenders like Investec.

Nick, partner at Pemberton Capital, a turnaround investor in manufacturers, says firms who lend against plant and machinery are playing a bigger role in financing the industry.

"Asset backed lenders tend to be more commercial and, these days, very competitive on pricing, which makes them ideal partners for SME manufac-

"We welcome alternative finance solutions that help business grow and prosper and in this sector there are a range of them that sit alongside the more traditional offerings. Some of the options offered provide bespoke, niche solutions which some customers find useful."

Mike Rigby, Barclays

"We are seeing substantially more activity from the challenger banks this year – they are very competitive on pricing and obviously keen to do deals in this market, but at this stage they still seem to lack deep experience of lending to UK manufacturing"

Nick Brainsby, Pemberton Capital

turers and their investors. Many borrowers in the manufacturing sector see them as the first choice of debt finance. They came into their own during the economic crisis and we expect their sector to continue to grow."

Despite the rise of alternative finance, high street banks are still the dominant source of manufacturing finance.

According to the comprehensive SME Finance Monitor, which is funded by high street lenders, a third of manufacturers used bank finance in the second quarter of 2015. This was double the proportion who used all other forms of finance, including equity, put together.

Mr Rigby says high street lenders showed a "strong desire to bank the manufacturing sector" in 2015, and that the "demand for finance seems to be returning".

This demand is coming from companies wanting to ensure adequate working capital is in place as trade increases; the desire to fund new machinery - particularly investments in automation - and funding investment in new staff, as well as training the existing workforce, he says.

Research from Lloyds in November found that 40 per cent of UK manufacturers are planning to ramp up investment in research and development. A study by the government's Business Growth Service found that 71 per cent are planning to boost spending on training to boost productivity.

Lloyds is promising £1 billion in funding support for the manufacturing sector each year until 2017 and is training hundreds of its relationship managers in "manufacturing awareness" through the Warwick Manufacturing Group.

However, not everyone is convinced the rhetoric has been matched by action. "The major banks say they are reentering the market, and some are making a very public push back into this part of the economy," says Mr Brainsby. "However, we have not seen much direct evidence of that.

"I suspect the reality is that the banks are still very cautious about lending to SME manufacturers, and if they do lend, the terms are not necessarily attractive. This, in turn, has provided opportunities for other types of financing to step into a market once dominated by the main banks."

He has spotted more activity from challenger banks, such as Handelsbanken, Metro and Aldermore, however.

"We are seeing substantially more activity from the challenger banks this year – they are very competitive on pricing and obviously keen to do deals in this market, but at this stage they still seem to lack deep experience of lending to UK manufacturing."

Equity has typically been underused by small and medium-sized companies of all types in the UK, with manufacturers particularly wary about giving up a stake to outside investors.

However, difficulties in securing conventional finance during the downturn has inspired a reappraisal. Gaynor Dykes, regional manager for the Business Brow th Service, says: "A lot of the anecdotal information we are getting is that companies are increasingly receptive to equity as an option."

Mr Rigby says that while plenty of reticence remains, the arrival of the bank-funded Business Growth Fund, which only buys minority stakes in businesses, is inspiring more trust in equity funding among manufacturers.

Mr Brainsby adds: "Equity is definitely playing a bigger role, partly because many lenders are requiring a greater equity contribution as a condition of lending. However, the more interesting driver of this trend is that investors are now seeing more attractive investment opportunities in innovative, niche UK manufacturers."

In short, he says investors have finally woken up to the fact that specialised British manufacturers can be competitive. "[They have realised] a strong niche is capable of generating good margins and can easily withstand competition from low cost manufacturers."

Mr Rigby says savvy manufacturers like the ones Mr Brainsby identifies are increasingly looking for finance to get ahead of Britain's productivity puzzle and problems with skills shortages.

"Investment in automation and robotics is becoming far more frequent and this is brought on by a shortage of labour, a continuing sharp eye on cost control and a desire to produce consistently high quality products. This is an area of investment we see continuing to rise as the sector invests for growth."

BMI Engineering, a West Midlands manufacturer of components for industries including defence, electronics, automotive and plumbing, is a case in point.

Chris Peare, production manager at BMI Engineering, says the company borrowed £300,000 in 2015 from NatWest to fund new machinery which should deliver £1 million of new orders.

The company spoke to challenger banks, alternative funders and high street lenders but settled on its existing bank. "NatWest understand our business very well and could see how the machine would transform our ability to grow and increase turnover.

"It's a decision that is already starting to pay off with a new part secured that will eventually be going into vehicles made by Jaguar Land Rover. We've just this week finished the first sample parts and volume production should start in early 2016.

"The majority of manufacturers these days know they have to invest in order to be competitive and we are no different. It's the only way we can stay ahead of foreign rivals."

Those that follow in BMI's footsteps will find more funding sources to pick from than ever before. **UKMR-15**

Asset Finance and Asset-Based Lending

With the UK economy continuing to enjoy economic growth, there is increasing demand from companies looking to meet their Capital Expenditure plans using Asset Finance and Asset Based Lending products.

Companies seeing the benefit of matching repayments to the income generated by an asset are using Lease Purchase, Leasing or Operating Leases to meet that need. Asset Based lending products are also being used to optimise working capital or diversify their sources of funding.

Asset Finance is popular for purchasing fixed assets. The underlying feature of Asset Finance is that the bank takes its security by physically buying the asset and leasing it to the client. Often no deposit is required and the legal title remains with the bank while the client has full use of the asset.

Additionally, Asset Finance covers many business asset types, with the exception of buildings, and can be used for acquiring new assets or for re-financing existing assets using as sale and leaseback. Barclays finances an extensive range of assets including: cars, commercial vehicles, industrial plant and machinery, yellow plant, agricultural equipment, medical equipment and IT assets.

On the other hand, Asset-Based Lending (ABL) is a viable alternative. This is where a company may not have the strongest cash flow, but instead has strong assets on its balance sheet. It takes a holistic view of asset classes in order to improve its working capital. Unlike traditional bank lending products, Asset-Based Lending focuses on the current status of assets and cash generation, as opposed to leverage tests, and thus results in the product gaining increased advocacy from the professional community. However, ABL isn't only focused on receivables and inventory. It is increasingly an option for businesses with large, asset rich balance sheets requiring higher levels of funding than is typically available through traditional loans or overdrafts.

Suitable uses for Asset-Based Lending:

- As ABL grows in line with the business, it is being increasingly used by businesses entering a period of high growth where there may be a disconnect between earnings and growth
- ABL works well for businesses with a distinct seasonality e.g. build-up of inventory to support seasonal selling period
- ABL is collateralised and is a good use of capital for any bank. As such ABL providers can consider higher hold levels than traditional leverage deals whilst still considering club or syndicated deals.

To find out more about how Barclays can help your please visit our website www.barclayscorporate.com or call our dedicated team on 0800 015 4242*.

*Lines are open Monday to Friday, 8am to 6pm. To maintain a quality service we may monitor or record phone call.

Baby steps to growth

BY SUSAN SCURLOCK

Primary Engineer does what industry says needs doing: it introduces engineering to children at primary school. After a decade of operation, its founder explains why it is working

It is a decade since 13 schools had to have their arms twisted to join a teacher training course called Primary Engineer.

How times have changed. The course now trains more than 1,000 teachers a year from over 600 schools, which we link to over 800 engineers: who offer support to the teacher and context for the pupil's learning in the classroom.

For the last six years Primary Engineer has been supported by the Institution of Mechanical Engineers and its members, plus more than 500 companies, including Babcock International, Rolls-Royce, EDF Energy, Parker, Weir Group, Nissan, Allied Vehicles and the MoD, as well as a host of SMEs.

This community of engineers that we have established is keen to support local schools, inspire pupils with its passion, and develop teaching staff.

In 2015, Primary Engineer will have worked with more than 1,200 teachers and 35,000 pupils new to the programme, demonstrating a steady 15% year-on-year growth in the last four years.

Every year we see more councils and government bodies recognising the value of engineering in primary schools, bringing more teachers, schools and engineers with them.

In Scotland, Primary Engineer has designed and implemented a three-year engineering education plan for East Ayrshire Council. In 2015, this three-year model began: it will run in Burnley as part of the 'Making it in Burnley' programme, in conjunction with Burnley Council and AMS Neve, an English firm which makes world-leading analogue and digital recording consoles. Primary Engineer was founded in the North West of England.

This aims to coordinate local industry to enthuse pupils and teachers alike with practical STEM activities as well as informing students of career possibilities in the engineering and manufacturing industry.

The last six years have seen the programme provide schools with curriculum-embedded projects from ages 4-19; it has held celebration events, exhibitions and award ceremonies to highlight achievements and motivate pupils in their STEM engagement; to provide CPD skills training for teachers and to implement projects that run from basic structures, mechanisms and electronics through to 3D printing and Scratch Programming into the school. In 2014 we developed a master's level course, 'Engineering STEM Learning', accredited by the General Teaching Council in Scotland. In2015, funded by Skills Development Scotland, the first cohort of teachers began to develop teaching strategies related to engineering and the motivation of engineers and deploy them into the classroom.

In 2013, the first Scottish Engineering Special Leaders Award asked primary pupils, "What would you do if you could be an engineer in Scotland?". Eighteen-hundred pupils entered.

Since the,n our numbers have more than trebled, with 3,000 entries in 2014, and 6,000 in 2015. The ingenuity displayed is remarkable. Children are able to visualise the manufacturing process from concept to a functional prototype: primary pupil invention and design to university student development and construction.

In 2014 we launched the Institution of Primary Engineers and the Institution of Secondary Engineers, two professional engineering institutions for children and young adults. These will map pupil achievement against recognisable engineering competencies – effectively talent spotting engineers in the making – girls and boys alike. UKMR-15

PRIMARY ENGINEER, 2015 HIGHLIGHTS

Fifth year Strathclyde mechanical engineering students build a functional prototype of one of the Scottish Engineering Special Leader's Award entries

Babcock board of directors acts as judge for the Primary Engineer East Coast Scotland Final

Professor John Perkins joins Primary Engineer Advisory Board

THE GROWTH OF THE SCOTTISH ENGINEERING SPECIAL LEADER'S AWARD SINCE ITS LAUNCH

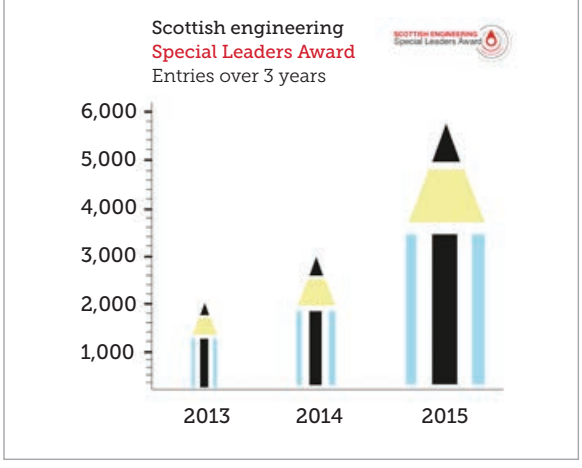


Image: Shutterstock

Taking flight (above): 2015 saw existing engineering initiatives grow

Left: The proliferation of education engagement schemes shows that STEM outreach could be more focused, and effective, in 2016 and beyond

BETTER LATE THAN NEVER

2015 may come to be viewed as the year in which the plethora of engineering skills initiatives took off, says George Edwards

2015 has come to a close, so it's worth assessing where industry is at with regard to the skills agenda.

This year has been one of some stability and progress. A great many new initiatives and ideas have sprung up over the last few years, including the Born to Engineer Campaign (2014), Queen Elizabeth II Prize for Engineering (2013), Big Bang Near Me Fairs (2013), and The Royal Academy of Engineering's Launchpad award (2012).

It is encouraging that after 30 years of neglect, manufacturing and the wider engineering community's skills gap were getting some attention from institutions and government.

MARKETING MANUFACTURING TO YOUTH

However, my view is that the primary issue to overcome is the way engineering is 'marketed' to young people and their influencers.

As such, the 27 fragmented engineering institutions and this ever increasing number of independent and separate initiatives really threatened the likelihood of a clear and consistent message being put across to students.

As many of these initiatives have matured and refined their work, a balance seems to have been struck: 2015 feels like the year that many of these organisations started singing the same tune.

The Big Bang Fair had its biggest year yet, with nearly 70,000 visitors. The Queen Elizabeth II Prize for engineering had a record number of applications from students to design the trophy, with several hundred teams competing.

What and how we communicate with young people has been a key focus of this year's research. Now we have some reasonable buy-in, we need to make sure that the work that is being done is effective.

This year the IMechE released a report, STEM Tribes: Personalising Engineering Education. This research identifies five key groups of individuals by their personality types and explains how they can be most effectively shown what STEM opportunities are all about.

While I think it is worth distinguishing between general training and specifically encouraging young people to consider careers in STEM, Unipart's Institute for Advanced Manufacturing claims that billions are wasted annually on ineffective skills training.

I would certainly encourage more objective research into the relative effectiveness of different approaches to this problem. There seems to be a strong consensus, that human and tailored interactions, ideally in a production environment, are most likely to be effective.

One such problem in the way engineering is presented to young people is the miniscule number of positive portrayals of manufacturing and engineering environments in popular culture.

Taking medicine as an example, there is a plethora of documentaries, dramas and comedies on most channels in prime time slots, targeted at young people and families. This constant cultural reiteration of the human and social side of medical careers subtly reinforces this as a key and mainstream career option.

Unfortunately this isn't a social trend afforded to engineering. 2015 however, seems to be the year that this is starting to change. I was delighted to see James May's childish glee as he followed a car around the MINI plant in Oxford, in Building Cars live, a primetime BBC two documentary. The BBC also announced a serious boost to its technology agenda with the BBC MicroBit, a free barebones computer board for every year 7 student in the country, so that they can learn to code.

A GOOD YEAR FOR SKILLS

So 2015 has been a positive year, with few new initiatives, but real impact as existing projects mature and develop. Looking forward, this year's work suggests that there is a great opportunity to be more focused and effective in STEM outreach.

Additionally, we must make sure that all of the work done to promote digital technology and technology entrepreneurship is linked back to engineering and manufacturing, as those are the industries which enable it. UKMR-15

ENGINEERING AND EDUCATION

How BAE Systems is leading early stage engineering promotion to young people

Ranked as one of the world's power brands and as one of the UK's most politically influential businesses, BAE Systems is well placed to have an impact on the country's skills agenda.

BAE Systems accounts for nearly 1% of Britain's total exports, with many products whose headline specifications can rarely be expressed without the use of superlatives. However, today's generation of young people are greatly distanced from the UK's military capability. Students today are unlikely to have ever seen a Spitfire fly or witnessed, even second or third hand, the impact of Britain's military industry and several generations of its work. As such the innate interest that BAE (and its previous constituent companies) has previously received is dwindling. The company, as well as all large companies in the engineering sector, has had to reinvent the way it engages with young people.

In 2010, BAE Systems started one of the most ambitious education programmes in the UK, The BAE Schools Roadshow. In partnership with the Royal Air Force, BAE Systems visits around 350 schools to engage with some 35,000 students every year. Purely in terms of scale, this is a very impressive programme and exactly the magnitude needed to help close the skills deficit.

As well as their own programmes, which include the Roadshow, BAE is the lead sponsor for The Big Bang Fair, the award-winning week-long extravaganza for young people. Held annually at the NEC, it attracts around 70,000 visitors. Having exhibited at the event for several years now, BAE is refining the way it works there.

There is an internal debate about whether its presence should be more fun and attractive to young people or more relevant and educational. The current thinking is that just by being engaged at this event, children will learn about some of the opportunities STEM careers have to offer. As such, in 2015 BAE decided its theme would be gyroscopes, linking to augmented reality, stable jet fighters and a few other (slightly obscure) parts of the company's work. This culminated in an enormous queue of children lining up for the "Human Gyro", a large gyroscopic frame, where people are strapped in and then spun upside-down, while a Go-Pro videos their face and posts it on social media. To say the least it was popular, attracting one of the biggest crowds of the whole fair.

Matthew Petticrew and Callum Aiken from Ballymena Academy, Co. Antrim, Northern Ireland

As the lead sponsor of the Big Bang Fair, BAE Systems has its own "Inspired Work" prize. In 2015, this was awarded to Matthew and Callum from the Ballymena Academy, for their proposal for a life support pod for long distance space travel. Having researched in great depth, the options for water recycling, aquaponic farming and the psychological impacts of living in confined spaces, the team wowed the judges and took first prize. However, in discussions with the judges, they talked about how difficult it was to prototype and prove something like the project they had proposed. Since the competition, BAE Systems has arranged CAD software and training for the team, with a view to fully prototyping the pod and then using the virtual reality headsets in the aerospace R&D teams, they will get a chance to virtually experience their work.

BIG BANG FAIR 2015 IN NUMBERS:

- 200 participating organisations
- Nearly 70,000 attendees, mostly 11 – 18 year olds
- 15 million reached on Twitter
- 8.6 million reached through BBC breakfast coverage
- Cost to put on +£1 million

WHAT NEXT?

Across its programmes, BAE is getting in front of a huge number of children. Looking forward, it would be great to see a very thorough analysis of the impacts and relative effectiveness of this work and for this to be shared openly, to let other companies, ideally SMEs, benefit and help inspire.

BAE Systems is in a unique place; with a core corporate understanding of the importance of tomorrow's STEM skills, the company's culture really supports this work. Nigel Whitehead, Group Managing Director, Programmes and Support at BAE Systems said: "We have a long and proud history of nurturing young talent and we recognise the importance of providing consistently high levels of training.

"Each year we invest more than £80M in education and skills-related activities to ensure that we are developing the right skills to meet the future demands of our business. The apprentices and graduates joining our business have exciting futures ahead of them, and many of them will end up playing pivotal roles in developing, building and supporting cutting-edge products that will safeguard national security in years to come." UKMR-15

ENGINEERING:
A Case of Enlightened Self-Interest

BY SIR RICHARD BROOK OBE

Progress in a developed economy thrives on the presence of three factors: first, a ready appreciation of the benefits which can result from change, second, access to the financial resources sufficient to bring about that change and, third, a happy integration of engineering into the national culture.

Change itself has always been recognised for the challenges which it brings. The French view is a model of scepticism: 'the more things change, the more they stay the same'. The Italian view suggests a technique: 'to keep things the same, you have to change everything'. But the British view hides reality under a shroud of nostalgia.

The interaction between finance and change is critical for both, either, happily and more commonly, in advancing matters with resolution or, more rarely, in delaying advance to protect existing interests. The one certainty is that change cultures and financial cultures are intricately and creatively intertwined.

While the first two factors are fully acknowledged, the third can remain hidden. The successful engineer recognises a challenge facing the surrounding society, identifies a solution, sets it in place, and then gets on with the next challenge. The person moves on.

If the challenge is concerned with communication, health, transport, energy, trade, then the solution provided often blends with the resulting social structure so effectively that it becomes a part of existence, only called into question and noticed when things go wrong.

While there are inspiring exceptions, the resulting risk is that a society may fail to integrate engineering into its main paths of thinking. The almost total absence of engineering from British political circles illustrates the outcome. No wonder there is a call for a Golden Era of relations with a country which teems with engineers in its upper political echelons!

The great safeguard is of course that individuals recognise the third factor even if the wider society chooses to play it down. The chance to acquire skills relevant to societal well-being, be this at home or abroad, the chance to shape effective solutions to shared problems, the chance in short to contribute with significance either as an individual or in a team, these offer the surest path to personal fulfilment and creativity. No wonder that the fine initiatives of EngineeringUK and its many supporting agencies have encountered success in spreading the word to the future generation.

The message is not that 'your country needs you' – though that is true. It is rather a message delivered by oneself: my best chance to show what I can do, my best chance to bring benefits to those around me, and to provide solutions to fascinating and significant problems for my community, is to enter engineering – and to advance it as a crucial part of the country's thinking. UKMR-15

The aqueduct at Segovia is an engineering structure which can never be accused of self-effacement. Twenty litres a second of fresh water were provided for the city for a period spanning two millennia.
The interdependence of a culture and its embedded engineering are splendidly revealed, and one suspects that nimby-ism played little part in the debates.

The UK does not have either the current capacity, or the rate of growth, needed to meet the forecast demand for skilled engineers by 2022, says Engineering UK.

Engineering has the potential to generate an additional £27 billion per year from 2022. This is equivalent to the cost of building 1,800 secondary schools or 110 new hospitals.

If the UK is to benefit from this, it needs to meet the forecast demand for 257,000 new vacancies in engineering enterprises in the same timescale. The importance of engineering is significant not only economically but also with regards to employment. For every new engineering role an additional two jobs are created in the economy.

"The message is not that 'your country needs you' – although that is true. It is rather a message delivered by oneself: my best chance to show what I can do, my best chance to bring benefits to those around me, is to enter engineering"

Sir Richard Brook, The ERA Foundation

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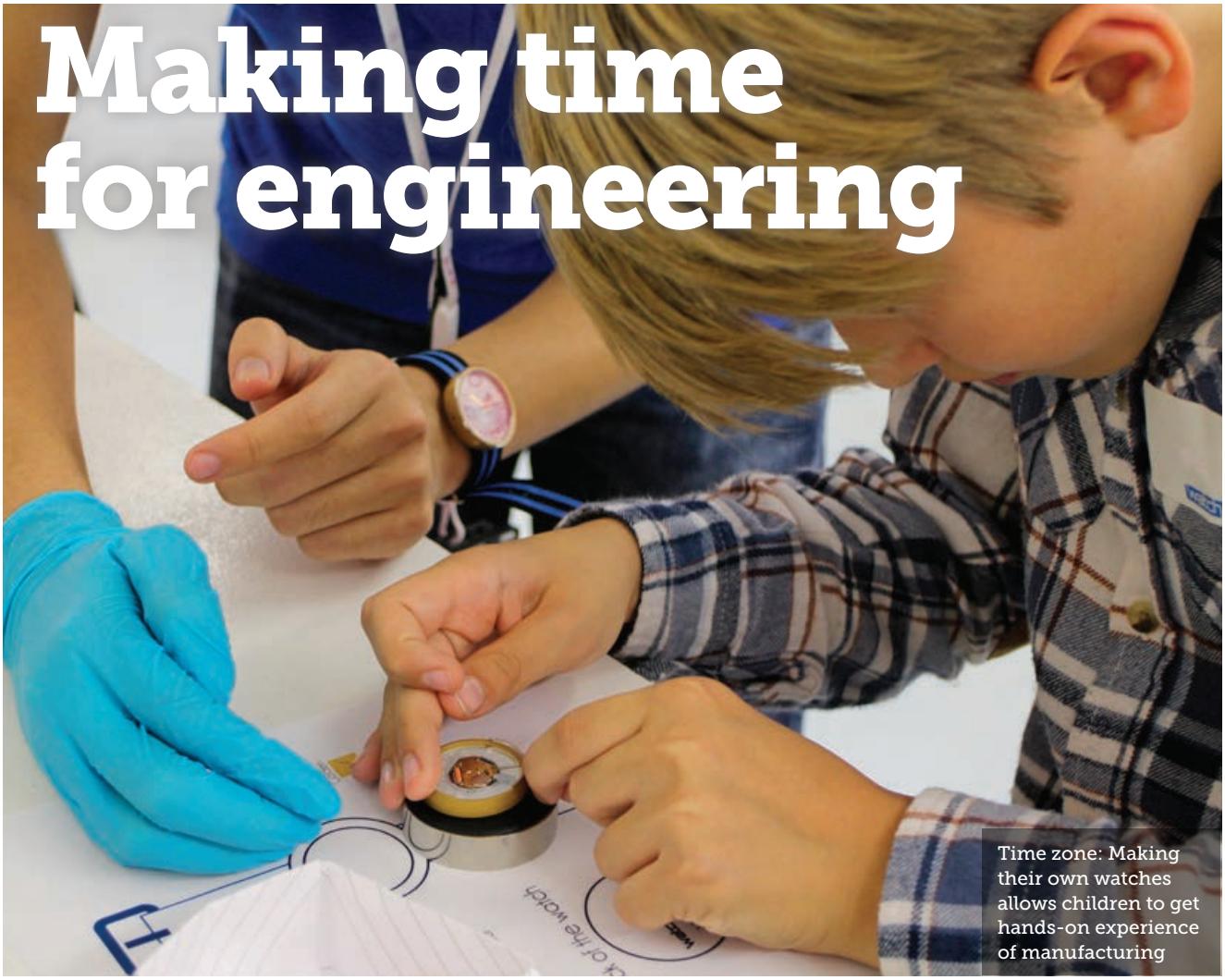
Making time for engineering



Time zone: Making their own watches allows children to get hands-on experience of manufacturing

The Precision Engineering Institute at Cranfield University is internationally recognised as a centre of excellence in ultra-precision machines and processes.

It operates over 2,000 square metres of thermally controlled precision, ultra precision, microengineering and surface structuring laboratories, housing many unique ultra-precision research facilities, designed, manufactured and built by their leading experts.

The Institute has had a significant impact across many fields of science and industries, including the manufacture of many of the mirrors of NASA's James Webb Space Telescope, and the large prototype aspherised mirror segments of European Southern Observatory's Extremely Large Telescope.

Other achievements include the design and build of a highly compact ultra precision micro-milling machine capable of producing advanced infra-red (IR) optics and watch components. Ultra Precision technologies are also being used by Cranfield University to inspire the next generation of engineers.

TAKE PRIDE IN BUILDING THINGS

Watch-It-Made is a Cranfield University educational programme introducing pre-GCSE children (years 7-8) to engineering, through designing and making their own quality watches. The people behind the course, Cranfield alumni Florian Caroff and Armand Dider, hope to capture children's interest in science, technology, engineering and mathematical subjects before they make their GCSE choices, through feeling the 'pride of production'.

The experience is based in bespoke studios within the Precision Engineering Institute at Cranfield, part of the EPSRC Centre for Innovative Manufacturing in Ultra-Precision.

Initially children choose the design of their watch face dial and see how it is printed, using UV ink jet technology. They then get to experience manufacturing, by finishing off the machining of their watch case on a lathe. They can then personalise the back of their watch with their own brand.

Finally, they get to put all the pieces together, including some pre-supplied parts (such as the watch hands, glass and strap) before taking their watch home.

The scheme opened in November 2014 to children from local schools; funding from the EPSRC Impact Accelerator Account has enabled more than 150 children to visit the centre. UKMR-15

More details can be found on the Watch-It-Made website: www.watchitmade.org

In August Brompton Bicycle announced a big expansion with the move to a 86,182sqft Greenford site by January 2016. The aim is to produce 100,000 bikes by 2021, currently making 48,000 per annum. Exports of the popular British bicycle is driving the growth

Country Reports

COUNTRY REPORT

THE USA

Oil companies are reluctant to cut production, even though prices have dropped

Reborn in the USA

BY MONICA SCHNITGER

Manufacturing across the Pond has all the technology – but global oil woes and scandals affecting big auto are taking their toll

For the US, 2015 was either a year of manufacturing renaissance spurred on by energy, technology and re-shoring – or it will be remembered as the year in which trusted brands failed their buyers.

From automotive recalls for faulty airbags and emission sensor hacking, to 3D printing of industrial products and consumer devices, design and engineering technology changed how we look at the world around us.

The year in the US played out against a troubled global backdrop. Energy dominated the news, as the price of oil plummeted due to oversupply and low demand.

President Obama's focus on cleaner forms of energy, including natural gas, and his administration's reluctance to approve Arctic oil and the massive Keystone pipeline, came at a time when US crude production has already been expanding for seven years.

This growth in production, coupled with increased efficiencies, means that the US is poised to become a net exporter of oil and natural gas for the first time since the 1950s.

The US, Russia, other non-OPEC nations and OPEC are playing a dangerous game of chicken: even in the face of oversupply and very low prices, no one has cut production. They want to hold on to market share and drive out more costly, inefficient competitors.

As a result, high-risk projects were postponed or cancelled and oil service companies laid off large chunks of their workforces. When will the situation stabilise? Opinions vary widely: OPEC thinks in 2016 but others are more cautious. No one, however, questions that industrialisation and electrification in the developing world will cause energy demand to grow through at least 2040.

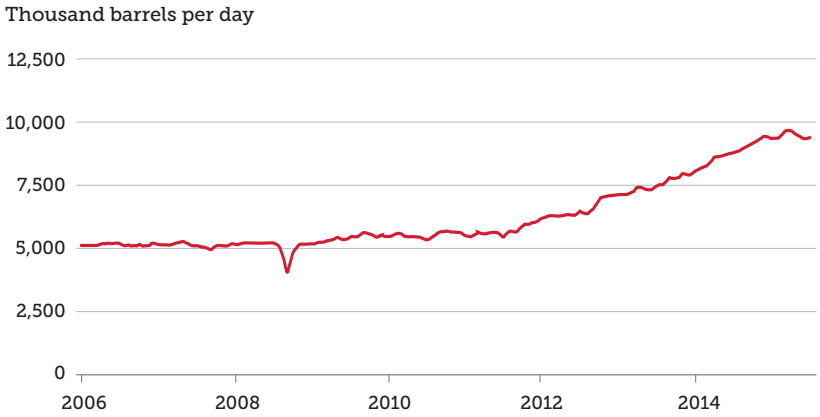
Much of that demand is projected to come from China, India and Brazil, each of which had its own crises in 2015 — and that affected US industry as well. After the global financial crisis of 2008 dragged developed economies into recession, China emerged as a significant driver of global growth.

Cheap credit fuelled investments in its manufacturing and infrastructure sectors, which created huge demand for energy and commodities such as copper, steel and concrete. As China's middle class moved to manufacturing centres and

Image © GE

Stronger components, less waste: this jet engine is one example of how GE is innovating with an advanced 3D printing method called direct metal laser melting

US CRUDE OIL PRODUCTION



US Energy Information Administration

demanded more goods and services, exporters like the US began to rely on the Chinese market for growth.

More recently, however, Chinese government economic policies tamped down growth, leading to lower demand for commodities. At the same time, China's manufacturing sector's success in improving quality and choice reduced reliance on foreign imports.

One result was that the US trade deficit rose sharply as exports, hammered by a strong dollar and weak demand from trading partners, fell to their lowest levels since 2012.

Other outcomes of China's manufacturing success are rising wages and strong competition for trained workers. That altered the economics that made moving production to China so popular in the 1980s and 1990s.

US manufacturers are re-evaluating where to put production facilities, offshoring some operations while bringing others back to the US. Companies as diverse as Walmart, General Motors and General Electric are reshoring to take advantage of tax incentives, trained workers, easier access to some end markets and technological innovations that are reshaping manufacturing as we know it.

3D OR NOT 3D?

One such advancement is Additive Manufacturing, aka 3D printing. All that's needed is the design, a printer and a material that can be printed. This could be resin or plastic, a metal – or even chocolate. The design is either created from scratch using Computer Aided Design (CAD) technology that runs on any computer, or can be created from a scan of an existing object.

3D printing is unlikely to completely replace subtractive methods that carve away material from a base shape, but leading manufacturers are looking at how to combine the two techniques.

For example, it can be used to print replacement blades, so that the wear patterns match those on the broken blades, to keep an aircraft engine in balance. This would be near impossible to do with traditional techniques and can extend the life of an engine by several years.

Additive techniques also bring new business models. Old-style manufacturing requires a big upfront investment to build the factory and buy production equipment. Additive, on the other hand, needs an office, someone to create the model, a 3D printer and materials, and is potentially significantly cheaper as a result.

The way in which 3D print-based manufacturers interact with their customers is different and can be more personal and immediate. In Liverpool, a car buyer can get a 3D-printed steering wheel moulded to fit his hands; in New York, you can have custom-fitted earphones made while you wait. Personalised, local, and immediate appeals to a demographic that is often willing to pay extra for these attributes.

The machines and materials used in 3D printing are evolving quickly to bring down cost and improve quality. This wider adoption of 3D printed parts creates significant issues for regulators, intellectual property holders and consumers. Was a 3D-printed replacement part made to spec and with the correct materials? If anyone with a printer can replicate an object, how will we protect the inventor's rights? This is another case where law will have to catch up to market adoption of a new technology.

Sweeten the deal: 3D-printed sugar cubes show how the technology can help with customer engagement

Image courtesy of 3D Systems

A YEAR OF RECALLS

2015 will certainly be remembered as the year the automotive industry disappointed us. In the largest recall in US history, 20 million vehicles were recalled so car makers could fix faulty air-bag inflators with the potential to explode and send shrapnel flying into cars.

Vehicles affected may have defective, shrapnel-shooting inflator parts from Japanese supplier Takata; the issue involves defective inflator and propellant devices that may deploy improperly in the event of a crash, shooting metal fragments into vehicle occupants. Approximately 34 million vehicles are potentially affected in the US, and another seven million have been recalled worldwide.

Initially, only six makes were involved when Takata announced the fault in April 2013, but a Toyota recall in June 2015 – along with new admissions from Takata that it had little clue as to which cars used its defective inflators, or even what the root cause was – prompted more automakers to issue identical recalls.

In July, the US regulator, the National Highway Traffic Safety Administration, forced additional regional recalls in high-humidity areas in the US, including Florida, Hawaii, and the US Virgin Islands, to gather parts and send them to Takata for review.

Another major recall took in several big brands. For its part, Toyota, which recently overtook Western rivals to officially become the world's biggest carmaker, was forced to concede that if replacement parts were unavailable, dealers should disable the airbags and affix "do not sit here" messages to the dashboard: not what is typically thought of as lean production.

And then, as the year ended, the usually reassuringly reliable Volkswagen was caught upwip in the largest engineering-related scandal to hit the industry for decades, as it acknowledged using software trickery to produce false emissions testing records on many of its diesel models.

But while these two cases grabbed the headlines, and might lead you to believe otherwise, cars are significantly better than just 10 years ago. Overall, the car you drive today is more efficient, reliable and has more features than the one you drove last decade.

Why? Because cars are designed to the tiniest detail and are rigorously tested before production begins to fully understand the driver/passenger experience — first digitally, as computerised models are put through their paces then, near the end of the design process, as physical mock-ups are driven and crash-tested.

The introduction of a new passenger car model can take anywhere from two to six years, depending on how new and innovative it is. This often involves hundreds of designers, engineers, programmers and analysts, working on the car body structure, chassis, airbags, seat belts and harnesses, air handling, and so on.

These systems are modelled in CAD and managed and coordinated using product lifecycle management (PLM) technology. PLM ensures that everyone is working with the latest version of the design and handles who can access specific data. Each team of engineers performs simulations (known as Computer Aided Engineering, or CAE) on their portion of the design. The air conditioning team may test out hundreds of potential air vent configurations before settling on the final design. Then, at set points during the project, all current design states are gathered together for full-vehicle simulations.

Prices are low and there is an over-supply of oil, but production has not been cut back

Image courtesy of BP

The US is poised to become a net exporter of natural gas and oil for the first time since the 1950s

Image courtesy of BP

One of these full-vehicle tests is a crash test. You have undoubtedly seen a video: a car, with a family of crash test dummies strapped into the seats, rams into a concrete barricade. The airbags deploy, the steering wheel crumples, perhaps the front end does, too. This test costs hundreds of thousands of dollars and so is often done digitally during the earlier stages of design.

In the case of airbags, CAE enables engineers to develop an inflation system that deploys quickly to protect the car's inhabitants at the moment of impact. Examining all of the possible alternatives, especially given that there are now six or more airbags on most cars, would be impossible using only physical testing, so CAE is a must.

Designers create CAD models of the car, the airbag and the crash test dummy and define how the vehicle travels and crashes – including vectors such as speed, angle, height – and then complex solver algorithms take over. The result is a detailed analysis of how the vehicle and airbags behaved during the crash, and the forces that were "felt" by the virtual crash test dummies.

Engineers use these results to inform their next design and iterate until they get to the optimum solutions for this scenario. It's not clear why so many airbags were at risk of faulty deployment, but without CAE, overall car safety would undoubtedly be far worse.

CARS AS COMPUTERS

Most cars today are really computers with mechanical parts; they have more lines of code than the Space Shuttle. Simulation is also crucial to ensuring that all of this computing works as intended, with all of the permutations that make modern cars possible. A car with an electric sunroof, for example, requires different code than one with heated seats.

And here's the problem with the Volkswagen emissions probe: a fix may be as simple as installing new software into affected models but this would mean that other such cases would be nearly impossible to find. One would have to know what software and hardware to disable to verify the true emissions state of the car. Again, the investigation is ongoing; recalls are expected to start in 2016.

For both the airbag and emissions cases, knowing which cars are affected is critical. Recalls cost big money: the auto maker must find the car owner, train the mechanic, source and stage replacement parts, and make the fix, all on its dime. Getting the number of affected cars right is crucial.

Original estimates for just the US portion of the airbag recall put the total at 35 million cars; today, that's down to 20 million because some cars were double counted, and others weren't sold in the US. The cost difference between 35 million and 20 million warranty replacements is enormous — and someone needs to know which specific cars to recall.

That's where PLM and similar systems come into play: they can track what went into each model, down to the component or software iteration, and map that against the production process in particular plants. It can be a big data headache, but it is an effective way to manage product complexity in the market today.

MINOR THREATS

2016 could be choppy. Will oil prices rise? Will China's demand for commodities return to prior levels? Perhaps, but no one knows when. Given the uncertainty, American manufacturers are going to focus on innovations that can improve productivity and competitiveness.

More 3D printing of industrial objects will mean increased investment in cutting-edge material science and new manufacturing processes. Will 3D printing take off in every household? Probably not, until there's a really good reason to invest.

We'll see more connected devices in industrial contexts that will create opportunities for manufacturers to add services such as predictive maintenance. We may see less focus on connected devices in the home, as more people are wary of the uses to which that data may be put.

Business models enabled by 3D printing and the Internet of Things will continue to favour agile companies. They'll continue to pose a minor threat to the larger players, but will get the lion's share of investor and media interest.

Mega-corporations will need to explore these new methodologies in order to understand their risks and take appropriate mitigation actions. Finally, the US will wise up: we'll start putting a greater focus on energy efficiency in manufacturing, and end products, because it's good business – and not just the right thing to do. UKMR-15

COUNTRY REPORT

GERMANY

BY MANUEL HECKEL

Trust issues must be dealt with

Image: Shutterstock

Germany celebrated 25 years of reunification in 2015 – and its industry had every right to feel in a party mood, despite slowing Asian demand. The Volkswagen diesel emissions scandal, however, has cast a dark cloud over the efficiency and quality principles synonymous with Germany.

Looking at the current numbers and statistics, many companies are still on a good run. Nevertheless, conflicts and difficulties arising in the global context have an increasing impact on the performance of the export-oriented industry – both corporations and the small and medium enterprises, well known as the backbone of the German economy. In addition to that, Germany itself will face some important changes in the near future, as the Volkswagen scandal brought the spotlight on some underlying problems in German industry.

Roughly 22% of all gross value added in Germany in 2014 was produced in the manufacturing industry, according to the Federal Ministry of Economic Affairs and Energy. Adding service providers to these companies, the members of the BDI, the main business group of national industry, represents around 30% of German GDP – up to 12 million people are employed by BDI members.

The "Geschäftsklima-Index", a periodically-performed survey on business climate and outlook, increased significantly in the early months of 2015. In the September index, while manufacturing industry expects a small downturn for the near future, incoming orders are rising again. Combining different sources, Germany still expects GDP in 2015 to grow at around 2%.

INTERNATIONALISATION: BUSINESS BEYOND BORDERS

Whatever happens in Germany, its industry continues to be heavily dependent on the global economy. Exports represent around 50% of the total manufacturing industry. For some sectors, for example the manufacture of wind- and hydro power plant, it goes up to almost 80% . For 2015, the BDI estimates growth in German exports of about 5.3%, beating the 3.8% of 2014 considerably. Despite the weak euro and some cheap prices for resources such as oil, German companies were able to perform well overall.

With such a dependency on exports, the companies are highly affected by changes in the global landscape. This has been especially relevant for two markets in 2015.

Following the Crimea crisis, new sanctions were imposed on Russia at the end of 2014 by the EU – and vice versa by Russia. This led to a financial breach for several sectors, first of all the food and car industries. In total, the "Ost-Auschuss" of the German economy expects only €10 billion in exported

OPTIMISTIC OUTLOOK

Estimated development of the surveyed companies' business in different markets for the 12 months following May 2015

MARKET	INCREASING	STEADY	DECREASING
Worldwide	53%	41%	6%
Central America	64%	32%	4%
South America	45%	43%	12%
North America	58%	41%	0%
Europe	48%	45%	7%
Australia	60%	40%	0%
Asia	58%	37%	5%
Africa	55%	37%	8%

3000 german companies with foreign branches surveyed in the Geschäftsklima-Index

goods to Russia. Compare with 2012 when the figure was up to €20 billion. Industry is appealing to the German politicians to find a way around the sanctions. With Russia engaging in the Syrian civil war in the autumn of 2015, this seems unlikely so far.

Secondly, a huge shock for several German companies was the financial crisis that befell China in the summer. At the beginning of 2015, the Chinese economy was seen as the Holy Land for high value manufacturing companies, bringing together an increasing demand for highly developed machinery and products with a positive outlook on the financial side. The sudden decline of the Chinese stock market was very unexpected even for the big companies. Germany's car industry, especially, has projected a huge share of its growth plans on the rising Chinese middle class wanting to drive a BMW, Audi or Mercedes.

Although India was featured heavily in the 2015 Hannover Messe, Germany's largest industrial fair, German companies still struggle with the high level of bureaucracy and problems with the infrastructure in India. But there are hopes for better prospects: during a visit to India in October, German chancellor Angela Merkel promised to resume the talks that might lead to a Free Trade Agreement between the European Union and India. "The progressing urbanisation in India is a huge opportunity for the German electrical industry", says Klaus John, responsible for International Trade at ZVEI, the interest group of companies in this sector.

A nice-to-have problem remains for German industry: the largest markets are almost exclusively already covered. The potential for new markets is not that big anymore. That explains a certain level excitement within industry about the – more or less – successful peace talks with Iran.

Some of key sectors of German industry will have a good shout if it comes to modernising the Iranian infrastructure, such as utilities, machinery and all the equipment needed for producing and processing oil and gas. The BDI estimates a potential market volume of €10 billion per year if the market finally opens up. The competition is tough: "The plane between Frankfurt and Teheran is regularly booked", says Sven Brunner, managing director logistic service provider Militzer & Münch. But the seats are also filled with business travellers from the UK and the US.

Image courtesy Schaeffler

Headquarters of Schaeffler in Herzogenaurach: The automotive supplier had to adjust the revenues for a planned IPO by 50% after the Volkswagen scandal was revealed

"The plane between Frankfurt and Teheran is regularly booked"

Sven Brunner, Militzer & Münch on Iran opening up to Germany – and her competitors

Image courtesy Deutsche Messe

Angela Merkel, chancellor of Germany, and Narendra Damodardas Modi, prime minister of India, at the inauguration of the 2015 Hannover Messe, the largest industrial trade fair

INFRASTRUCTURE: DIFFICULTIES OF GETTING CONNECTED

Looking at the internal organisation of German Industry, one topic in 2015 stands out: After a few years of a cautious approach and some early-bird pilots, "Industrie 4.0" has made it to the main stage.

This label is the German idea of dealing with an increasingly digitally connected production line, known both in and outside the factory as the "Internet of Things". After three industrial revolutions, the next step might include features like a production line where every machine is connected to each other and highly individualised products from still highly efficient industrial

Digitalisation in manufacturing: the production line of the Maserati Ghibli was optimised by Siemens

production. Seen as an opportunity to secure the industrial advantage of Germany, even politicians have backed this initiative: several government programmes have been set up to support pilot projects to make some basic technologies available for small and medium enterprises, according to the High-Tech Strategy 2020 action plan of the German Bundesregierung.

"It is therefore no wonder that mechanical engineering companies and other classical industrial corporations are intensively contemplating the digitisation of their operations – and are looking into how this will transform current business models," says Frank Riemensperger, Country Managing Director of Accenture in Germany. "This transformation, after all, will yield further increases in productivity, and it constitutes future growth potential in terms of markets and sales units."

Nonetheless several challenges remain. There is still no broadly accepted single set of protocols and standards for communication. And companies are still highly sceptical about the security of their data being stored somewhere other than on their own servers. The revelations of the US National Security Agency scandal have left their scars in Germany. Some companies are experimenting anyhow: Siemens has transformed several sites into "digital factories", and Daimler has been given the permission to test an autonomous lorry driving on public highways.

Several steps away from the vision of an intelligent industry, there remain some very real challenges. First of all, the digital infrastructure is not suitable for this to happen in the present. Especially in some areas, such as the Black Forest in the south-west or the Siegerland in the west, there are still places where only slow internet connectivity is possible. Telecommunication providers like Deutsche Telekom do not want to invest in expensive optical fibre in regions where only a few customers will connect and pay for it. The Bundesregierung has promised to give more money towards a technology fund to support this.

Worse still, the very basic infrastructure is an increasing problem for some industrial companies in Germany. With very specialised and well-connected industrial networks, collaboration between suppliers and producers are efficient and well organised. This gets increasingly difficult, as the roads – as well as some canals – are in a bad shape, leading to highway bridges being closed for transports over 3.5 tonnes and creating very costly detours for logistics. Some renovation programmes have started in 2015, but they will take time. The highway A45 for example, connecting the Ruhr-Area with the Rhine-Main-Area, is now undergoing the renovation of several bridges along the road. Estimated time of the construction work: up to 25 years.

POLITICS: FRAGILE TRUCE

With good growth performance for industry and public households, some issues between business and politics were not as present this year as they were in preceding years. Why? Firstly, the ambitious German project "Energiewende" has a huge impact. A benefit for the energy providers, which have to adjust to a more unstable energy network as there is an increasing amount of electricity coming from renewable energy sources. This led to several traditional power plants becoming unprofitable. The biggest German utilities RWE and E.on are operating deeply in the red and are planning to change their structure quite radically. Ideas include the splitting off of new business models and the legacy capital, such as nuclear plants, into separate companies. Politics has a very careful eye on the question of who is going to pay for the liabilities. Besides this, the manufacturing industry has to deal with relatively high energy prices. 2015 has brought a small relaxation for energy-intensive sectors, such as chemicals and metalworking, but prices are probably going up again in 2016 – and so will the protests.

> "We want a corporate culture where malpractice is prevented, critical questions are welcome, violations of law are averted and mistakes are self dependently corrected"
>
> *BDI president Ulrich Grillo, after the VW scandal was exposed.*

OUTLOOK FOR 2016: "MADE IN GERMANY" REVISITED

Up to mid-September 2015, the further development of German industry seemed easy to predict. The only important variable was the global economic condition. Over the summer,

INSECURITIES AHEAD

Main challenges for companies to adjust to increasing digitalisation.

CHALLENGE	MENTIONED
IT-security	59%
Legal insecurities	50%
Insufficent competences of staff	39%
Large investments needed	39%
Lack of technical standards	34%
Insufficent broadband connection	32%
No restraints	21%
1849 companies surveyed in the Geschäftsklima-Index	

Source: DIHK

FOCUS ON PEOPLE

Main challenges for corporate growth in 2015, according to companies.

CHALLENGE	MENTIONED
Recruiting skilled staff	33%
Recruting management	32%
Pressure on prices	29%
Commitment of crucial employees	29%
External effects	28%
Reduction of cost structure	28%
Managing complex tax structure	27%
Economic situation	27%
Securing new/existing orders	25%
War on talents	25%
Source: The Geschäftsklima-Index	

Source: DIHK

things have changed markedly – two internal issues will have a huge impact on German industry.

Firstly, the revelation of the Volkswagen scandal will have a direct impact on many business activities – and an indirect effect on the culture of German companies. Widely branded as "Dieselgate", the car manufacturer had to admit in September that it had manipulated the emissions tests on some of its diesel cars. The compensations and penalties could cost the company up to $18 billion and will affect many suppliers as well as other car manufacturers. One of the first victims was automotive supplier Schaeffler who announced its plans for an IPO just days before the revelations and had to reduce the expected revenues by almost 50%.

More important, and much more difficult to put a price tag on, is the trust in German engineering that might be damaged. "We want to have a corporate culture where malpractice is prevented, critical questions are welcome, violations of law are averted and mistakes are self dependently corrected", BDI president Ulrich Grillo says. Being too confident about their own work – where Volkswagen uses "Das Auto" as its slogan – could have tempted VW engineers and managers to find their way around the system. Following this, 2016 might bring compliance and leadership back on the agenda of German industry. Right now, it is still quite common for company CEOs to switch to the supervisory board without any delay or procedure, for example.

INHERITANCE TAX: REVOLUTION OF THE FAMILIES

In most cases, German industry is able to speak with one voice – no matter which size or structure the companies have. One case is very different: The political consultations on a reform of the inheritance tax have infuriated many family-run businesses in Germany. So far, owners can pass on their company to the next generation with very little tax to pay compared with other countries. This is seen as unfair by wide parts of the society. Among the richest Germans, there are several families like the descendants of BWM-founder Quandt or construction machine producer Liebherr. Lobby groups like the "Stiftung Familienunternehmer" argue that the entrepreneurs are responsible for millions of jobs in the country and any increase of this tax might stifle enterprise and compromise these jobs. The current version of the new law on the inheritance tax was adjusted for this argument – but the political process is not finished yet.

Image: Rolf Sturm/E.ON

E.on-power station Irsching in Bavaria. Although one of the most modern plants in Germany, Irsching is scheduled to be shut down next year

Secondly, the huge number of immigrants into Germany will become a constant challenge for industry. Several business leaders like Daimler CEO Dieter Zetsche expressed the need for the country to integrate new citizens as an important boost to Germany's labour force. The skills shortage, especially in the manufacturing industry, is already a huge topic for small and medium companies outside the big cities. On the other hand, much effort and also money will be needed to ensure formal qualification and integration of this labour force into the German economy. Going into its 26th year as a reunited country, German industry will be faced with several big challenges. But it is facing these challenges – compared to other countries in Europe and worldwide – from a strong position. UKMR-15

COUNTRY REPORT

FRANCE

Le révolution digitale: French President Francois Hollande at a digital conference in the context of European Round Table of Industrialists in October. Earlier this year Mr Hollande launched a public funded project at aeronautical company Figeac Aéro to make France a leader in composites, 3D printing and augmented reality within five-years

Image: Shutterstock

Catching up in spite of economic stagnation

BY MARCO PISANO

Stymied by a complex tax regime and an unwieldy labour market, France has struggled to emerge from recession as smoothly as other European countries. But a new generation of innovation in manufacturing means there is light at the end of the tunnel.

Despite a long-awaited economic recovery seemingly on track in 2014 and extending to a positive first quarter in 2015, the French economy reverted back to stagnation during quarters two and three in 2015.

Even though figures for September 2015 registered the highest month on month drop in unemployment in France in eight years, the socialist government's objective to reduce unemployment is taking some time to materialise.

The French Minister Emmanuel Macron is sympathetic towards a drastic shake-up of a workplace still dominated by highly unionised employees. The Macron Law, introduced in 2015, is a package of reforms designed to reinitiate economic growth and simplify layoff procedures.

According to the Organisation for Economic Cooperation and Development (OECD), the law should boost growth by 0.3% over five years. Hence, more government action is needed to generate a faster and long-lasting recovery.

Yet the last full-year budget before the April-May 2017 presidential election estimates a conservative growth rate of 1.5% for 2016, slightly more optimistic than OECD predictions.

STRUGGLING TO COMPETE

So what about industry? Is French manufacturing still competitive and, if not, what's the sector doing to modernise itself?

The industrial sector in France represents over 12% of GDP and provides more than 3 million full-time jobs. However, unsurprisingly, 17% of the value-added comes from the food and agricultural sector, followed by machinery/equipment installation and maintenance (9%) and metal manufacturing (8%). The automotive industry, for example, barely represents 4% of the economy.

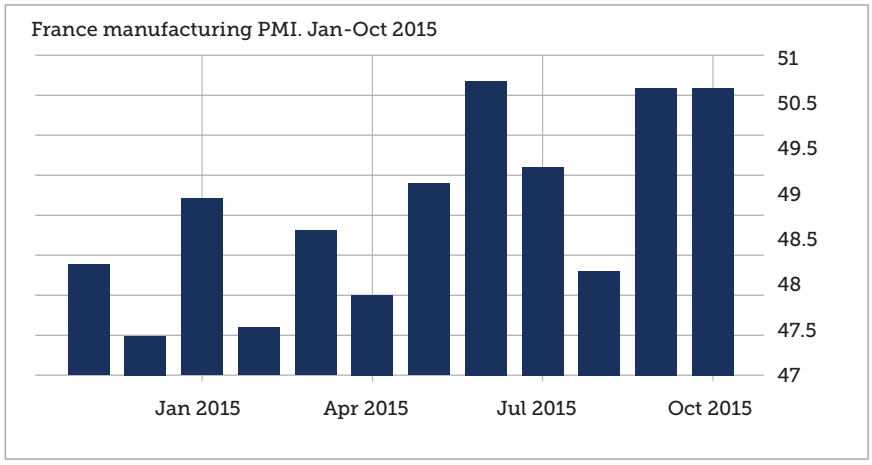
The sector as a whole fluctuates between periods of decline and modest growth – the latter generally triggered by more affordable prices of raw materials allowing indigenous companies to cut costs.

Even Christine Lagarde, director of the International Monetary Fund, recently stated that with low oil prices, a weaker euro and monetary stimulus, France should be able to achieve more substantial growth.

Unlike Germany, which has enjoyed an export-led robust economic recovery, France is struggling to compete globally in terms of exports whilst also displaying over dependency on its European neighbours and weak domestic demand.

"Labour is over taxed in France despite the fact that we have better productivity compared to our neighbouring countries."

Thierry Daudignon, managing director of Starkey France



France's manufacturing recovery has stuttered but has showed positive signs recently

HELD BACK BY HIGH CORPORATION TAX

France features among the 20 countries with the highest top marginal corporate tax rates in the world. It Europe, it is second only to Malta.

With a rate of over 30 percent the country is well above the world's average of 22.6 percent and the average in Europe of 18.6 percent.

The situation might change as François Hollande's government has recently approved €9 billion of corporate tax breaks in 2016 attempting to bring the deficit down in line with the limits imposed by the EU.

The 2016 budget, labelled by the Finance Minister Michel Sapin as a "budget of the kept promises", is part of a bigger plan to support French businesses and boost investment between 2014 and 2017.

Whether this move will work is too early to say but it shows that the government has realised the second biggest economy of the Eurozone, still struggles to come out of the crisis originated in 2008.

The US, the UK and to a lesser extent Germany, have all implemented pro-growth policies, whereas France had to face Moody's recent downgrade of sovereign debt credit rating to Aa2, which reflects how the economic recovery in the country has already proved to be significantly slower than expected.

2015 HIGHLIGHTS

- President François Hollande launches a government funded programme on future factories during his visit at Figeac Aéro in April 2015
- The Macron Law is approved by the National Assembly between June-July 2015
- The 2016 Budget is presented by the Cabinet on September 30, 2015 and will need approval by the end of the year
- September 2015 - government figures show highest monthly fall in unemployment in France in eight years

The European Commission's 2015 Country Report on France, for example, highlights a series of non-cost factors that explain the deterioration of exports in the country since 2000. These include poor product quality, innovation, after-sales and distribution networks.

PUSHING WATER UPHILL

Poor profitability, particularly in the manufacturing sector, has also hampered French companies' ability to move upmarket. The country's relatively unfriendly business environment with regards to labour laws together with a lack of investment in innovation and complex tax bureaucracies are additional challenges.

Hence the main message of the report was to focus on improving the overall business environment by making taxation and the labour markets more efficient.

The labour market, in particular, has always been one of the biggest headaches of a country where the trade unions remain extremely influential over the economy and can get in the way of an imperative need for rapid reform.

It is perhaps this apparent inability of France to quickly embrace change and equip its economy to compete globally that affects the country's long-term attractiveness as a place to do business.

The Air France story is a typical example of how difficult the 'social dialogue' can become. The high-cost airline, which is currently going through a restructuring process to reduce its size, has had to deal with numerous workers' demonstrations, some of which have turned violent

A 14-day strike by Air France pilots in September 2015 to oppose a cost savings plan to be implemented by 2017 was followed by an incident on October 5 where the company's HR director Xavier Broseta had his shirt ripped off at an angry rally.

Air France employees were resisting a strategic plan to cut 2,900 jobs. Eventually, Air France conceded and only around a third of the initial figure will be cut in the short term, de facto making any profound and urgent change in the company's workforce almost impossible.

Areva, the world's biggest nuclear company, which is in a challenging position financially, is also cutting 2,700 jobs in France. However, this process appears to be going more smoothly for the energy company.

Patrick Besson, Professor of Strategic Leadership at Business School ESCP Europe, said: "Areva is a striking French story of bad strategy, bad governance and bad management but successful social dialogue."

It is ironic that, given that the company has made losses for €5 billion, anyone including Areva's management team is nonetheless proud of its social dialogue actually ignoring business results.

THE SEARCH FOR VALUE ADDED

At the other end of the spectrum, Starkey Hearing Technologies, an American-owned medical devices

manufacturer, is a good example of how French know-how is still valued by multinational companies despite high labour costs.

The company has been in France for 35 years and has developed many highly customised products such as in-the-ear hearing aids, which are miniaturised devices that go deeper in the ear thanks to advances in technology.

According to Thierry Daudignon, managing director of Starkey France, the company has been involved in rapid prototyping and 3D printing for over a decade, whilst technologies such as software modelling and simulation have triggered a delocalisation of production.

"Now you can scan images and send them over the internet, it makes the technology exportable in lower cost economies than France, including the UK," he said.

Starkey has its largest European manufacturing capability in Cheshire, UK, due to cheaper labour costs, though ease of communications and cultural affinities also help, the company says.

"Labour is over taxed in France despite the fact that we have better productivity compared to our neighbouring countries," said Daudignon. Nevertheless, the company has taken the opportunity to create in France its first R&D centre outside the US thanks to homegrown skill-set in custom fabrication and advantages in local R&D tax credits.

EMBRACING CHANGE

Notwithstanding the somewhat gloomy economic situation and labour market challenges, French manufacturers are gradually embracing digital technologies. Schneider Electric, a global energy management specialist headquartered in France, aspires to become the first digital industrial company by focusing on connected devices, process automation and software services in addition to its historical industrial manufacturing core business.

Cem Yondem, IT director , delivery & operations at Schneider, highlights how the company has invested heavily in digitisation accelerating pace in 2015 following the launch of a new strategy called '2020 Vision'.

"Digital technology enables us to deliver better service to our customers and produce internal efficiencies across all our locations," Yondem said.

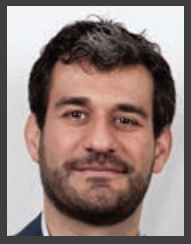
The company also has a specific Industrial and Technological Transformation programme for France, aiming to upgrade its industrial footprint in the country with supporting information systems such as state-of-the-art ERP solutions.

Clément Viard, senior director at DXO, which has kept product design and software development in-house

"This transformation will be expanded for services and customer relations as well, through modernised customer care centres and restructured front- and back-office functions, which are integral parts of the strategy," said Yondem.

Aurélien Fabre, the regional sales and marketing director EMEA for ProSoft Technology, a company which provides communications solutions to large industrial automation suppliers, is realistic about the state of digital innovation for French manufacturing.

The automation market in France is facing two main challenges, Fabre says: the arrival of the Industrial Internet of Things (IIOT) and the migration to Ethernet protocols. "Many French plants are still equipped with more than 20 years old PLCs (programmable logic controllers) and this represents a high risk as PLC vendors are now making these products obsolete," he says.



"Digital technology enables us to deliver better service to our customers and produce internal efficiencies across all our locations."

Cem Yondem, IT director, delivery & operations at Schneider Electric

He adds that Industry 4.0 is also becoming a reality. "We see more and more factory workers equipped with tablets," he says.

"They are connecting wirelessly to machines, cranes or the automated guided vehicle. Hence we see more and more slip ring or festooned cables being replaced by industrial radios in combination with radiating cables."

INNOVATION PUSHES THROUGH

Businesses operating in consumer markets are similarly able to innovate in France despite sourcing senior engineering skills becoming a real challenge. DXO Labs, for example, an image processing company headquartered in the west suburbs of Paris, outsources its electronics manufacturing but has kept product design and software development in-house.

"The innovation climate in France is very dynamic and we have a lot of very talented young engineers who join our teams," says Clément Viard, senior director at DXO. Though, he also recognises: "It is difficult to hire senior engineers with experience in our field as there are very few companies in France involved in image processing or making consumer digital cameras."

The picture is thus not dissimilar from Germany, the UK or the US. French industrial businesses are recognising the need to innovate and digitise – and some sectors are even seeing growth again.

According to the French Federation of Mechanical Industries, the mechanical engineering sector is now ranked sixth in the world with a turnover of nearly €115 million. This was the result of a steady growth in the past five years (apart from a slight decrease in 2013), almost matching pre-recession figures.

Other positive initiatives are underway. The April 2015 launch in Figeac, south-western France, of a government backed scheme to make France the global leader in 3D printing, composites and augmented reality – is a good step in the right direction to regain competitiveness in industrial robotics and future factories.

Even though it is unlikely 2016 will be the year of return to considerable growth, the government has the chance to introduce bolder reforms that enable industry to re-emerge stronger in the global arena and decisively leave the 2007-08 financial crash behind. UKMR-15

SPECIAL FOCUS

CHINA

NEW ENERGY INVESTMENTS PAY OFF

China is investing heavily in developing rapidly growing sectors and products that harness new sources of energy. Such innovation could help boost the economy as a whole, reports Dr Chao Lu.

In response to the ever growing imbalance in the supply-demand of oil combined with air pollution, efforts to develop new energy vehicles are being carried out all around the world.

As the world's largest automotive manufacturing country, China put forward an eight-year plan in June 2012 to develop its new energy automotive industry. Three types of vehicles were covered by the plan: pure electric vehicles (PEVs), plug-in hybrid electric vehicles (PHEVs) and fuel cell vehicles (FCVs).

The following years witnessed a significant expansion of the market. Production and sales figures reached 76,223 and 72,711 respectively and, by the middle of 2015, China had overtaken the US and become the world's largest market for new energy vehicles.

The driving force of this was policies introduced in alignment with the plan. According to incomplete statistics, 136 new policies designed to encourage new energy vehicles rolled out from January 2014 to September 2015. These policies operated in various ways to shift customers from conventional petrol-powered vehicles to new energy models.

In August 2014, the State Administration of Taxation granted exemptions on purchase tax for new energy vehicles within specified ranges. In April 2015, the Ministry of Finance offered price subsidies up to Rmb55,000 (£5,500) per vehicle between 2016 and 2020.

In October 2015, the State Council released guidelines on accelerating the construction of charging infrastructure for electrified vehicles. The target is to establish an infrastructure network over the country by 2020, capable of charging five million electrified vehicles.

In Beijing and Shenzhen, two of China's largest cities, where people used to have to wait for months to be allocated a number plate for a new car, the local governments started reserving more than a thousand plates every month for allocation to new energy vehicles.

Shanghai went a step further by granting number plates for free to listed new energy vehicles. This policy boosted the new energy vehicle market in the local area and was applauded by vehicle makers.

BYD Auto, a Chinese automotive manufacturer specialising in new energy and battery technology, is one company that has benefited from the country's policies on new energy vehicles taking a growing share of the 29.8% of the new energy vehicles in the domestic market over the first half of 2015.

The company is also introducing the K9 model, an all-electric bus, to the European market. The K9 bus has passed the EU's Whole Vehicle Type Approval (WVTA) and can be sold to EU countries without any restriction. In October 2015, the model made its debut in London.

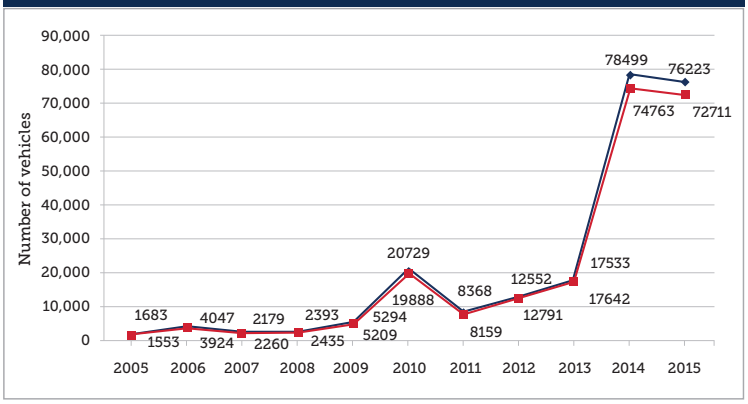
BYD's all-battery powered forklift trucks are now available in Japan and Australia since September, following its first show in Germany in 2013.

In general, China's new energy automotive industry has bright prospects in terms of increasing market and public acceptance over the next five years, owing to the continuation of central governmental policies and the progression of charging infrastructure construction. The Made in China 2025 plan, launched in May 2015, should boost this, providing additional propulsion to the development of the industry over this period.

The time further ahead might witness a downturn due to policy attenuation and demand saturation. The key to tackling such a problem might lie in fostering new business and service modes to reduce of the coupling of the advance of new energy vehicle industry to governmental policies.

Chao Lu is a lecturer in Shanghai University. His research focuses on industrial policy for new-energy vehicles and innovative city construction. UKMR-15

CHINA CAIXIN PURCHASING MANAGERS' INDEX



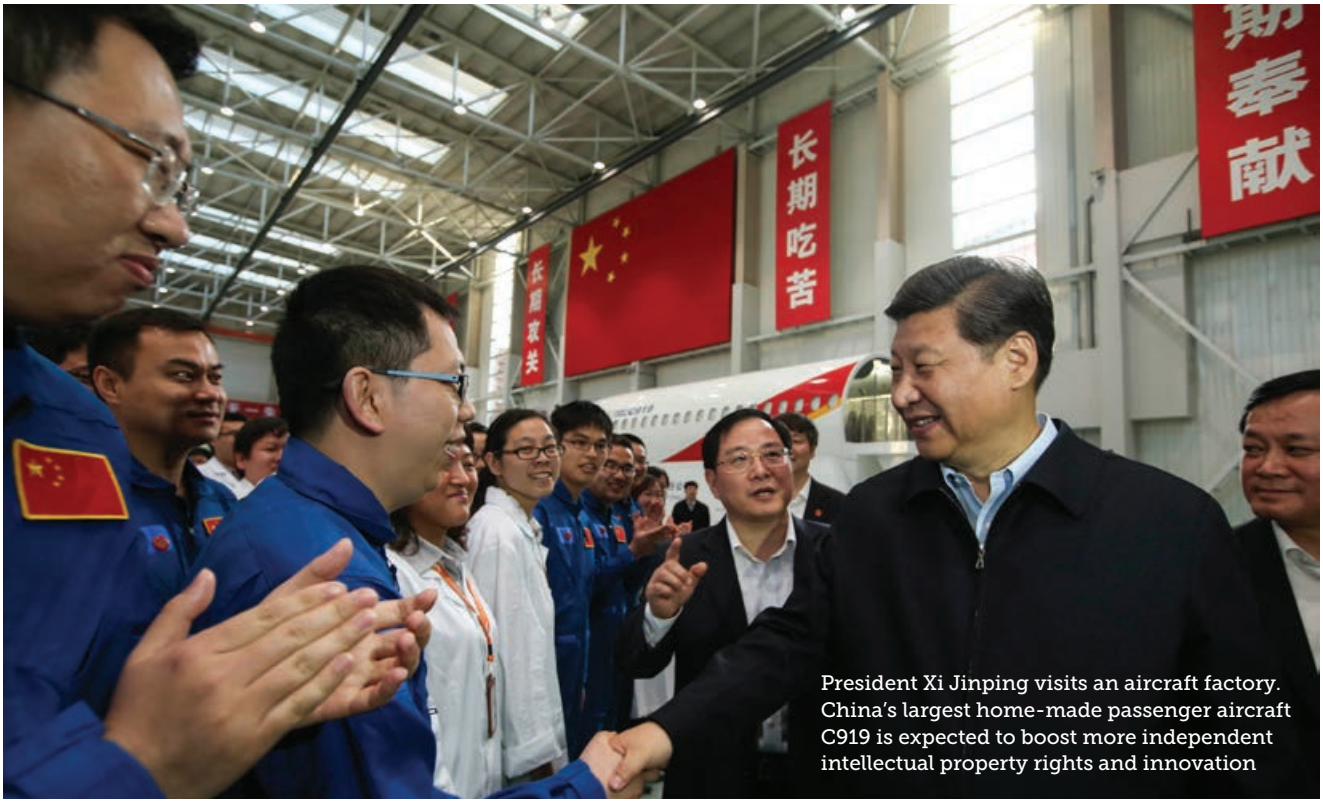
Energy-Saving and New-Energy Vehicles in China 2010 to 2014
Source: China Automotive Technology and Research Centre Report

BYD Auto

BYD Auto is making inroads into several overseas markets with its products, including the UK with electric buses

COUNTRY REPORT

CHINA



President Xi Jinping visits an aircraft factory. China's largest home-made passenger aircraft C919 is expected to boost more independent intellectual property rights and innovation

Xinhua News Agency, photographer Hongguang Lan

Reinventing the world's factory

BY YUAN TAO

China's manufacturing industry has endured some turbulent times lately. Ambitious government plans will disrupt the status quo but should also reinvent the sector and create a world-leading manufacturing sector in the years to come.

In 2012, some predicted that China's manufacturing industry would collapse by 2015 and its economy would follow. While this forecast has clearly not come true, as of October 2015, the growth of China's GDP had slowed significantly following the crash of its stock market in the summer and the devaluation of its currency.

The slowdown can be seen in its manufacturing sector. The Caixin China manufacturing purchasing managers' index (PMI) fell to a six-and-a-half-year low of 47.0 in September 2015 (figure 1).

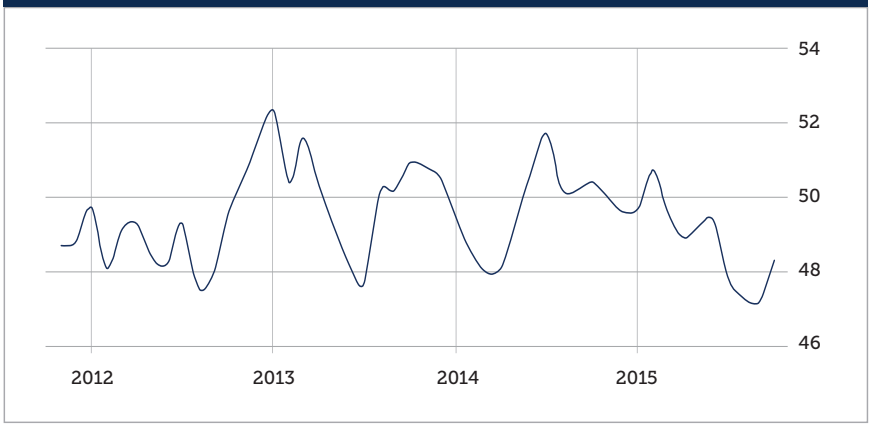
Since 2010, China has replaced the US becoming the world's largest industrial producer, with 19.8% of the manufacturing output. Nevertheless, due to its middle/low level of technical innovation, the one-time attraction of "international subcontracting – Made in China" can do nothing to decelerate what has been a sharp downturn in some manufacturing sectors.

Although the One Belt, One Road programme has invested heavily in foreign infrastructure, China's manufacturing overcapacity is still a problem. Low-tech firms are increasingly attracted to Southeast Asian countries that offer both cheaper labour and cheaper taxes and environmental requirements. Equally, for high-tech mechanical equipment, China still replies on imports.

China's manufacturing still has a long way to go. This "world factory" is waiting to be a "strong world manufacturer".

Facing with these various challenges, China's industry is changing shape with service-oriented manufacturing

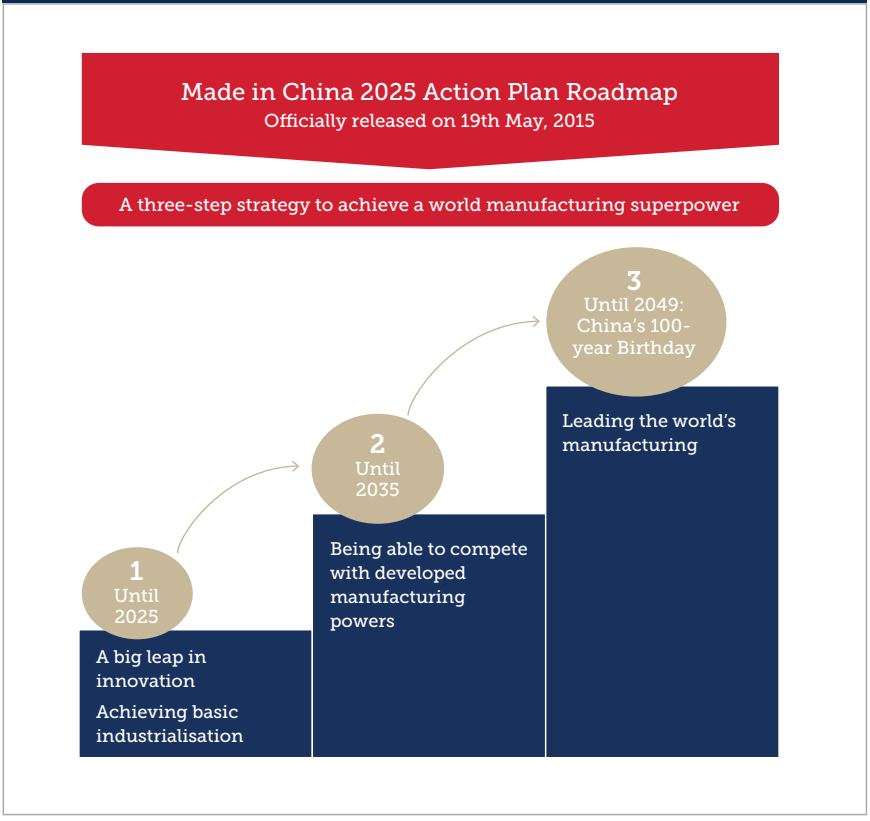
FIGURE 1: CHINA CAIXIN MANUFACTURING PURCHASING MANAGERS' INDEX



www.tradingeconomics.com

China's manufacturing sector is at a six-year low

MADE IN CHINA 2025 ACTION PLAN: CHINESE MANUFACTURING IS MOVING UP



Graph created by Yuan Tao

progressing quickly. Internet financing has helped revolutionise conventional manufacturing. The recently unveiled Made in China 2025 initiative, designed to upgrade Chinese industry, may spur a new robotised industrial revolution, where intelligent manufacturing may upgrade Made in China to Created in China and even Chinese Speed to Chinese quality or Chinese products to Chinese brands.

POLICY INTERVENTION

In the third quarter of 2015, China's GDP growth slowed down to 6.9%, its lowest level since the last global crisis in 2009. prime minister Li admitted that China's economy is facing difficulties. Several provinces with heavy industry even recorded negative nominal GDP in the first six months of 2015.

In fact, China's manufacturing industry has three problems: a lack of innovation, weakness in core technologies, and excessive energy consumption and severe pollution.

In response to these, China's central government has started to unveil its plans to give manufacturing a makeover.

In May 2015, the long-awaited Chinese version of Industry 4.0 was released by China's central government. It takes a leaf from Germany's Industry 4.0 playbook, though many enterprises are not even in the era of Industry 3.0 yet. The heart of the Industry 4.0 idea is intelligent manufacturing – applying the tools of information technology to production.

Made in China 2025 (formerly called China Manufacturing 2025) is China's first 10-year industrial action plan. It was authorised by Premier Li Keqiang and drafted by the Ministry of Industry and Technology (MIIT) over a two-and-a-half-year period with input from more than 150 experts from the China Academy of Engineering.

This plan has been launched at a critical time. The so-called world's factory is struggling with an economic slowdown, decreasing domestic demand, decreasing exports and increasing competition with foreign countries increasingly equipped with both cheaper labour and better technology.

China is being pressured from both advanced industrialised economics such as Germany, the US and Japan with their high-end technologies, and emerging economics like Brazil and India, which are catching up with cheaper labour, cost and taxes.

In response, Made in China 2025 aims to make China a world manufacturing power by 2025 through comprehensively upgrading Chinese industry.

In fact, Made in China 2025, merely the first step of a 30-year three-step strategic plan, will be followed by another two 10-year plans to fully change China's manufacturing sector. By 2035, the aim is that China will be able to compete with developed manufacturing powers and, by 2049, China will lead the world's manufacturing – all just in time to celebrate New China's 100th birthday.

AMBITIOUS PLANS

The Made in China 2025 plan is be market-oriented. Its guiding principles are to ensure manufacturing is innovation-driven and quality-driven, to achieve green development, to optimise industrial structure and nurture human talent.

To fulfil this, Made in China identifies nine goals: improving manufacturing innovation, integrating information technology and industry, strengthening the fundamental capacity of industry, fostering Chinese brands, enforcing

Jiangsu Donghua Textile Co.

Jiangsu Donghua Textile Co.

China's textile and garment industry is enduring tough times but plans are underway to make it more innovative

"The sharp rise in Chinese private sector investment into the UK could pave the way for deeper China-UK private sector cooperation."

green manufacturing, promoting breakthroughs in 10 key sectors, advancing restructuring of the manufacturing sectors, promoting service-oriented manufacturing and producer service system, and internationalising manufacturing.

The 10 key sectors are: new-generation information technology, high-end robotics, aviation and aerospace equipment, maritime engineering, rail transportation through the One Belt, One Road initiative, new energy vehicles, electrical power equipment, new materials, biomedicine and advanced medical apparatus, and agricultural equipment.

To get the plans off the ground, Made in China 2025 will focus on five projects with specific targets.

1. Fifteen innovation centres will be established by 2020 and 40 by 2025 focusing on IT, intelligent (digital) manufacturing, additive manufacturing, new materials and biotech. All will be supported with funding from the government. For Beijing, research spending will be increased to 1.68% of manufacturing revenues by 2025 from 0.88% in 2013. It also aims to raise the percentage of core components and materials sourced locally to 40% by 2020 and 70% by 2025.
2. Intelligent (digital) manufacturing will be targeted with reducing costs by 30%, the development cycle shortened by 30%, and the number of faulty products cut by 30% by 2020 and 50% by 2025.
3. The aim is that the sourcing of core components will be less reliant on imports through advanced manufacturing techniques, engineering and platform sharing. The goal is to create an independent (domestic) supply of 40% of core components/parts, especially in aviation, telecoms, power generation, construction machinery, power transfer, railroad and home appliance. The aim is to increase this to 70% by 2025.
4. A new emphasis will be placed on so-called green manufacturing. The scheme is targeting a 20% reduction in waste in key industries by 2020 and reaching global standards by 2025.
5. To produce more high-end equipment in large planes, aviation engines, combustion engines, civil aviation, green trains, renewable energy and hybrid vehicles, marine project equipment, high-tech ship vessels, intelligent power grids and numerical control machines, nuclear equipment, high-end diagnostic/treatment equipment. The targets are for independent R&D and application to be in place by 2020 and a material increase in market share to be achieved by 2025.

Unlike some previous schemes, Made in China 2025 emphasises on the entire manufacturing process, not only indigenous innovation. It also encourages both advanced industries, conventional industries and service industries. Moreover, although most of these key sectors are state-owned and guided by government departments and officials, the implementation is market-oriented.

INCREASED COMPETITION

For multinational companies (MNCs), the plan will bring benefits. First, greater attention and investment will be given to the 10 key sectors and five projects described which will provide new opportunities for MNCs.

This will bring about more competition between MNCs and domestic Chinese firms in some ways, especially due to elements such as the buy-local push. But MNCs will likely still be needed in terms of supplying new and high-end technologies, critical components and advanced management.

As China embraces intelligent manufacturing, it might be easier for China to collaborate with MNCs. In addition, MNCs will benefit from China having better fiscal and financial systems, a strengthened education system and better access to information.

It may not be a smooth transition, however. Increased competition between MNCs and China's domestic brands will mean the market share of some companies will change. But it is a two-way street. China is becoming an increasingly popular location for international R&D departments, yet Chinese firms are being encouraged to invest abroad supported by governments measures and market incentives, potentially posing challenges to advanced manufacturing in Europe, the US and East Asia in the process.

CUTTING THROUGH THE RED TAPE

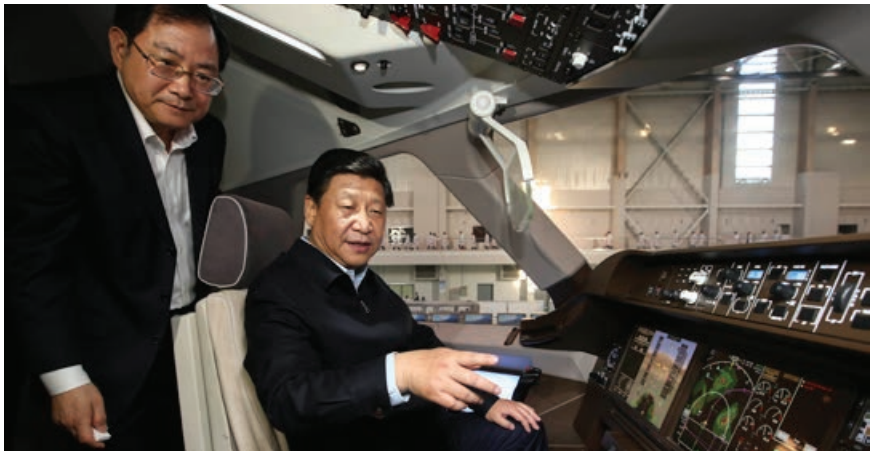
The government will encourage change in several ways. Premier Keqiang Li has said cutting bureaucratic red tape is one key to unlocking creativity and has promised to eliminate unnecessary government approvals. The market-oriented plan also promotes the trading of energy-use rights and carbon emissions, and changes environmental protection fee to tax.

Government funding and policy support will focus on key areas in the transition such as upgrading intelligent manufacturing and high-end equipment manufacturing. By applying a public-private partnership model, the plan calls for public investment in 10 key sectors and five major projects. Government funding will support demonstration projects and innovative public procurement. Firms with innovative manufacturing facilities will also benefit from tax refunds and reductions to help subsidise the high-end equipment, for example.

NURTURING TALENT

The plan is to transform the education system in China shifting it from low-end manufacturing to value-added production. The Chinese government has introduced what it calls a dual vocational training system to plug the gap in the production of high-end manufacturing needs. The scheme is designed to equip students with both academic theories and practical skills.

The Chinese government anticipates that the number of students receiving dual vocational education will increase to 38.3 million from 29.2 million by 2020. Tianjin Sino-Germany Vocational Education College and Shenyang Equipment Manufacturing Engineering School are leading a pilot training scheme.



Xinhua News Agency, photographer Hongguang Lan

President Xi Jinping visits the Commercial Aircraft Corporation of China. China has big ambitions for a domestic aerospace industry

CRISIS AND REFORM IN THE TEXTILE INDUSTRY

Specifically in the textile and garment industry, there have been numerous closures and bankruptcies in 2015. A number of big firms including Zhejiang Red Sword Group, Baojiali Group and Zhongjing Group have all experienced financial difficulties in recent years.

This bankruptcy upsurge has created enormous unemployment. Some attribute the crisis to the 2012 Chinese economic stimulus plan whereby some Rmb4 trillion was pumped into the economy to boost domestic demand so as to survive in the global crisis. With many firms heavily reliant on state loads, their underlying poor liquidity has finally caused problems.

But the crisis is not restricted to the textile industry. Increasing labour costs, land costs, taxes and environmental protection costs have also harmed the labour-intensive textile industry. On top of this, a number of large companies including Adidas, Uniqlo, Tokyo Style and Muji are all accelerating the transfer of their operations to Southeast Asia or India.

The changes in China are attempting to redirect the textile industry towards being more intelligent, internet savvy and green. Under the Internet Plus strategy, state funding and policy supports the use of smart technology, mobile internet, cloud computing, Big Data, the Internet of Things, and e-commerce. For conventional industries like textile industry, it targets for upgrades with internet technology include manufacturing, logistics and finance.

The aim is that a focus on intelligent advanced textile equipment could initiate the robot revolution and flexible manufacturing.

CHINA-UK COOPERATION

President Xi's visit to the UK in the autumn of 2015 was just the latest indication of a strengthening of ties between the nations. According to a UK report entitled "Engaging the Chinese Private Sector", the sharp rise in Chinese private sector investment into UK could pave the way for deeper China-UK private sector cooperation.

During Xi's visit this was cemented and a long-term cooperation strategy for mutual benefit was kick-started with £40 billion of contracts signed by UK and China which included projects in nuclear, high-speed rail, and equipment manufacturing.

FORECAST IN 2016

The 13th Five-Year Plan aims to double GDP and the income of individuals in China between 2010 and 2020.

China will need 6.5% GDP growth over the next five years to become what it calls "a moderately prosperous society." The government's wants to move away from a dependence on low-cost exports towards more sustainable growth. It wants to spur innovation, retool the state-owned sector and give markets more influence and focus on the service sector, high-end manufacturing and domestic consumption.

Based on Made in China 2025 and the Internet Plus action plan, conventional industries will be better aligned to boost the development of the sharing economy and the Big Data sector in the next five years. UKMR-15

COUNTRY REPORT

INDIA

Inidan prime minister Narendra Modi and German chancellor Angela Merkel visited the facilities of German automotive major Bosch in Bengaluru as part of the chancellor's three-day state visit to India in October

Image courtesy of Robert Bosch GmbH

THE GOOD ROAD AHEAD

BY HUNED CONTRACTOR

Despite some challenges, optimism is creeping into India's manufacturing industry, which continues to attract foreign investments. Some predict a bright future for the sector if only the government push through some critical and widely anticipated reforms.

Based in Pune, about 149 kilometres from the commercial capital of India, Mumbai, Siraj Gangardiwala is a global jetsetter. He loves nothing more than visiting trade exhibitions across the world to source ideas and products for his company, Husiraz Engineers, a manufacturer of pipe couplings used in the hydraulic braking systems of commercial vehicles.

For the past year, however, he has not left the country. "Blame it on the economic slowdown," he says. "We are waiting for the promised boom in the automotive industry to take off."

It's a statement indicative of the pulse of the nation. Ever since Narendra Modi led his Bhartiya Janata Party (BJP) to a massive win in the general elections in 2014 and took charge as the prime minister, the manufacturing industry of India has been living on hope.

This is not to imply that Modi has been a disappointment. His government's biggest achievement so far has been the Make in India campaign, which has fuelled optimism in the production sector and buoyed the spirit of entrepreneurs. The programme is designed to facilitate investment, foster innovation, enhance skill development, protect intellectual property, and build best-in-class manufacturing infrastructure.

"The Make in India campaign, launched by the Modi-led government is being marketed in a big way. Various business, regulatory and social reforms are being introduced to make India globally competitive," says Arbinder Chatwal, audit director at BDO and head of Indian Advisory Services.

"Meanwhile, competitive federalism is also being promoted by ranking the states individually on global 'Ease of Doing Business' parameters."

Some of the sectors chosen for this campaign include automobile and automotive components, aviation, biotechnology, construction, chemicals, electrical equipment, defence, food processing, mining, ports and shipping, railways, renewable energy and thermal power.

The positive effect of the initiative is beginning to show. For example, the World Bank has maintained the growth forecast for India in 2015-16 at 7.5%, while pegging it at 7.8% for 2016-17 and 7.9% for 2017-18.

"However, acceleration in growth is conditional on the growth rate of investment picking up during FY16 – FY18," the bank said in its latest India Development Update, released on October 29, 2015.

Onno Ruhl, country director, World Bank India, says: "This is a major change since our last update is that capital expenditure has increased."

Backing this up is the fact that India has moved ahead an impressive 12

TABLE 1: THE GROWTH OF INDUSTRIAL PRODUCTION BY SECTOR

		Annual		Cumulative	Monthly	
Groups	Weight	2013-14	2014-15	April-August, 2015-16	July 2015	August 2015
Mining	141.57	-0.6	1.4	1.2	0.9	3.8
Manufacturing	755.27	-0.8	2.3	4.6	4.6	6.9
Electricity	103.16	6.1	8.4	3.2	3.5	5.6
General Index	1000.00	-0.1	2.8	4.1	4.1	6.4
Use Based Classification						
Basic goods	456.82	2.1	7.0	4.5	5.0	3.4
Capital goods	88.25	-3.6	6.4	7.4	10.6	21.8
Intermediate goods	156.86	3.1	1.7	1.8	1.7	2.6
Consumer goods	298.07	-2.8	-3.4	3.0	0.9	6.8
i) Consumer durables	84.60	-12.3	-12.6	7.7	10.3	17.0
ii) Consumer non-durables	213.47	4.8	2.8	0.1	-4.6	0.4

Source: Central Statistics Office

MANUFACTURING HIGHLIGHTS FOR 2015

- Up to USD 130 billion proposed spend on railways over five years.
- Foreign equity cap in defence raised to 49%; 74% in case of tech transfer.
- Union Cabinet nod for 100 Smart Cities.
- Definitive steps forward in introducing pan-India goods and services regime.
- Mining sector impasse ends with new bill for regulation and development.
- Launch of 'Make in India', 'Digital India' and 'Skill India' initiatives.
- Mudra Bank launches with Rs 20,000 crore corpus to extend loans to small entrepreneurs.
- Commencement of divestment programme in public sector companies.

places since last year and now ranks 130 out of 189 countries in terms of its ease of doing business.

"A forward movement of 12 spots in the ease of doing business by an economy the size of India is a remarkable achievement," Kaushik Basu, chief economist and senior vice president, World Bank, has been quoted as saying.

Basu feels that India can be among the top 100 in the World Bank's ease of doing business report by next year if it continues with planned reforms, most importantly the implementation of the Goods and Services Tax (GST).

In Basu's opinion, GST will be one of the big ticket reforms. "Once the GST is in place, India can very easily have a rule that there will be no check-posts on the way. All charges will be paid at the source or at the destination," he told reporters at a media briefing.

A PRIME DESTINATION

Even amid change, India remains a profitable manufacturing and marketing platform for multinational companies. Huge investments have, and are, being made. Bosch, a supplier of technology and services in the areas of mobility solutions, industrial technology, consumer goods and energy, recently revealed its plans to invest Re650 crore (over €100 million) in the country. "India is a key location in our global innovation network," said Peter Tyroller, member of the Bosch Board of Management, at the time.

Bosch has announced its plans to invest Rs650 crore (over €100 million) in India

Robert Bosch GmbH

Bosch also made headlines when prime minister Narendra Modi and German federal chancellor Angela Merkel visited the company's production facility at Bangalore. "The Indian government is systematically addressing the key issues. We are confident that this will positively impact the country's development," says Dr Steffern Berns, president, Bosch Group, India.

But Bosch is not alone. General Electric (GE), has doubled its

TABLE 2: ON THE RISE: INDIA'S GDP IN REAL TERMS

Quarterly gross value added (GVA) at basic price at constant 2011-12 prices									
	2013-14				2014-15				2015-16
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1
GVA at basic prices (Rs. in crore)	2243389	2215458	2324256	2386683	2409770	2402189	2481715	2533415	2580056
Growth (%)									
GVA at basic prices	7.2	7.5	6.6	5.3	7.4	8.4	6.8	6.1	7.1
Agriculture	2.7	3.6	3.8	4.4	2.6	2.1	-1.1	-1.4	1.9
Industry	4.8	4.0	5.0	4.3	7.7	7.6	3.6	5.6	6.5
Manufacturing	7.2	3.8	5.9	4.4	8.4	7.9	3.6	8.4	7.2
Services	10.2	10.6	9.1	6.4	8.7	10.4	12.5	9.2	8.9

Disclaimer: CSO has stopped providing data at Factor Cost on quarterly basis, therefore quarterly estimates of sectoral share in GDP at Factor Cost has been discontinued

Source: Central Statistics Office

investment in India over the past five years and delivered approximately $3 billion in economic value. Investments have ranged from supplier development programmes to new, large, infrastructure projects and manufacturing facilities.

"India is a growth engine for Asia, and we see huge potential for the country in the manufacturing space. Infrastructure is a key driver of India's growth. We are keen to invest much more in India and in projects to boost its infrastructure in sectors such as railway, power and healthcare. These efforts will have a ripple effect on the overall economic growth in India and beyond," says Jeff Immelt, chairman and CEO, GE.

The company's multi-modal Brilliant Factory manufacturing facility in Pune in particular is now leveraged by the company as global supplier for a number of its businesses including aviation, turbo machinery, wind turbines and diesel locomotives. The levels of local sourcing have increased by 20% for locomotives, 30% for power equipment and 15% for aviation.

DOMESTIC PACE PICKS UP

This growth should not solely be attributed to multinational companies, however, especially in the automotive sector. India's domestic companies are taking big steps forward, too.

This was driven home when prime minister Modi expressed his vision at Hannover 2015, an annual global technology fair, held in April 2015 in Germany, at which India was the partner country.

"Whatever we choose to do, from reaching the cutting edge of industry to meeting the most critical social need, we require investment and technology, industry and enterprise. Make in India is not a brand. Nor is it simply a slogan. It is a new national movement," he said.

This optimism radiating from the government is shared by the heads of many Indian conglomerates despite some setbacks including the inability of the new government to push through some reforms such as the GST Bill and a delay in public spending for infrastructure development.

Saurabh S. Dhanorkar, the managing director of Finolex Industries, India's largest rigid PVC pipes and fittings manufacturer and the second-largest PVC resin manufacturer, is one such optimist. Even though the agriculture sector is poised to take a beating this year, the company's management does not see prospects dimming. In fact, there are plans to foray into new territories and even widen its distribution network.

"We will now target both the construction and infrastructure sectors. The company sees a lot many opportunities to expand and grow here in the Indian markets," Dhanorkar says. "The impetus given to business by the present government through announcements like the Smart City Development Programme and the Pradhan Mantri Krishi Sinchai Yojana (a scheme for farm irrigation) are huge."

Indian companies are now willing to go international, too. Bharat Forge, a specialist in forging, for example, has signed a multi-year contract with Boeing Commercial Airplane to supply titanium forgings to be used in the wings of next-generation 737 and 737 MAX.

"The company is targeting revenues in excess of $100 million per annum from this sector," says Baba Kalyani, the company's managing director. Further, Bharat Forge has also announced a joint venture with Israel's Rafael Advanced Defence Systems to produce the Spike anti-tank guided missile.

There are many other examples. Tata AutoComp Systems opened its second manufacturing plant in China on October 16, 2015, in Changshu Economic and Development Zone (CEDZ), Changshu.

The company makes automotive components and systems such as engine cooling solutions, automotive batteries, rear view mirrors, command systems, HVAC, exhaust and emission control systems for passenger and commercial vehicles as well as seating systems and suspensions for heavy commercial vehicles.

"We are committed to growing our presence in China as it plays a vital role in our global business. While our operations in India are focused on serving OEMs in India, our operations in China – both at Nanjing and Changshu – are focused on serving OEMs in China as well as exporting to OEMs in Europe and North America," says Ajay Tandon, managing director of Tata AutoComp Systems.

The Changshu plant has commenced its production with supplies for Cherry-Jaguar Land Rover Evoque and Discovery, and will start supplying for Jaguar cars from next year. The company has invested Rmb20 million ($3.1 million) in the first phase of operation.

The automotive industry is tipped for big growth in India

(Below) Finolex Industries is on a growth trajectory

Finolex Industries

Faurecia

(Left) French engineering company Faurecia has invested heavily in new facilities in India

(Right) Henkel Technologies wants to be at the forefront of evolving technologies

Henkel Technologies

EMERGING SECTORS

Playing an important role in driving forward the manufacturing index of India are some emerging sectors, the largest being automotive and automotive components. While global automotive companies like Volkswagen, Mercedes-Benz, Renault and others have already set up operations in India, there are bigger plans afoot.

According to a report by Standard Chartered Bank, Hyundai plans to source engines for its global operations from India; Ford plans to make India its manufacturing hub for engines for the Asia-Pacific region and Africa; and Volkswagen plans to increase sourcing from India to 70% of its total global sourcing. "By 2020, India is likely to overtake Thailand in global automotive export market share," the report estimates.

Automotive exports from Thailand at $24 billion are double that of India's $12 billion. But the domestic demand for two-wheelers, three-wheelers, passenger cars and commercial vehicles continues to rise. Maruti's sales continue to enjoy strong growth, for example. The company sold on an average 3,207 vehicles in a day in FY14-15 and 1,170,702 units in a year – a remarkable rate of more than two units sold every minute.

Renewable energy also deserves a closer look as a sector. The creation of a national infrastructure investment fund and the doubling of coal cess in the Union Budget have buoyed the renewable energy industry.

Even first-time entrepreneurs are moving into this space. Bangalore-based Anu Solar Power, for example, a supplier of solar water heaters, is now offering the integration of small solar power generators for homes while also making invertors through a joint venture with SEI, a German company.

Similarly positive prospects and strong growth is forecast in the electrical equipment industry. According to Sunil Misra, director general of the Electrical & Electronics Manufacturers Association (IEEMA), the 2012-22 mission plan for the sector forecasts its output to reach $100 billion by 2022 compared with $25 billion in 2012.

"The electrical equipment manufacturing technology is witnessing significant modernisation. Thus, technological advancements, smart grids and policies on emission reduction will influence the future direction taken by the power sector and this industry," Misra says.

TECHNICAL EXCELLENCE

Moving in tandem with the expected growth in the manufacturing industry both Indian companies and multinational corporations are keen to set up innovation and technical excellence centres on Indian soil.

Bosch's largest development centre outside Germany is located in Bangalore and Coimbatore and has over 12,000 research and development associates. "Since 2014, the development centre in Bangalore has been focusing on Big Data analytics – an important enabler for connected manufacturing," Steffen Berns, president of the Bosch Group in India, states.

Other companies have similar facilities. Faurecia, a French engineering company, has two technology centres in India, one in Pune for interior, seating and exterior and the other in Bangalore for emission control technologies.

Henkel Technologies has a Pune-based R&D centre focused on innovative technologies and solutions to cater to the automotive and transportation industry in South Asia, Middle East and Africa.

"We are working here on projects that are specifically at the forefront of evolving technologies in adhesives, sealants and other materials in an effort to help customers enhance productivity and significantly reduce operational costs," says Shabbir Attarwala, director, product development, AG-Asia Pacific, Henkel Technologies.

CONNECTED PRODUCTION

Now, as China's economy falters and India's economy is anticipated to pick up, Industry 4.0 is being heralded as the future of manufacturing in India. A meeting of the real and virtual worlds in manufacturing, this involves the integration of manufacturing technologies and systems to create so-called smart factories. These are already being implemented by the larger conglomerates.

"By 2018, we aim to implement connected production in all our 14 manufacturing locations across the country," says Berns of the Bosch Group in India.

It's a move that is being echoed from many sectors. "We are concentrating on the key components of our business strategy with a focus on safety, environment-friendly technology, fuel efficiency and information solutions for vehicles. And Industry 4.0 will of course play a very important role," says Girish Kamala, head, Key Account Management, Continental Automotive Components.

The predictions presented by several leading research agencies now point to the fact that India is now ready to move into the big league. As per a report by KPMG, the manufacturing industry in India has the potential to reach $1 trillion by 2025 and contribute approximately 25-30% to India's GDP.

It also has the potential to create approximately 90 million jobs by 2025. This contribution is expected to put India on par with the manufacturing levels of countries including China, Germany, Japan and the US. UKMR-15

COUNTRY REPORT

JAPAN

© Yamazaki Mazak

Metal cutting movers: several Japanese manufacturing sectors are growing. Output of metal cutting machines for 2014/ 2015 is forecast to rise 12% on that for 2013/2014, even though Japanese exports have been badly affected by exchange rates. (Source: MTA)

BY MIHO OKADA

Domestic drive

After two 'lost decades' economically, Japan is turning the corner, but manufacturing is having to transform itself – a drive that includes an upswing in domestic investment

The Japanese economy is improving as a result of Abenomics – prime minister Abe's economic strategy – which includes quantitative easing and the Yen's depreciation as inevitable consequences. The trade surplus has shrunk for four consecutive years to its lowest ever level.

Japan now earns not through exporting products and services to the foreign market, but through producing in foreign markets. The share of GDP of manufacturing has been declining, to about ¥90 trillion (£483.3 billion), after peaking at ¥114 trillion in 1997, caused by further servitisation of the Japanese industry, an increase in Japanese manufacturers' overseas production, and local procurement – and by a slump in domestic demand.

Despite this, in recent years the big Japanese corporations have pushed re-shoring, particularly through domestic investment in cutting-edge electric and electronic devices, general machinery, and the automotive parts industry.

Yuzo Toda, Director and Executive Vice President, Fujifilm

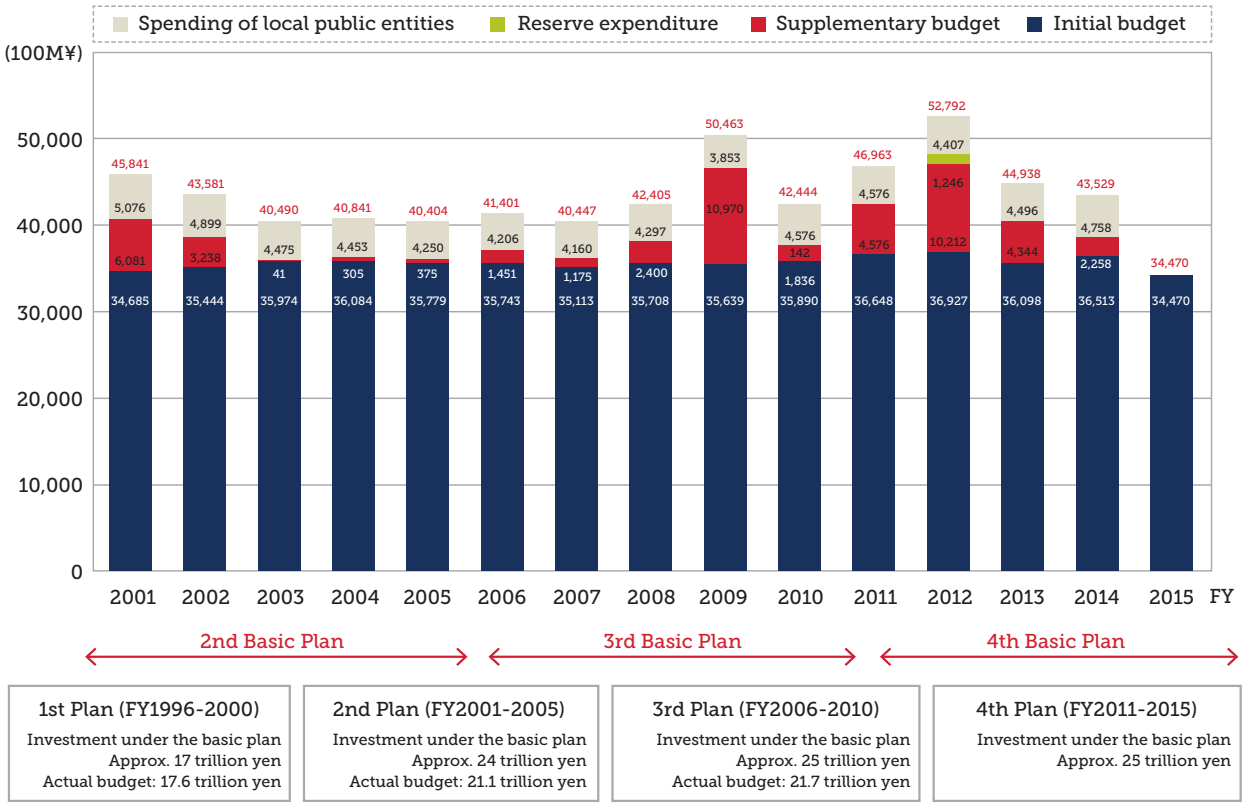
The major reasons for re-shoring by manufacturers are similar to the ones cited by British companies, such as difficulties in ensuring just-in-time delivery and high quality in foreign production, as well as issues related to exchange rates, and increasing costs overseas.

Most of the Japanese companies promote different roles in domestic and overseas bases, by keeping corporate planning and business management, as well as R&D functions in Japan as an innovation base – for developing new technologies and new products.

OVERALL BUDGET FOR SCIENCE AND TECHNOLOGY (S&T) POLICY

Transition of overall S&T budget

as of March 2015



1st Plan (FY1996-2000)	2nd Plan (FY2001-2005)	3rd Plan (FY2006-2010)	4th Plan (FY2011-2015)
Investment under the basic plan Approx. 17 trillion yen Actual budget: 17.6 trillion yen	Investment under the basic plan Approx. 24 trillion yen Actual budget: 21.1 trillion yen	Investment under the basic plan Approx. 25 trillion yen Actual budget: 21.7 trillion yen	Investment under the basic plan Approx. 25 trillion yen

Source: Council for Science, Technology and Innovation, Japan

FOURTH SCIENCE AND TECHNOLOGY BASIC PLAN: 2011-2015

GOVERNMENT PRIORITISED OBJECTIVES (¥ BILLION)	ACTUAL FY 2011	ACTUAL FY 2012	ACTUAL FY 2013
• Reconstruction and revival from the disaster	64.4	86.8	100.8
• Promoting green innovation	507.1	560.8	635.1
• Promoting life innovation	716.6	792.6	899.0

Source: Ministry of Education, Culture, Sports, Science and Technology - Japan

Production facilities in Japan should function as a "mother factory" to which to transfer production technologies with back-up capacity, and also as a flexible factory for low volume production, as well as for manufacturing for shorter periods.

The Science and Technology Basic Law, enacted in 1995, encourages Japanese industry to carry out more R&D activities. The previous Third Science and Technology Basic Plan, developed between 2006 and 2010, identified eight focus areas: life sciences, information and telecommunications, environmental science, and nanotechnology and materials; as well as energy, manufacturing technology, infrastructure, and frontier science.

The Fourth Science and Technology Basic Plan, for the period 2011–2015 (see table, above), however, articulates objectives including "recovery and reconstruction from the Great East Japan Earthquake", "green innovation", addressing environmental and energy issues, and "life innovation" – or fostering an active ageing society.

This is a drastic policy change.

UNDER PRESSURE

The total size of the budget for science and technology policy has been declining since 2012. A breakdown of budget allocation shows that basic research is invested in most, then energy, system innovation, and life science. The Japanese government has invested most in these basic research areas for the last 15 years.

But there have been some notable research successes. The 2014 Nobel Prize for Physics was awarded to a trio of scientists in Japan and the US for the

Toyota: world-leading experience with the hybrid vehicle power system platform

invention of blue light emitting diodes (LEDs), which was the outcome of close industry-government-university collaboration. Through this collaboration, technology seeds were produced by universities as part of government-commissioned development projects, and transferred to and commercialised in domestic company.

Professor Sadao Nagaoka of the Research Institute of Economy, Trade and Industry, says: "In Japan, 90% of industrial research and development has been funded by companies' internal revenue sources, and less than 2% have received governmental support."

Companies' R&D efforts have tended to be on the successful side, reflecting the long-term view of Japanese corporations, their entrepreneurial spirit, and independent mindset – but also a small budget for government technology policy.

In 2015, Honda began commercial production of the Honda Jet after more than 20 years of its own research and development, while in December 2014, Fujifilm Holdings Corporation made Japan Tissue Engineering Company (JTEC), a consolidated subsidiary, the only company operating a regenerative medicine products business in Japan.

Subsequently in May 2015, Fujifilm acquired Cellular Dynamics International, a leading developer and manufacturer of fully functioning human cells, derived from induced pluripotent stem (iPS) cells in industrial quantities to precise specifications.

These decisions are part of Fujifilm chairman and chief executive Shigetaka Komori's aim "to be the best regenerative company in the world".

Fujifilm has built up a wealth of advanced technologies in the field of photography since its foundation in 1934. However, the transition from the analogue to digital age caused a sharp fall in demand for film, and indicated the need for the establishment of new core businesses to survive.

One of the core business areas to which it can apply its proprietary technologies is healthcare including medical systems, pharmaceuticals, and regenerative medicine. Fujifilm is aiming to earn ¥1 trillion sales from its healthcare

Yoshihiko Masuda, Executive Chairman, Toyota Central R&D Labs

INDUSTRY VIEWPOINT

Professor Sadao Nagaoka, programme director, Research Institute of Economy, Trade and Industry, Professor of Economics, Tokyo Keizai University

"A great strength in Japanese industry lies in the long-term view toward R&D and culture of entrepreneurship, of not all, but a significant number of firms, which persistently seek technology solutions to the problems we face.

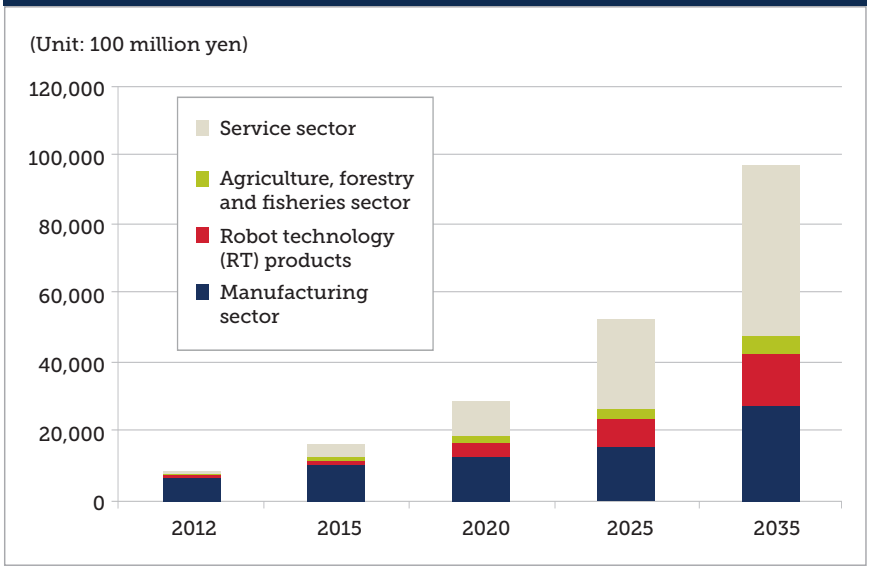
"This entrepreneurship has enabled some Japanese companies to make major breakthroughs, examples of which include hybrid cars, carbon fibres, LEDs and innovations in business jets, all of which required the firms to make long-term, uncertain investments to solve technical difficulties – one after another.

"On the other hand, considering that the domestic market has been shrinking due to an ageing society with a declining birthrate, Japanese industry needs to take a more global business perspective to compete in foreign markets.

"It would also need to enhance mobility of human resources in its labour market, which would allow more experimentations and more combination of resources across organisations.

"The Japanese government can play a significant role in this, by developing policies which serve to create better conditions for industrial competition, including the cultivation of the absorptive capability toward science, support to early-stage embryonic industrial research, the development of technology market and VC industry, protection of intellectual property and innovations of standards."

CURRENT ESTIMATES OF MARKET SIZE OF THE ROBOT INDUSTRY IN JAPAN



Industrial Machinery Division, Ministry of Economy, Trade and Industry

business in the fiscal year ending March 2019, or about two-and-a-half times the current level.

Fujifilm firmly believes that technology cannot be obsolete, even though film products may have a product life. Yuzo Toda, director, and executive vice president, Fujifilm Corporation, says: "In the face of rapidly declining revenue of our core photographic business since the early 2000s, we had to reinvent ourselves, which we call our "second foundation".

"We reprioritised our technology assets which we cultivated through our photographic film business, and applied them to the healthcare business. Photographic film has 29 evenly coated layers, which are 20 micrometres thick, equivalent to a cell size. Functional materials are precisely placed in these layers.

"In fact, our technology to control the micro environment is fully used in the pharmaceutical and regenerative medicine business. As a game changer, Fujifilm is addressing unmet medical needs by taking multiple approaches."

PROBABLY THE BIGGEST CARMAKER IN THE WORLD

At the time of writing, Toyota had just reclaimed the title of leading carmaker globally by sales from troubled Volkswagen. The Japanese giant can boast developments such as Mirai, the world's first series production hydrogen fuel cell saloon, which benefits from Toyota research and development into fuel cell technology spanning two decades, and world-leading experience in the hybrid vehicle power system platform.

Yoshihiko Masuda, executive chairman, Toyota Central R&D Labs, says fuel cell vehicles will "drive societal change towards a better world. Our wide variety of powertrains – FCVs, EVs, hybrids, plug-in hybrids – reflects our belief in the importance of offering more choices on the type of fuel to strengthen environmental protection and energy security in Japan, where resources are limited, and also in other countries. We expect government to establish clear direction on energy policy, and lead initiatives with sustained assistance."

Another key area for Japanese industry is automation. The Japanese government estimates the market size for robots will expand to ¥2.9 trillion by 2020 (see graph above). In May 2015, the Japanese government launched the Robot Innovation Initiative aimed at promoting cooperation between industry, academia and government to use robots in various fields, including manufacturing, agriculture, medical care and nursing for elderly people.

It is joined by more than 200 companies and groups, as well as national research institutions and researchers from universities. For example, robots that can assist humans, typified by the HAL Robotic Exoskeleton, offer promising technologies for construction sites, nursing-care facilities, and factories – as a solution to Japan's ageing society, and labour shortages. Panasonic Corporation's nursing-care robots device Resyone obtained ISO 13482 for robots and robotic devices – safety requirements for personal care robots – the first in the world to provide its users with this standard for safety and security. Sales commenced from June 2014.

2016 AND BEYOND

In summary, Japanese industry is facing a new challenge: to transform its business and industrial structure by looking at new ways in which products and services can serve Japanese society, strengthening its existing expertise and technologies toward new values, re-shaping business models; and creating a fair business environment to get the new products adopted by society.

Some examples of the fruits of this challenge are in Toyota entering a hydrogen energy industry, Fujifilm a regenerative medical industry, and Panasonic a robotics industry, all in 2015.

These transformations are perhaps comparable to the past structural changes of the Japanese economy, from textile industries in the 1950s, to heavy industry in the 1960s, to automotive and home electronics industries in the 1970s, to automotive and electronics industries in the 1980s, to information industry in the 1990s – and then "the lost two decades", which was the period of long-term economic slowdown, after the bubble economy.

Finally, Japanese industry has now started to regain confidence and hope for the future. Companies' robust vision and beliefs and their own long-term investment in research and development, has helped this to take place.

The Japanese government should now play a significant role in supporting the transformation of a business structure, with solid, sustained support and clear direction through policy settings, allied to deregulation or rationalisation of regulation to complement new values and the effectiveness of new business models; with involving in the global standardisation to create a fair market, which enable them to share new values globally.

More collaboration between government and manufacturing industry in these areas will be expected in 2016. UKMR-15

COUNTRY REPORT

AFRICA

Opportunities exist for Africa despite troubled times

Shutterstock

BY ANDRES ILVES

There is plenty of entrepreneurial drive and desire for innovation in evidence in African manufacturing. But the sector is plagued by political upheaval as well as power supply and logistics problems

"It is going to be hard for next year to be worse than 2015." So says Deji Adenusi, chief executive of Energeria, which provides equipment and services to the Nigerian petroleum industry.

Across Africa, the manufacturing sector had to function in a climate of uncertainty as the continent was buffeted by the global plunge in oil prices, African currencies saw a huge drop in value, security challenges from Boko Haram and al-Shabab continued unabated, stable power supplies seemed unattainable and uncertainty prevailed as national elections were held in three of Africa's most populous countries.

It was not a year of big changes for the manufacturing sector in Africa. In the event, Nigeria saw a peaceful transfer of power, and the respective ruling parties stayed in office in Ethiopia and Tanzania. A significant new manufacturing-focused initiative was launched by the government in Kenya and the existing Nigerian industrialisation programme looks likely to be retained under the new administration of president Muhammadu Buhari.

Although the fruits of these initiatives will not be visible in the short term, they provide a boost in the level of confidence in the commitment of two of Africa's biggest economies to increasing the role of the manufacturing sector.

The biggest factors in how the manufacturing sector fared were, arguably, the drop in the price of crude oil from $100 to $50 a barrel, and the dollar's relatively steady trend toward strength as the year wore on. Other factors saw no significant change, as the role of China remained stable and the threat posed by militant groups remained, and as many economies' reliance on the commodities and extractives sector continued.

Above: reliable power and cheaper transport are a must if manufacturing in Africa is to fulfil its potential

SLOW BOAT TO KANO

"It's cheaper to ship from China to Nigeria than it is to ship from Lagos to Kano," says Ambrose Oruche, director of economics/statistics at the Manufacturers' Association of Nigeria with a sigh, noting the challenges faced in transporting goods between Nigeria's capital and its second-largest city less than 850 km away.

And yet he is optimistic that a brighter future lies ahead: "I believe that in 2016 there will be an increased focus on manufacturing and addressing the challenges facing it."

March's presidential election in Nigeria — postponed by six weeks —held great significance with regard to national policy regarding the manufacturing sector. In 2014, then-President Goodluck Jonathan launched NIRP, the ambitious Nigeria Industrial Revolution Plan, which he said was intended to "increase the contribution of the manufacturing sector to GDP from the present 4% to more than 10% over the next five years".

With Goodluck Jonathan's defeat, uncertainty about the future of NIRP has been exacerbated by the delay in the appointment of the Federal Executive Council, or cabinet. However, indications are that the cabinet of newly-elected President Muhammadu Buhari, once it is complete, will maintain

a strong commitment to the development of the manufacturing sector, and that NIRP may be fine-tuned but not abandoned entirely. The UN Industrial Development Organisation (UNIDO) has also publicly encouraged the new administration to retain the plan.

INVESTMENT CONTINUES

Despite the gloom occasioned by oil prices and exchange rates, Energeria's Adenusi notes that some companies are still investing in their own growth. He cites Lekoil, a Nigerian oil and gas exploration firm that has not shied away from taking a more optimistic view and planning for the long term.

And in August, the Nigerian government approved licences for a dozen new automotive assembly plants in the country, adding to the 33 that are already operating or being built. In the words of one observer, however, "there's not even 1% local content in those cars – except for Nigerian labour".

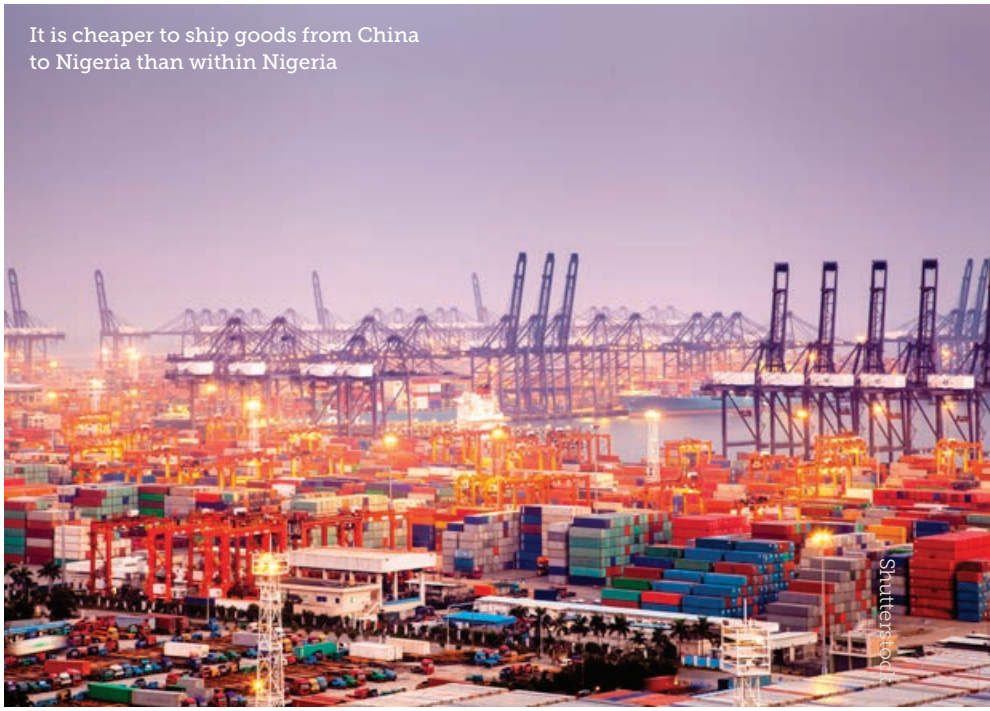
At the other end of the continent, the African Development Bank believes that East Africa will become the continent's fastest-growing region next year, predicting 6.7% growth in GDP in 2016. In September, the government of Kenya announced, in its words, a "grand industrialisation roadmap that seeks to make Mombasa a food processing hub targeting the export markets even as it locks in the billions of dollars East African nations spend on imports".

The statement continued: "Investors will have access to a Sh10.5 billion ($100 million) state-backed fund aimed at accelerating industrial investment, especially among financially challenged firms" and that "manufacturing's contribution to the GDP has averaged at 11% in the past 10 years showing a general stagnation of the sector".

DECLINE AND FALL

Pradeep Paunrana, chair of the Kenya Association of Manufacturers, terms this roadmap "a significant step". Looking back at how manufacturing has fared in Kenya over the past years, he laments that "no industry has done well. There has been a steady decline in the contribution of manufacturing to the GDP in the last 10 years."

There is also the problem of the devaluation of currency: on paper, ARM Cement, of which Paunrana is managing director, has lost $200 million in value.



It is cheaper to ship goods from China to Nigeria than within Nigeria

CHEERS ALL ROUND FOR THE DRINKS INDUSTRY

With their high-profile merger — the third-largest in history — South Africa's SABMiller and global drinks giant AB InBev are highlighting the healthy state of the beverage industry on the African continent.

The Nigerian drinks industry is benefiting from improved capacity utilisation, and is now expected to reach an annual growth rate of more than 10% in 2019. Meanwhile, Nigerian aluminium beverage can maker GZ Industries and the packaging concern South African Golden Era Group have signed a joint venture agreement to set up a large beverage can plant in Johannesburg.

No form of beverage is left out of this growth. Sibusiso Leope, one of South Africa's most popular DJs, under the name DJ Sbu, has launched an energy drink called Mofaya – "more fire" – and is aggressively marketing it across the continent — though not without a great deal of attendant controversy, as he has repeatedly promoted his drink at public events and ceremonies and even tweeted a fake cover of Forbes magazine, putting himself on the cover holding a can of Mofaya.

The one bright spot, Paunrana says, is construction, including all the sectors involved in it. Paunrana notes that the Comcraft Group, a conglomerate focusing on steel, aluminium, and other construction-related manufacturing with a presence across Africa and the globe, thrives under Manu Chandaria, one of the most successful businessmen in East Africa.

"Apart from South Africa, there is no real heavy industry in Africa," comments one observer. According to the Manufacturing Circle of South Africa, the manufacturing sector employs more than 1.6 million people in that country; among the largest manufacturing sectors are metals and machinery, chemicals, and food processing.

There is no doubt that the automotive sector is one of the most significant in the South African economy; industry studies suggest that it is the country's most important manufacturing sector, contributes 6 or 7% to the South African GDP, and may provide one-eighth of the country's manufacturing exports.

In August, Volkswagen announced that it would invest 4.5 billion rand (approx. $350 million) in production facilities and improving its supply chain in South Africa; in September, South African authorities announced that they would investigate VW in South Africa to see if the global VW emissions rigging scandal had affected cars sold in the country.

Without a doubt, a key challenge on the continent remains that of reliable

ARM Cement

ARM Cement has lost $200 million on paper thanks to currency devaluation

power. In his inaugural speech, the new Nigerian president said: "No single cause can be identified to explain Nigeria's poor economic performance over the years than the power situation.

"It is a national shame that an economy of 180 million generates only 4,000MW, and distributes even less. Continuous tinkering with the structures of power supply and distribution... have only brought darkness, frustration, misery, and resignation among Nigerians. We will not allow this to go on."

It is a refrain repeated across the continent. Nigeria's Deji Adenusi says: "It's quite simple. Manufacturing requires power." A senior figure at an international energy company building power projects in sub-Saharan Africa says that, "Western governments need to stop lecturing African governments on what kind of fuel they can use to increase electricity. If a dirty fuel like coal can provide an immediate boost to the national grid, then that should be the way forward... cleaner fuel does not provide electricity today or tomorrow.

"Its going to be hard for next year to be worse than 2015 was." Deji Adenusi, chief executive of Energeria, the equipment and services provider to the Nigerian petroleum sector, laments a tough year when the price of oil crashed and national security challenges in Nigeria were rife. But Africa still has so much offer for firms that can handle the see-saw politics

"And African countries need to realise that the big reason other countries don't want to invest in Africa is because of the fear of massive corruption. Without addressing this huge challenge, it will be difficult to imagine a dramatic improvement in electricity access in sub-Saharan Africa, which must be fuelled by massive foreign investment."

BRIGHT SPARKS

Everyone is wading into this crisis: even American-Senegalese rapper Akon, whose Akon Lighting Africa initiative has the ambitious goal of "bringing power to 600 million Africans" by providing solar street lamps, micro-generators, as well as other equipment.

Neil Anderson, an innovation and technology strategist and entrepreneur, spends a good deal of time thinking about where Africa's economy and business are headed.

He says: "Africa has every opportunity to break out from being perennially under-sold and under-competitive. It can do this by taking a proactive stance on technology, infrastructure and energy trends and provisioning for manufacturing sub-sectors accordingly."

For the short-term, however, sub-Saharan Africa in 2016 will face many of the same challenges it faced in 2015. As always, elections loom: presidential and parliamentary elections in Ghana and Zambia are the main ones to watch. Global market forces such as the price of crude oil and the strength of the US dollar will continue to have an effect in Africa as they do around the globe. The African Growth and Opportunity Act, dating back to 2000, was renewed for another decade by the US Congress in 2015, thereby continuing to provide African countries duty-free access to the US market.

Uncertainty remains about the general state of affairs in the manufacturing sector in sub-Saharan Africa, but some countries stand out. In the words of one analyst, "Kenya is the one to watch." And there are positive regional signs: the Barclays Africa Trade Index notes that "Members of the Southern African Custom Union (SACU) and EAC present regional bright spots in terms of better global supply chain integration, especially South Africa, Ethiopia, Kenya and Tanzania.

"These countries have had some success in incorporating industries such as manufacturing, agriculture and agri-business, transport and tourism into global value chains."

As Africa grows and changes, the chances for the manufacturing sector to develop remain: as always in the marketplace, there are opportunities to be seized. UKMR-15

South Africa's SABMiller and global drinks giant AB InBev merger, the third-biggest in history, has highlighted the mature and healthy state of the beverage industry on the continent

Image © SAB Miller

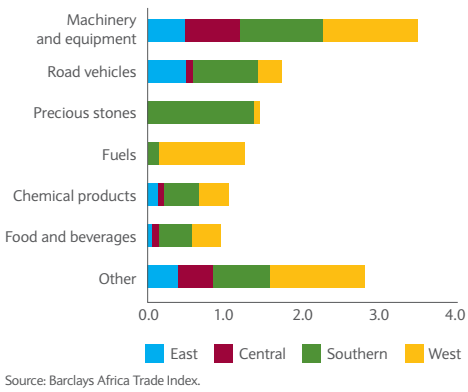
BARCLAYS

UK-Africa trade in focus

Sub-Saharan Africa (SSA) has become much more open to international trade over the past decade. The increase and diversification of trade flows have been driven by a range of factors, including evolving partnerships with fast-growing emerging markets and substantial investment in extractive sectors and associated infrastructure.

- The UK exported around £8.2bn (USD$12.8bn) worth of goods to SSA in 2013, made up of high-value manufactured products including machinery and equipment, road vehicles and chemical products, as well as fast-moving food and beverages
- In 2013, machinery and equipment were the largest single area of export trade representing 27% of total goods exports (exported to all major sub-regions), followed by road vehicles (14%; mainly to South Africa), precious stones (11%; predominantly to Botswana), fuels (10%; largely to Nigeria), chemical products (8%), and food and beverages (7%)
- Exports from the UK to the region have increased by about 6% annually between 2004 and 2013
- UK-based firms have a strong presence in South Africa, Nigeria, Botswana, Angola, Kenya, Ghana and Senegal where the UK's share of goods imports is typically between 4-5% of total imports
- UK-based firms have a strong foothold in the smaller but fast-growing economies of Tanzania, Côte d'Ivoire, Ethiopia, Zambia and Cameroon, typically between 1-3% of imports
- UK-based firms have a distinct advantage in terms of being able to leverage cultural and linguistic commonalties and political connections
- They can also call upon technically advanced goods, highly professional services, effective supply chains and marketing expertise to tap into Sub-Saharan Africa's emerging markets.

UK exports to SSA (USD$bn, 2013)



Source: Barclays Africa Trade Index.

Printing with electronic links: This "super inkjet printer" can print very fine lines of electronic ink. The lens is part of a camera so researchers can see what the printer is doing

EPSRC CIM in Large-Area Electronics

EPSRC
Engineering and Physical Sciences
Research Council

Manufacturing Research

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The future of mission-critical research

2015 saw the launch of two new Future Manufacturing Research Hubs, the first in a new phase of support augmenting the EPSRC's highly successful Centres for Innovative Manufacturing (CIMs).

The EPSRC sees the hubs as an evolutionary step forward in its long history of critical-mass investments in needs-based research.

The 16 CIMs, established from 2010 onwards, covering disciplines from food, and advanced metrology to intelligent automation, were themselves developments of the earlier Innovative Manufacturing Research Centres.

In each case, the EPSRC saw its role as giving the best people the best environment and connecting them up: leading academics teaming up with experts from Britain's leading industries to find new opportunities for the future.

The first two hubs have themselves grown out of highly successful CIMs, in Southampton University and Brunel University, London.

Beyond the focus of talent in each hub, and the expertise from manufacturing, the networks extend through spokes to connected centres of excellence, across the UK university system.

The key aim of the new hubs, as the EPSRC explains, "is to support UK manufacturing industries by supporting the commercialisation of early stage research opportunities in emerging areas."

The research council is currently considering a second round of applications to be established in 2016.

The International Year of Light (2015): The UK is very good at photonics research, which is applied in aerospace & defence, telecoms, space satellites, welding and cutting technology and much more

LIQUID METAL ENGINEERING

Britain could become a centre of sustainable metallurgy using aluminium and other alloys thanks to research to be carried out at the new Future Liquid Metal Engineering Hub, just established at Brunel University, London.

Building on research at the prior Centre for Innovative Manufacturing, LiME, the team's vision is to meet the global demand for metallic materials using full circulation of secondary metals through reduced usage, reuse, remanufacture, closed-loop recycling.

Half the 833 million tonnes of aluminium refined globally in the past century is available for re-use, for example, if only the recycled material was adequate for high-end engineering purposes.

And because sourcing aluminium from ore is so energy intensive, transitioning to global recycling could save the equivalent of three times the UK's electricity output, each year.

At the core of LiME's vision is the process of high-shear casting, first conceived by the hub's director Zhongyun Fan, around a decade ago.

In essence a form of vigorous stirring that allows precise control of nucleation and grain size during solidification, high-shear casting was identified by the EPSRC as a key technology in 2010, with the establishment of the Centre for Innovative Manufacturing at Brunel, also led by Fan.

In the past two years LiME has developed new casting alloys that have superior strength and improved resistance to cracking, and are more suitable to manufacturing processes used by its partner Jaguar Land Rover.

In collaboration with 'spokes' at Leeds, Oxford, and Manchester universities, and Imperial College, and 12 leading industrial partners, the hub expects to develop industrial-scale techniques for nucleation-control, and recycling-friendly metals that would be the basis for complete closed-loop recycling.

"EPSRC's support has been absolutely fundamental to our progress," Fan explains, "not just because it has allowed our centre to grow from 30 to 65 staff in the past five years and we're still growing, but also because of the flexibility of the funding which allows us to adapt our research path along the way and to engage more easily with industry, and because of the way it boosts our reputation."

In November the research centre in liquid metal engineering at Brunel University became the EPSRC Future Manufacturing Hub in Liquid Metal Engineering with a £10m grant

HIGH-VALUE PHOTONIC MANUFACTURING RESEARCH HUB

Photonics epitomise the kind of high-value, precision engineering the EPSRC sponsors. Worth £10.5 billion to the UK economy, the industry supports more than 1,500 SMEs, employs more than 70,000 people, and is growing at 8-10% annually.

Furthermore, more than 75% of UK-manufactured photonics product is exported. These are the kind of numbers that made the High-Value Photonic Manufacturing Research Hub, hosted principally by Southampton University, a compelling choice.

The hub will build on decades of excellence at the university's Optoelectronics Research Centre (ORC), which has seen ten specialist companies spun out. Among these is SPI Lasers, which makes fibre-based lasers that are used throughout manufacturing for laser cutting, welding, polishing and many other precision-engineering applications. Founded in 2000, on the strength of developments supported by EPSRC grants totalling £13.6 million, SPI was floated in 2005, and acquired by the global laser instrumentation company Trumpf in 2008. SPI now employs 350 staff, and has a turnover expected to exceed £50 million this year.

Having itself already made multimillion pound investments in direct funding of ORC projects and EPSRC/Innovate-UK supported projects, SPI Lasers is now one of 39 commercial partners in the new hub.

Hub director and principal investigator Professor Sir David Payne attributes the centre's success to the breadth of its research base.

He says: "We are incredibly fortunate here at Southampton in that we can go all the way from electrons to enterprise; from photons to production.

"Our research connects the planet," he adds, underlining the key role fibreoptic technologies play in the Internet.

The 'grand challenge' that unites the hub partners is the vision of integrated photonic devices, which could transform their industry, the way that integrated circuits transformed electronics 50 years ago.

"We will improve the manufacturability and integration of photonics," says Sir David, "laying the path to low-cost manufacturing and accelerating the wider adoption of photonics technology." UKMR-15

Building success stories

Intelligent Energy, a spin-out from Loughborough University based on ESPRC-backed research, sealed a £1.2 billion deal in 2015 to export clean-energy units to power 27,400 telecom towers in India.

Transmission towers: Telecoms in India powered by clean energy made in Britain

"This transaction delivers contracted revenues of approximately £1.2 billion over ten years, which is a major development for Intelligent Energy and the industry," says Henri Winand, chief executive officer at Intelligent Energy Holdings.

"Our technology will not only help to bring a stable, reliable power supply to these towers, it will also demonstrate the full power of hydrogen fuel cells today, and in the future."

Founded in 2001, Intelligent Energy produces clean electricity from hydrogen fuel cells, developed by researchers at Loughborough University.

Their work was made famous around the world when a fleet of 100 'green' black cabs powered by their units ferried VIPs during the London Olympic Games.

In collaboration with Boeing, Intelligent Energy has also prototyped a pioneering hydrogen-powered plane. With Suzuki it is bringing electric motorbikes to market.

The company says the deployment of hydrogen fuel-cell power to Indian telecom towers marks a watershed transformation of the Indian power grid, which has been criticised for stifling India's economic growth due to persistent unreliability.

More than 70% of India's circa 425,000 telecom towers experience power outages of approximately eight hours a day, leaving nearly half of the country's 935 million mobile phone users frequently disconnected for extended periods.

Diesel generators are currently the main back-up power source, but as a fuel, diesel is costly, inefficient, and emits high levels of CO_2, NOx and harmful carcinogenic particulate emissions. Hydrogen fuel cells are expected to be more efficient and cleaner and can be more economical on a total cost of ownership basis than diesel generators.

THE EPSRC HAS HELPED MORE THAN 400 START-UP TECHNOLOGY BUSINESSES TO GROW. AMONG THE SUCCESSES ARE:

Fuel cell-powered motorbikes developed by Intelligent Energy

Fuel cells powered London black cabs during The Olympics 2012

OXFORD PHOTOVOLTAICS

Also dealing in 'green' energy, Oxford Photovoltaics hopes to transform solar power, making it far cheaper and more efficient, using thin-film technology based on EPSRC-backed materials science.

Co-founder Henry Snaith, Professor of Physics at Oxford University, is the world-leading expert on a new class of sunlight-capturing materials called perovskites, which are taking the world of photovoltaics by storm.

Easy to process, and based on cheap, abundant and environmentally friendly materials, perovskites are confidently expected boost the efficiency of solar panels by 2020. Discovered only in 2012, perovskites are showing an unparalleled improvement in performance – one reason so much is expected of them.

A relatively new start-up, Oxford Photovoltaics this year secured an additional £13 million of venture capital, doubling its equity, to help its team of 30 chemists and material scientists exploit the new materials.

Their vision includes effectively painting the perovskites onto the windows of high-rise buildings, turning them into vertical solar farms, the company says. UKMR-15

THE BENEFITS OF FORESIGHT

In 2015, the EPSRC announced the first in a new series of fellowships, The Foresight Fellowships. They aim to produce world-class research by academics, but also act as leaders for the UK manufacturing research community, and work with relevant EPSRC-funded activities.

JOHN BATCHELOR, BIO-PATCHES

John Batchelor dreams of tattoo-like transfers that people can wear as temporary RFID tags on their skin – part of a simple, robust health-monitoring system.

It's just one example of the use he expects for the passive bio-sensing wireless tags he is developing with EPSRC support as a Foresight Fellow.

With more than 20 years' experience in developing novel antenna systems at the University of Kent, Professor Batchelor hopes to create long-lasting microscale sensors that might also be directly integrated into the surfaces of medical implants, for example the silicone valves in voice prostheses, where the growth of dangerous biofilms could be detected.

"Producing these tags crosses several discipline boundaries," he says. "Biosciences, materials science, electronic engineering, chemistry, ink formulation and additive manufacture.

"If we can mass produce them, they will have many potential applications including health monitoring, assistive technologies and the Internet of Things."

JONATHAN AYLOTT, 3D PRINTING FOR MEDICINE

Pills could soon be printed in the pharmacy, on demand, if the Foresight Fellowship awarded to Nottingham University's Jonathan Aylott bears fruit.

"This could bring an entirely new dimension to personalised medicine," Aylott says. "The chemist could offer the formulation precisely to suit the customer waiting at the counter. Dose, size, combination of active ingredients, colour even, if you like. With an ageing population, this will greatly improve compliance of taking the right medicines at the right time."

The challenge is to combine the flexibility and responsiveness of additive manufacturing with the highly controlled conditions of pharmaceuticals processing.

That is where Aylott's skills as an analytical chemist come to the fore.

"The technical challenge is ensuring there is the right amount of drug in a tablet and ensuring it is pure and how it's supposed to be. My challenge is showing the technology is viable in a real world setting."

SIMON WEBB, PERSONALISED BIOMATERIALS

Progress in biomaterials has been frustratingly slow, says Simon Webb, from Manchester University, who has been awarded a Foresight Fellowship to accelerate the technology.

The reason, he suggests, is that progress needs the coordination of so many different disciplines, from his own, chemistry, through materials sciences, biotechnology, to cell biology and medicine. As a result, new biomaterials are far more expensive than they need to be.

"We need technologies that are going to take the raw materials which are typically low-cost and add value with high-throughput processes where we can 'dial in' the particular properties we need".

The aim is products for personalised medicine, specialised wound dressings for example, that can be designed for each patient, or to be tissue-specific.

"My aim with the Foresight Fellowship I've been awarded is to build the networks that can make this vision possible – not just with other UK academics, but with overseas centres, and with medical companies like Convatec UK who understand the realities of patients' needs.

"It sounds trivial, meeting people, but it's important to question other experts in detail about the techniques they use, the possibilities they see – even the way they organise their research. So this fellowship is a great opportunity for me to make the right contacts and help push this field forward."

PHILL DICKENS, ADDITIVE MANUFACTURING

Nottingham University's Phill Dickens is among the best known researchers in additive manufacturing, which he has pioneered since 1990, when it was typically called rapid prototyping.

3D printing has become embedded in much of industry, but Dickens believes that its true potential has barely been seen yet. With his Foresight Fellowship, he intends to reach out to researchers who have yet to see how they can contribute to the revolution.

Dickens says: "I really want to enthuse other academics to take up the challenges of next generation additive manufacturing. I will marry academics from disciplines such as physics, chemistry and materials with the existing UK community to explore the potential for volume processing materials at high speed." UKMR-15

Casting roles for metals technology

Alloys | EPSRC Future LiME Hub

With consumption of natural resources at unpredecented levels, environmentally friendly means of producing metal components are under development – with the aim of preserving Britain's casting sector.

EPSRC FUTURE LIQUID METAL ENGINEERING HUB

Since 2010, the EPSRC Centre for Innovative Manufacturing in Liquid Metal Engineering (LiME) has been carrying out research to support the metals casting industry.

Now, at the end of its initial period of funding, and in recognition of LiME's achievements and the work that still needs to be done, the EPSRC has awarded Brunel University London a further £10 million award to lead LiME as a Future Manufacturing Research Hub – the EPSRC's latest vehicle for its national centres of excellence.

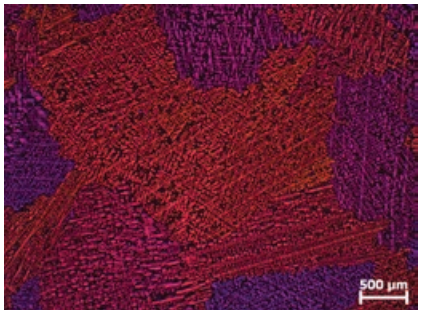
It is a shocking fact that our cumulative consumption of natural resources over the last 60 years is greater than that over the whole of previous human history. With an anticipated world population of 9.3 billion in 2050, the predicted global consumption of natural resources will be almost tripled.

This level of overconsumption is obviously not sustainable, and there is a compelling need for us to use our advanced science and technology to work with, rather than to exploit, nature.

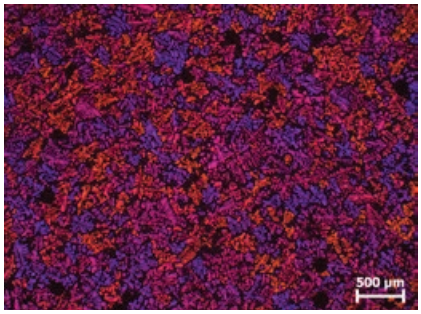
Metallic materials are the backbone of manufacturing and the fuel for economic growth. However, metal extraction and refining is extremely energy intensive and causes a huge negative impact on our environment.

The world currently produces 50 million tonnes of aluminium and two billion tonnes of steel each year, accounting for 7-8% of the world's total energy consumption, and 8% of total global CO_2 emissions.

However, the good news is that metals are, in principle, infinitely recyclable, and their recycling requires only a small



Above: LiME's understanding of nucleation has led its scientists to create new systems for grain refinement, and to improve the recyclability of scrap aluminium



Right: Direct chill casting of a 4.5 tonne aluminium alloy billet, implementing LiME's rotor-stator high shear technology

"Our work with the new centre will give us a strategically significant opportunity to expand our capabilities across a number of different manufacturing disciplines, gaining both environmental and economic benefits through the development of new, highly efficient alloy processing and recycling techniques."

Dr Roger Darlington, Research Manager at Jaguar Land Rover

fraction of the energy required for primary metal production.

CHALLENGES FACING 'HOLLOWED OUT' INDUSTRY

All but a few metallic components undergo a solidification process at some stage in their production. Thus the metal casting industry, which in the UK adds £2.6 billion a year to the economy and employs 30,000 people, underpins the competitive position of every sector of manufacturing.

However, the industry faces severe challenges, including 'hollowing-out' over the past 30 years, increasing energy and materials costs, tightening environmental regulations, and a short supply of skilled people.

The Future LiME Hub addresses these challenges. Directed by Professor Zhongyun Fan, the hub's long-term vision is full metal circulation, in which the global demand for metallic materials is met by a full circulation of secondary metals, with only limited addition of primary metals each year, through reduced usage, reuse, remanufacture, closed-loop recycling and effective recovery and refining of secondary metals.

This ambitious vision is deeply rooted in LiME's approaches to research, which range from atomic level basic research to industrial scale trials of new technology:

Fundamental research: Microstructural control through the nucleation stage of solidification

Development of new metallic materials: Creating new alloys that have significantly improved properties, and are suitable for closed-loop recycling

Technology development: The manufacture of high performance metallic components and feedstock materials by innovative solidification processing

Industrial applications: Working closely with industrial partners throughout the supply chain to up-scale and transfer new technologies

Sustainable metallurgical industry: Improving recyclability and reducing energy consumption and CO_2 emissions

The microstructure of metal in the as-cast state determines the ease with which any later stages of manufacturing, e.g. heat treatment, extrusion, machining or anodising, can be carried out and to a component's final properties.

LiME believes that microstructural control is most effectively achieved through a command of the nucleation stage of the solidification process, developed through the principles of liquid metal engineering.

NUCLEATION IS THE KEY

In all practical cases, nucleation occurs heterogeneously on a normally crystalline substrate. The structure of liquid metals is generally considered to be amorphous. Using molecular dynamics simulations, LiME researchers have demonstrated that prior to nucleation, within the first nanometre above the substrate the liquid tends to be layered and to exhibit a degree of order within the layers. This pre-nucleation phenomenon supports their newly developed epitaxial nucleation model in which the first few atomic layers of solid to form on the substrate do so with an atomic spacing that matches that of the substrate. Once the thickness of the solid reaches a critical value the solid takes up its natural crystal structure and grows.

For more than 50 years cast-houses have used master alloys containing titanium diboride (TiB_2) to refine the as-cast microstructures of aluminium alloys, despite TiB_2 not having a crystallography that is ideal for heterogeneous nucleation of aluminium.

However, an understanding of the mechanism of nucleation that underlies this grain refinement process has remained elusive. Using atomic resolution imaging and chemical analysis at the

Professor Zhongyun Fan

HUB DIRECTOR

Professor Zhongyun Fan is director of the recently announced EPSRC Future Liquid Metal Engineering (LiME) Hub, formerly an EPSRC CIM.

With EPSRC's support as a platform, LiME has grown to be the largest research group in solidification and casting in the UK, and one of the largest worldwide. It is world-leading in fundamental solidification research, and the development of metallic materials and new casting technologies.

"We are delighted that the EPSRC has recognised LiME's achievements and awarded us further funding to create the Future LiME Hub to sustain and grow our activities," says Fan.

The Hub puts LiME in a unique position to address the grand challenges facing the metals industry; in particular closed-loop recycling of metallic materials to deliver a sustainable future.

"Our vision for full metal circulation is now shared by government organisations, funding bodies and industry."

BCAST, also directed by Fan, and host of the Hub, is undergoing re-organisation to address this grand challenge by developing a translational pipeline for the new science and technologies developed within the Hub.

Fan explains: "LiME will continue to be our platform for long-term fundamental research. The large-scale facilities in the new EPSRC and HEFCE supported Advanced Metals Casting Centre will address the 'valley of death'. To support these functions we are creating an Advanced Testing Centre, a Centre for Microstructural Characterisation and a Virtual Engineering Centre as new developments within BCAST."

The UK metals industry is based upon a large number of SMEs. "Our SMEs lack the means to carry out high quality R&D," remarks Fan. "Our facilities will provide a number of points of entry for engagement with us, and in combination with flexible research space and our expertise provide a Technology Playground to facilitate the growth of SMEs."

Fan emphasises that another challenge facing the UK manufacturing sector is the critical shortage of skilled people: "We are meeting this challenge by creating a LiME Training Centre incorporating a centre for doctoral training in liquid metal engineering from which we aim to develop a Masters programme for existing industrial engineers."

national SuperSTEM facility, this problem has now been solved. Free titanium adsorbs onto the surface of the TiB_2 particles to form a single atomic layer with the composition of Al_3Ti, and it is this layer that acts as the nucleating substrate.

Based on the depth of understanding derived from its fundamental research, LiME is developing a number of new technologies which have enhanced nucleation at their heart.

For instance, a grain refiner for aluminium-containing magnesium based alloys has been developed. The effective grain refinement of such alloys has been demonstrated to increase the deflection before failure of vehicle front end carriers in industrial trials.

Another example of a technical application for nucleation control is to improve the recyclability of scrap aluminium through the removal of deleterious iron impurities.

LiME is aiming to improve the properties of casting alloys to allow new assembly methods in automotive manufacture

NEW ALLOYS

Aluminium alloys used for shape casting are generally not able to match the ductility and strength of aluminium alloys for wrought processing. LiME is continually aiming to improve the properties of casting alloys. New alloy developments include a 'super-ductile' aluminium casting alloy that has sufficient ductility to allow cast vehicle body components to be more readily joined by self-piercing riveting. In another example, a new high-strength casting alloy has been licensed to a Tier 1 aerospace supplier and allowed them to replace expensive, slowly made computerised numerical control (CNC) -machined components with less-expensive, rapidly produced high pressure die castings.

PARTNERS

The EPSRC Future LiME Hub has its central hub at Brunel University London, supported by spokes at the universities of Oxford, Leeds and Manchester, and Imperial College. Among others, its industrial partners include:

Jaguar Land Rover
Constellium
Grainger & Worrall
Aeromet International
Norton Aluminium
Innoval Technology
Sarginsons Industries
Sapa Technology
Primetals Technologies
JVM Castings

LIQUID METAL ENGINEERING FOR INDUSTRY

Professor Fan and LiME are well known internationally for the concept of conditioning liquid metals through the application of high shear forces. Originally embodied as a twin-screw mechanism, the high shear process disperses harmful oxide films into benign particles, and alloys cast after high shear processing have refined microstructures and uniform chemistry.

Fan and his colleagues have now created a much simpler and more compact rotor-stator mechanism that can be easily incorporated into conventional casting processes. They have combined the rotor-stator device with the twin roll casting process to cast thin magnesium alloy sheet that can be directly stamped into component shapes. This has the potential to revolutionise the use of wrought magnesium alloys.

They have also combined the rotor-stator device with direct-chill (DC) casting for the production of large ingots or billets of aluminium alloys for downstream rolling or extrusion. The resulting material has a refined microstructure and uniform chemical composition without the need for the commonplace addition of grain refiners.

A number of LiME's partners have trialled this process at an industrial scale. Their record to date is the production of a 650 mm diameter, 5 metre long billet, weighing 4.5 tonnes.

UP-SCALING TO CREATE A TRANSLATIONAL PIPELINE

With £17.4 million of support from the EPSRC, Brunel University London and industry, LiME is currently establishing the first phase of an Advanced Metals Casting Centre (AMCC) for light metals research on Brunel University London's campus in Uxbridge.

Housing pilot and commercial metals processing equipment in a 1,500 m^2 purpose-built building, the AMCC will act as a national scale-up facility to bridge the gap between fundamental, laboratory scale research and full-scale industrial trials. The major equipment installation comprises:

1. A commercial 1,600 tonne locking force cold chamber high pressure die caster with 600 kg aluminium and 500 kg magnesium melt capacities.

2. A commercial 240 kN closing force low pressure die caster with a 600 kg melt capacity.
3. A pilot scale hot-top DC caster with 200 kg melt capacity, capable of casting 2 m long billets.
4. A commercial 16 MN direct extrusion press with taper controlled billet heating and downstream handling.
5. A scaled-up melt conditioned twin roll casting machine for producing 350 mm wide magnesium alloy strip of less than 1 mm in thickness.
6. Real-time X-ray inspection for high resolution defect characterisation at the component scale.

In support of its industrial partners – Jaguar Land Rover, Constellium and a number of companies in the supply chain – the AMCC will initially serve the automotive industry, but the longer term aim is to make the facilities available to partners in the aerospace, defence, and general engineering sectors. Research will focus on nucleation centred solidification science, development of casting technologies, development of new metallic materials, and sustainability. The AMCC is due for completion in early 2016.

LiME's partners will continue to work with the Future LiME Hub for fundamental and long-term user-led research. Through the AMCC, they will now be able to translate laboratory developments created within the Hub to large scale pre-production trials, thus accelerating the path into full commercial production.

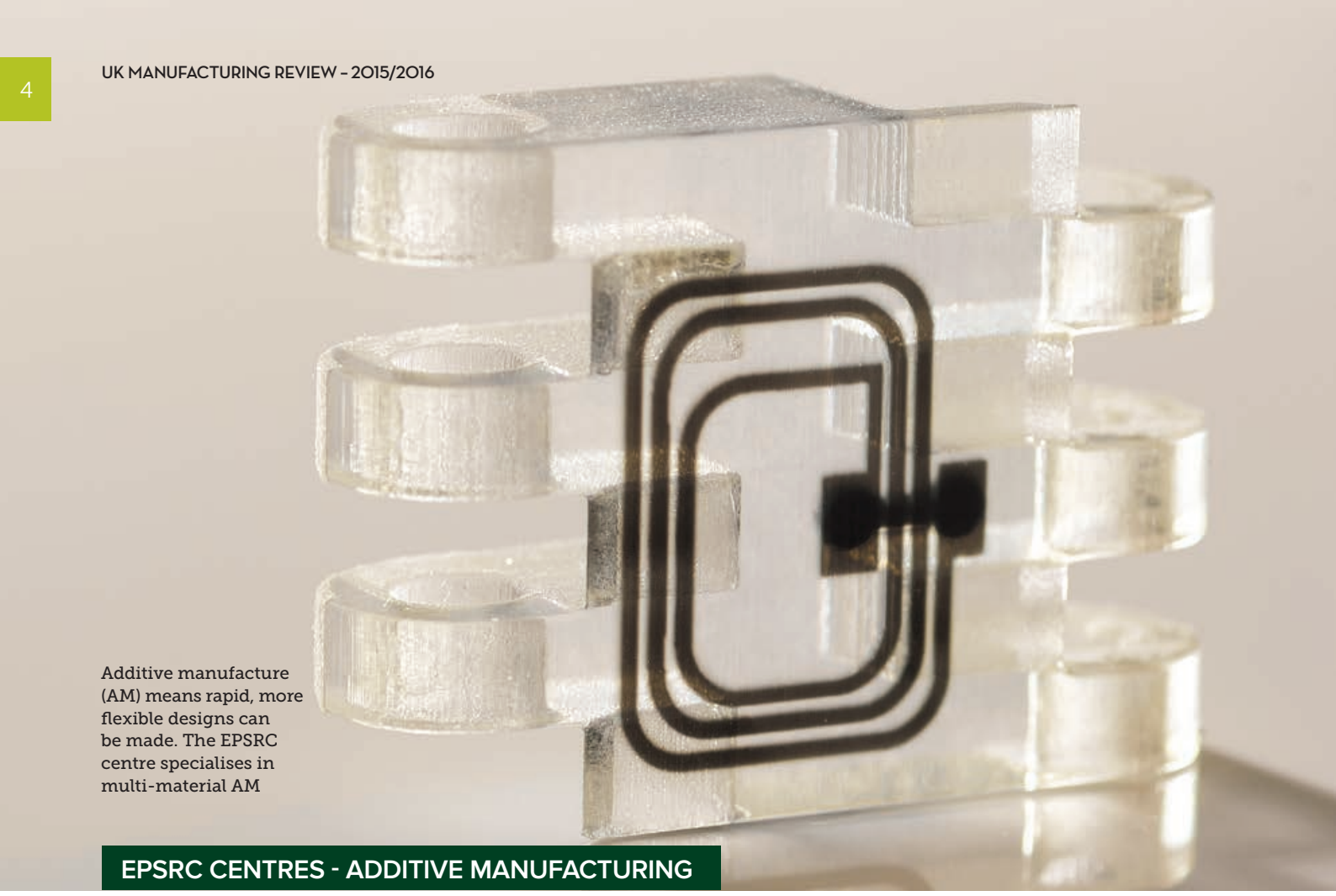
Earlier in 2015, Brunel was awarded a further £15m by HEFCE, backed by a further £3m from Brunel, and £62m of support from industry for research projects, to establish Phase II of the AMCC. This second 1,500 m^2 building will complete the range of industrial casting equipment and house large scale equipment for fabricating and testing assemblies of extruded profiles and castings. Due for completion in early 2017, Phase II will also provide a comprehensive set of non-destructive, analytical and mechanical testing facilities, and a simulation and modelling suite. UKMR-15

INDUSTRY VIEWPOINT

"We expect the market for extrusions in automotive structures, powertrain and chassis applications to grow rapidly over the next five years, and this represents a major business opportunity for Constellium.

"We believe the new centre will enable us to exploit this growth by mastering the cutting-edge of automotive light metals research. Furthermore, because we are part of the centre consortium, new developments will generally be carried out in close association with our strategic customer and supplier base to support the continued growth and evolution of our business."

Paul Warton, President of Constellium's Automotive Structures and Industry business unit



Additive manufacture (AM) means rapid, more flexible designs can be made. The EPSRC centre specialises in multi-material AM

EPSRC CENTRES - ADDITIVE MANUFACTURING

LAYER BY LAYER:

Manufacturing in 3D at the EPSRC Centre in Additive Manufacturing

ADDITIVE LAYER MANUFACTURING: A POTENTIAL GAMECHANGER

Viewed as a disruptive technology, additive manufacturing (AM) has the potential to replace many conventional manufacturing processes – and allow entire new business models to emerge. For instance, it may mean that sections of supply chains are omitted and designers design for manufacture at the customer's site, meaning there is no need to supply materials across locations and machine sets of components at different locations.

Engineering designers in aerospace and automotive find AM attractive because of its potential to radically reduce materials wastage and cut down on component weight in aerospace and automotive applications, saving money but also, crucially, cutting fuel consumption.

According to Innovate UK, the sector could be worth $7.5 billion by 2020, but needs support. The EPSRC Centre for Innovative Manufacturing CIM in AM, led by Richard Hague of the University of Nottingham, is working on the UK National Strategy for additive manufacturing, co-ordinated by Phill Dickens, executive team member. This is being led by a steering group, whose members include Rolls-Royce chairman Neil Mantle, Rob Sharman of GKN Aerospace, David Wimpenny of the Manufacturing Technology Centre in Coventry, Innovate UK, The Welding Institute, and officials from the Department of Business, Innovation and Skills.

Most of the companies the EPSRC centre deals with have a footprint in the UK, but much of its work is international. "National boundaries don't exist in manufacturing," explains Chris Tuck, the centre's deputy director.

Companies have been adopting additive manufacturing for longer in the US, which is where 3D printing machine builder Stratasys runs what it claims is the largest commercial parts bureau in the world.

Europe, however, is ahead in terms of its research base. Due to many of the initial technologies originating in the US, companies have had longer to adopt them. As a result, companies in North America have an edge in terms of implementation of AM.

BACKED BY BRITAIN?

Additive manufacturing is now funded by a range of academic institutions all over the country, as well as being backed by OEMs, some of whom, such as BAE Systems, have been flying functional AM parts on military aircraft for some time.

The EPSRC AM centre at Nottingham University – which opened just four years ago, although it has been gestating for two decades – has had a strong year and is developing novel pharmaceutical and chemical industry applications.

It has more than £25 million in funding, and additionally runs a Centre for Doctoral Training (CDT) that opened in April 2014.

All studentships within the CDT are sponsored by industry with real cash commitments for each one to allow stipends to be increased, demonstrating industry pull.

The CIM was instrumental to the CDT bid, says Dr Chris Tuck, deputy director of the AM centre, and director of CDT at the Centre. "The CIM has enabled a critical mass to be developed in the area and this has had a consequent impact on both the capability and capacity of AM in the UK," adds Chris. "The CDT with its other university parties exploit this by tapping in to the expertise, equipment and industrial contacts to develop the bespoke and unique training and research programme offered by the CDT." Tuck is focused on a research project involving polymeric materials.

The CIM has received £1 million from a big pharma company [GSK] for a project led by Professor Ricky Wildman. It makes dosage forms such as tablets using AM, designing new ways to deliver drugs using multi-materials. "With multi-material you can do polydrugs. Rather than have a drug dispensation box with five different pill dosages, have one pill, designed to dissolve the right drug at the right time in the right dose," says Dr Tuck.

According to Tuck, OEMs and major pharmaceutical companies are increasingly interested in researching AM instead of waiting for projects to come to fruition and seeing whether they are of commercial use.

OPTIMISTIC INDUSTRY LINES UP TO JOIN AM CENTRE

The EPSRC CIM in AM is split between the universities of Nottingham and Loughborough. Its industrial partners include:

3T RPD
AWE
BAE Systems
Boeing Company
Delcam International
Delphi Diesel Systems
Econolyst
EOS GmbH – Electro Optical Systems
National Physics Laboratory
Objet Geometries
Printed Electronics Limited
Renishaw
Smart Fibres
Solidica Corporation
TWI

In May the CIM finished an Innovate UK automotive project with three auto partners – Delphi Diesel Systems, Alcon Components and Axon Automotive, an SME. One company is going through a patenting process with a product concept that the group has enabled and have a case study that is nearly ready.

The move to multi-functionality within AM is littered with technical challenges, from accurate and reliable deposition of different materials together, and their interaction, to the design of these components, and how best to integrate different materials for a given function.

Current additive manufacturing technologies have clear advantages, but also some drawbacks for the production of multi-material parts. Among these are accuracy, resolution and the processing environment required during manufacture. The Nottingham CIM has carried out a strategic review of the available manufacturing routes for AM, with significant promise being shown by drop-on-demand inkjet techniques for processing conductive, dielectric and other materials.

New experimental material deposition test beds and in total three jetting systems have been commissioned, one based on the FujiFilm Dimatix DMP2831, two based on the PixDro LP50 architecture and a 6-head bespoke jetting system, commercially known as Toucan, also based on the PixDro architecture.

These systems are capable of depositing particulate-based inks, such as those filled with silver nanoparticles, and a host of other materials with various viscosities and surface tensions. In particular, the PixDro systems have five different configurations to enable contemporaneous multi-material printing, particulate printing and elevated temperature printing of hot melt polymers.

The project is now concentrated on multi-material printing in 3D, especially in the vertical direction, as well as printing onto existing additively manufactured substrates, such as those produced by ultrasonic consolidation, or materials developed in the sister project, Reactive Jetting of Engineering Materials.

Various inks were specially formulated to enable printing conductive routes in the Z direction as well as real-time UV

> "The hype around 3D printing and AM has helped us immensely because it has put the technology right in front of CEOs. They look for where they can do this and because we have an EPSRC centre we are the obvious place to call, and are the only centre like this in the UK," –
>
> *Dr Chris Tuck, deputy director, Nottingham CIM*

Dr Chris Tuck

Additive layer manufacturing at Nottingham University is building a world-class research base

and heat curing sources to establish printing functional multi-material structures. The research could ultimately lead to the development of 3D printing for the manufacture of photovoltaic cells, as well as other technologies.

The centre is also involved in a project to develop self-assembling hybrid jetting inks for regenerative medicine, seeking to expand the capability of current 3D printing techniques, particularly in biomedical applications.

New ink formulations are being targeted with desirable physical characteristics for jetting and that can produce the next generation of temporary templates, or scaffolds, for tissue regeneration. Current jetting inks are not suitable for tissue scaffolds and adapting current biomaterials for jetting is not sufficient, according to the CIM. A key objective of the feasibility study is to synthesise a new hybrid ink that can be jetted. Another objective is to generate sufficient preliminary data to enable a larger proposal to be written that will

Professor Richard Hague

CENTRE DIRECTOR

Professor Richard Hague, director of the EPSRC CIM in Additive Manufacturing (ALM) at the University of Nottingham, believes that the UK is already a world leader in 3D printing research.

The challenge here, as elsewhere, is to exploit its design potential at the level of mass manufacture. Hague is clear that that's where the future lies. "I regard domestic 3D printing as something of a nonsense," he says candidly. "The key to successful exploitation of ALM is at the level of complex design for industrial production."

The EPSRC CIM for ALM has evolved from a team primarily using stereolithography in the 1990s to one employing a sophisticated range of polymers, powders, metals and laser systems today. Novel combinations of materials and processes come under the banner of 'multi-functionality'.

Hague says that, unusually, the CIM has gone down the Technology Readiness Level (TRL) structure toward pure science (TRL 1-3), rather than trying to take the ideas of scientists and engineers closer to market (TRL 4+). "That's not the normal trajectory for a research group."

This is not to say that there is a lack of interest in the centre's work from the wider corporate world. Océ, the Dutch printing technology firm that specialises in ALM and was acquired by Japanese giant Canon, is working with the centre on the latest inkjet printing of molten metals.

It is also working on projects with GlaxoSmithkline and AWE, which is looking at high-temperature jet printing of dissimilar materials with the Nottingham University CIM.

The composition of researchers at the centre has changed, Hague says. There is a greater number of particle physicists, materials scientists and computer experts. "We have a team of 90 now, which is huge in research terms." The centre is working hard on developing software for ALM and may launch a spin-out exploiting this eventually.

Hague explains: "We use our own code all the time. We are very interested in taking our software forward – and ultimately selling it." He says that scale matters when building a business, and additive layer manufacturing is no exception.

"The key to additive is design. Complexity is key to the optimum use of additive manufacturing: if it's a simple shape, then you should probably machine it."

"The EPSRC CIM in AM is one of leading research centres in the world. This is the reason we would like to work with EPSRC CIM in AM. With their expertise, we believe it will accelerate the research progress for SABIC materials in the market of additive manufacturing"

Hao Guo, Global Application Technology, SABIC Innovative Plastics

explore candidate hybrid inks for optimal scaffold production for different tissues.

The long-term aim of this collaborative study is to develop new jetting inks that will allow the manufacture of the next generation of scaffolds for bone and cartilage regeneration.

The Nottingham CIM is also involved in projects with other organisations researching AM, including on smart photoreactive materials for AM with the University of Sheffield, University of Nottingham, Imperial College London, and University of Warwick.

A critical challenge faced in additive manufacturing is to increase the repertoire of materials that can be assembled, as well as to open up new possibilities in multi-material systems.

This project investigates the design of new ink formulations AM based on surface functionalisation with photo-responsive surfactants. By creating particles that are dispersed in the dark but agglomerate upon UV irradiation, it would be possible to control this aggregation process and tune it for two solid free form fabrication techniques, continuous extrusion and stereolithography.

This approach is simple, based on a single additive, and flexible, allowing for the use of different AM techniques. It is also versatie. Different ceramic materials could be printed.

The aim of the project is to explore a production route for ceramic-based 3D architectures. These will be built from a photoreactive nanoparticulate material. The project is due to be completed early in 2016. UKMR-15

2015 HIGHLIGHTS

- EPSRC CIM in additive manufacturing receives £600,000 from defence company AWE for two research projects
- By autumn 2015, the CIM had 90 staff. When it started at Loughborough it had 28. By 2017, it is expected to have more than 100 people

- In May 2015, the CIM finished an InnovateUK automotive project with automotive sector partners including Delphi Diesel Systems, Alcon Components and Axon Automotive, an SME. One company is going through a patenting process with a material the CIM has developed
- Most of the companies the centre deals with have a footprint in the UK, but much of its work over the past year has been international. "Those national boundaries don't exist in manufacturing," says Dr Chris Tuck
- The nature of industry engagement with AM has changed. Originally companies were interested in seeing how the sector developed as observers

CROSS SECTORAL APPLICATIONS

Research sectors for the EPSRC Centre in Additive Manufacturing:

Sector

Aerospace: 10%
Automotive: 10%
Defence: 20%
Pharmaceuticals: 20%
Chemical: 15-20%
Miscellaneous: 20%

Engineering for life

THROUGH-LIFE ENGINEERING SERVICES

Through-life Engineering Services (TES) are the technical services necessary to guarantee the required and predictable performance of a complex engineering system throughout its expected operational life with the optimum cost

Artificially aging samples to investigate degradation in gas turbine blade coatings

These maintenance, repair and overhaul services have become important as contracts for complex engineering products such as jet engines, trains and ships, are being let on a usage rather than ownership basis.

With the objective of optimising whole-life cost, companies must take into account all aspects of design, manufacture, maintenance, repair, overhaul and disposal or re-use.

In the future, customers will only buy services: product-only providers will not exist in many technically complex fields, leading to a polarisation of manufacturing between the so-called 'throw-away' and circular economies. Today, most major car manufacturers offer leasing and buy-back arrangements, as well as outright ownership.

In this vision of the future economy, nobody and no company will ever buy major assets again: they will simply pay for some kind of service or functionality and will not think about products and services as being separated.

With increasing interest in the circular economy, and the need to get more from aging infrastructure and other long-life assets, taking an 'end-to-end' perspective on design, manufacture, maintenance, repair, overhaul and disposal, enabled by Through-life Engineering Services (TES), will be a critical discriminator in the very large global market for engineering support and services.

Engineering services are already significant to the UK, engineering support and services with around 6,000 companies employing over 107,000 people, the most well-known of which is Rolls-Royce, with its Total Care™ 'power-by-the-hour' offering for its jet engines.

In this new economy there will be two types of players: service providers who will dominate profit recovery, sharing this with the service supply chain, who are able to understand the operating context, and make a value-add contribution to managing the assured performance of the underlying assets through-life.

'Traditional' manufacturers who provide only products and parts, without an ability to support or understand the service supply chain, will have their profits marginalised through global competition, competing in what the EPSRC Centre for Innovative Manufacturing in Through-life Engineering Services at Cranfield University describes as a 'race-to-the-bottom' – driven there by customers who understand TES, and who seek real value for money for the in-service support of their assets.

Philippa Oldham, head of transport and manufacturing at the IMechE, explains: "The days are gone when it was acceptable to sell products without support. Not only does it make good commercial sense to offer follow-on maintenance and upgrading, it gives

invaluable evidence back to the manufacturer on the performance of their goods as a guide to their continuous improvement.

"Optimisation of those characteristics that are valued by the customer and omission of unnecessary costs and features, is plain good sense. The UK already has a lead in this thinking with companies such as Rolls-Royce and BAE Systems. The potential for economic growth and for redefining what we understand by manufacturing are both clear."

Understanding how these complex products and their components degrade and fail is key to achieving better through-life performance. What look like sensible design and manufacturing decisions can be made without understanding the full-life consequences.

A manufacturer might decide to speed up a drilling process by increasing the power of the laser used to drill fine holes. What might not be understood is that this increased power affects a larger area around the holes and allows cracks to initiate more readily, reducing the life of the component.

The increased manufacturing throughput seems to save money but they are contracting for availability and have to bear the cost of the spares and the increased maintenance themselves.

Being able to predict the remaining useful life of a component is crucial in making the best possible maintenance decisions. The Centre is developing novel degradation-assessment techniques using Non-Destructive Testing (NDT), including pulsed thermography to investigate the extent of degradation in the thermal barrier coatings on hot-end components of gas turbines.

These components are actively cooled and covered in special ceramic coatings to protect them from temperatures above their raw material melting point. Knowing exactly when such components need replacing – and getting the best possible life out of them – contributes significantly to reducing the costs of maintenance.

DEVELOPING A NATIONAL STRATEGY

From the start, the centre has consulted widely with groups of industrial, government and academic experts. Initially it formed a think tank to help identify key research directions.

More recently this has formed the basis of a wider consultative body, called the Knowledge Hub. From an initial meeting in 2014 at the Institution of Mechanical Engineers, the need for the development of a National Strategy for TES has emerged.

A full-blown workshop at the Royal Academy of Engineering in 2015 led to Rolls-Royce and the High Value Manufacturing Catapult agreeing to lead this initiative, which was launched at the Houses of Parliament in early autumn 2015.

A steering committee, made up of industry and government, has been set up: the plan is to deliver a strategy by mid-2016.

HIGHLIGHTS 2015

Babcock International joins the Centre as a top member, with financial support through to 2018

The Centre inaugurates a low-level membership called TESClub, aimed at high technology SMEs. This attracts companies including Spherea Test and Service, Intelligent Energy, Warwick Analytics and TlmNexus

New technology is used to create facilities for industrial partners. Working with Copernicus Technologies, a founding TESClub member, rogue avionics boxes from a military rotor wing platform are tested, inducing intermittent faults, identifying relevant components, and feeding this information back through the Ministry of Defence

Route forward: The EPSRC Through-life Centre is working on a National Strategy for engineering services

HS Marston Aerospace, a UTC company, commissions the Centre to develop test rigs to replicate degradation in heat exchangers

The Centre wins a DSTL commercial contract to create and evaluate damage in complexcomposite shapes using sophisticated pulsed thermography capabilities

The Centre is awarded a further around £10 million in areas such as verifi cation and validation of sensors, large data and decision strategies, energy harvesting, Operations Excellence Institute and remote maintenance.

The Centre prepares to launch a TES Consultancy offering, to enhance the industrial impact of the research conducted at the EPSRC centre

New research has also started on visualisation of degradation dynamics, remote maintenance, IoT for maintenance and cyber security for TES.

The Centre's range of facilities allows for in-depth scientific study of degradation processes. A UK subsidiary of a major international aerospace company has recently commissioned the centre to build two test rigs, to experimentally examine the degradation of aircraft heat exchangers.

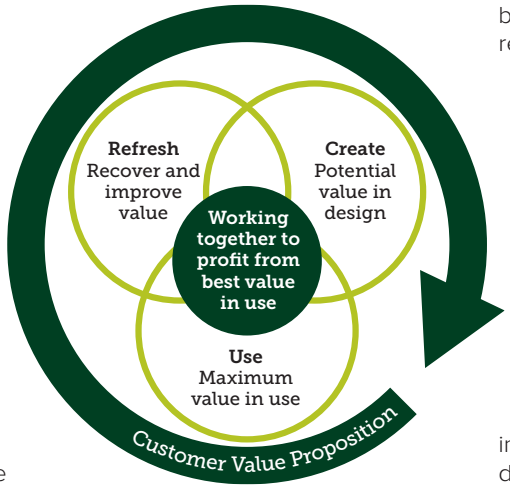
One of these rigs uses the centre's environmental test chamber, capable of replicating temperatures and humidity from aircraft take-off in a tropical environment, to the sub-zero temperatures experienced at 30,000 feet.

Pressure to do something quickly can have the effect of creating massive extra costs in support supply chains. A well-known phenomenon in the aerospace maintenance repair and overhaul (MRO) industry is the so called 'No Fault Found' (NFF) problem.

Aircraft carry a lot of interchangeable parts and in order to maximise flying time, the temptation is to swap a part when a fault is indicated on a system. If this cures the problem all well and good, but what happens to the part that has been removed?

Usually this goes back to a test facility either at the original manufacturer or in the MRO shop. Often here there is a failure to detect any problem with the part so it is either returned to the support stock as fully operational or flagged as suspect with no fault found.

This second option leads to a reduction in the pool of support parts, so that in order to maintain service levels extra parts have to be sourced. This inflates the number of items in the support stock, and costs money.



Model of the Through-life Engineering Services process © EPSRC Centre in TES

The Centre has developed a tool for evaluating this support process and the effectiveness of the diagnosis. It is aimed at helping organisations improve their management and operation of fault detection and root cause analysis.

This tool has passed Technology Readiness Level (TRL) 6 stage gate at Rolls-Royce, and also been deployed at Jaguar Land Rover. The centre also has access to RAF Fleet maintenance data and through some sophisticated data mining has established that NFF levels in these fleets are around three times the original estimate.

The science of degradation in rotating machines is quite well-developed. We balance rotors to reduce vibration and reduce wear on bearings, but what about mechanisms that don't spin?

The Centre has commissioned a one-year study into such devices, usually called linear machines, which are commonly found in train doors and aircraft landing gear. It has scoured the published literature, and after finding very little work done in this area, has developed models and built a test rig to collect data on common faults. This data will form the basis of a library that can be used to match in-service monitoring to detect and diagnose faults before they cause a breakdown.

Can a system fix and maintain itself? The centre has developed on-chip electronics that can successfully re-organise itself after damage, or revert to its original functionality. This avoids the use of double or triple redundancy, and hence can reduce component cost and weight issues.

A Durham University laboratory that is part of the EPSRC Centre has been awarded patents in this field. The long-term fundamental research is aimed at self-healing electronics. This avoids

Professor Rajkumar Roy

DIRECTOR, EPSRC CENTRE FOR INNOVATIVE MANUFACTURING IN THROUGH-LIFE ENGINEERING SERVICES

Professor Rajkumar Roy is director of the EPSRC Centre for Innovative Manufacturing in Through-life Engineering Services, a collaboration between Cranfield and Durham Universities, with Rolls-Royce, Bombardier Transportation, BAE Systems, Babcock International and the UK MoD as core industrial partners.

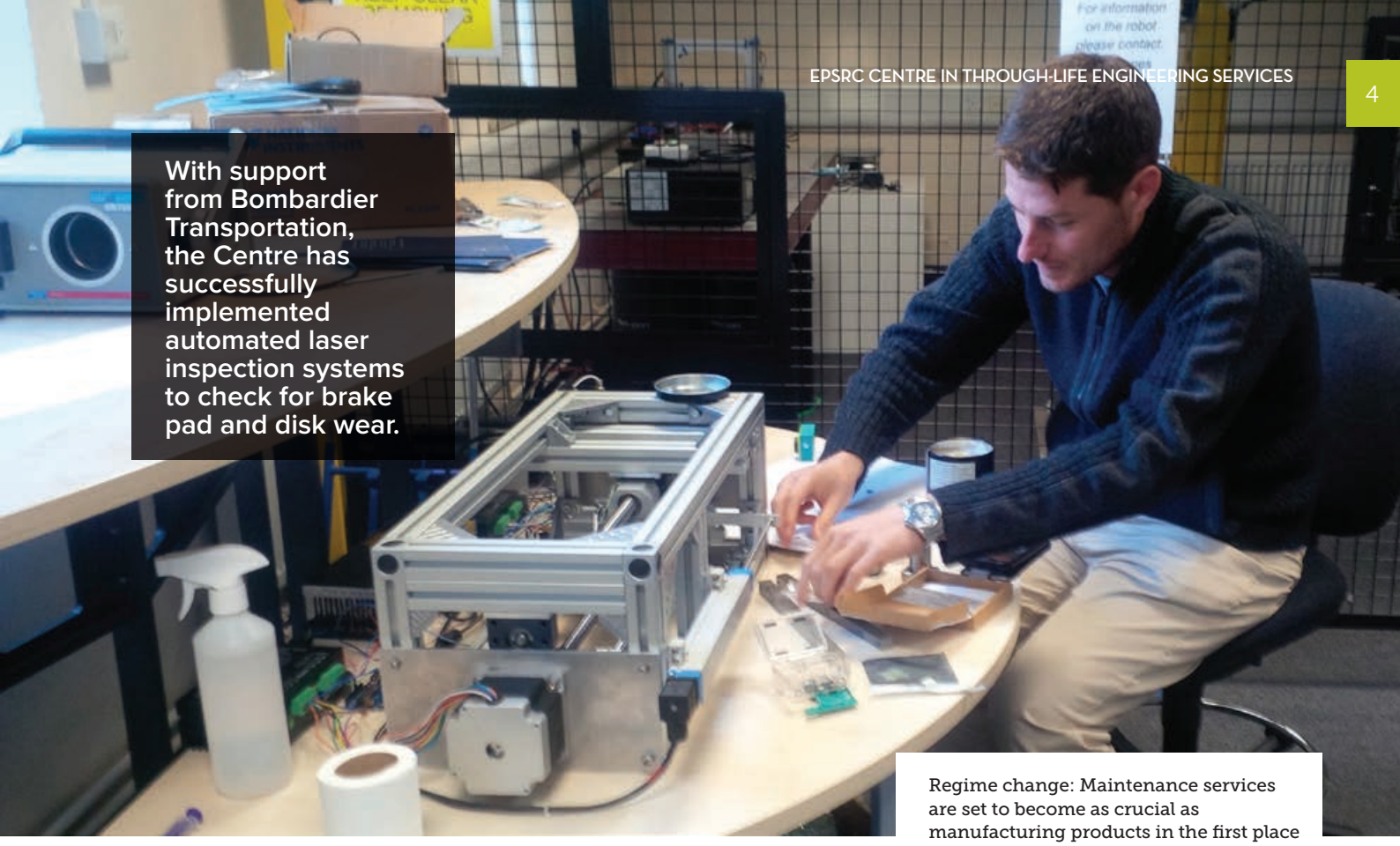
Professor Roy is also director of manufacturing at Cranfield University, director of the Operations Excellence Institute, and editor-in-chief of Applied Soft Computing, an Elsevier journal. He has more than 21 years' academic and industrial experience in manufacturing research and education.

His research interests include through-life engineering services, cost engineering, product-service systems, design optimisation and applied soft computing. He has published research papers in more than 185 conferences and journals.

Professor Roy's research sponsors include BAE Systems, Rolls-Royce, the MoD, Tata Steel Europe, Airbus, GE Aviation, Lockheed Martin, BOC Edwards, Nissan, Bentley Motor Company and Ford Motor Company.

He is a chartered engineer and a Fellow of the International Academy for Production Engineers (CIRP), Institution of Engineering Designers (IED), Association of Cost Engineers (ACostE), and The Chartered Institute for Logistics and Transport (CILT).

Currently Professor Roy is serving on the IET Manufacturing Policy Panel and on the Specialist Advisory Group on Manufacturing for the Aerospace Technology Institute (ATI). He is the founder of the annual National Manufacturing Debate at Cranfield and The Manufacturing Co-operative.



With support from Bombardier Transportation, the Centre has successfully implemented automated laser inspection systems to check for brake pad and disk wear.

Regime change: Maintenance services are set to become as crucial as manufacturing products in the first place

the use of double or triple redundancy, and hence can reduce component cost and weight issues.

The use of robots for autonomous maintenance has also been investigated. True autonomy is when a robot is able to carry out a maintenance task, making decisions as it goes. For example, if a robot needed to undo a nut and bolt, how should it decide how much force it should use? How do you integrate alternative strategies, such as applying heat, when a pre-determined level of force fails to undo the nut and bolt?

All these questions and others were investigated in a one-year feasibility study which explored the use of robots in maintenance, and identified cleaning of trains as a promising area of application.

Supported by Bombardier Transportation, the Centre has investigated the use of automation in train support. Bombardier Transportation has successfully implemented automated laser inspection systems to check for brake pad and disk wear.

Use of this technology helped Bombardier win the Crossrail rolling stock contract, as its systems require one less train than their competitors to guarantee availability and service levels. UKMR-15

FAST FACTS: THE UK TES MARKET

Engineering services includes:
More than **6,000** firms employing more than **105,000 people**
Average wages are **1.5 times other manufacturing**
There is a big opportunity: a world market by 2025 of **approximately £1,000 billion and rising**
The UK **has a 5% share**, and it is falling
The current UK opportunity: **£12 billion**

THE EPSRC TES CENTRE'S CORE PARTNERS ARE:

BAE SYSTEMS

Rolls-Royce

BOMBARDIER

MINISTRY OF DEFENCE

babcock trusted to deliver™

Kilos through keyholes

CMAC NATIONAL FACILITY

The EPSRC CIM in Continuous Manufacturing and Crystallisation, based in Glasgow.

Attracting big pharma to the UK is the aim of CMAC, which could help bolster Britain's reputation as a world-leading engineering resource for the drug industry.

CIM city: £89 million of pharma aid for the British industry in Strathclyde represented by the new building [opposite page]; above, a technician researching new drugs in the CMAC laboratory

VIEW FROM INDUSTRY

"At AstraZeneca (AZ), we believe that continuous manufacturing and crystallisation has the potential to drive a step change in our ability to control the physical properties of our active pharmaceutical ingredients (API).

"AZ joined CMAC to leverage future investment in the area of continuous crystallisation through increased collaboration and, also rebuild industrial crystallisation capability in UK academia. We have got significantly more. The financial leverage has been substantial.

"The centre has driven collaboration across the pharmaceutical industry in the manufacturing science area and has created a number of new collaborative opportunities.

"CMAC has had an impact both at a national and international level in this area and AZ has benefited substantially from being associated with the centre."

***Jon-Paul Sherlock**, Director of Product Development, US & United Kingdom, AstraZeneca*

DRUG DELIVERY PARTNERS

- GlaxoSmithKline
- AstraZeneca
- Novartis
- Bayer
- University of Strathclyde, Glasgow
- University of Bath
- University of Cambridge
- The University of Edinburgh
- University of Glasgow
- Heriot-Watt University
- Loughborough University

"We are taking technologies that we've worked on in a research perspective through into commercialisation. The UK pharma landscape has changed beyond recognition"

Craig Johnston, CMAC Industry Director

The Centre for Innovative Manufacturing in Continuous Manufacturing and Crystallisation (CMAC) led from the University of Strathclyde, Glasgow, is benefiting from high levels of capital investment as the UK enhances its world-class research into pharmaceuticals.

Among the concrete signs of success was the opening of the CIM in a £89 million National Facility within the Technology and Innovation Centre (TIC) building at University of Strathclyde this year. With the Centre for Process Innovation, CMAC is now working on a £50 million proposal to take its research to higher levels on the Technological Readiness Levels (TRL) scale.

CMAC is keeping manufacturing in Britain. "We are taking technologies that we've worked on in a research perspective through into commercialisation," explains industrial director Craig Johnston. "In the last few years, the UK pharma landscape has changed beyond recognition."

CMAC aims, through its research expertise and capex, to attract multinational pharma companies to the UK to manufacture within ten years. "It's fair to say these companies would not come to the UK without this ecosystem we have created: with it we are more likely to attract them."

The centre sees a multidisciplinary academic team delivering its applied research programme, which encompasses chemical engineering, operations management and pharmaceutical sciences. It features researchers in chemical and process engineering, materials chemistry, pharmaceutical science, informatics and manufacturing and operations management working together.

CMAC's research encompasses end-to-end manufacturing, including tools for rapid assessment of molecules, particles and formulated products, crystallisation and secondary processing. It is also working on the development of future supply chains.

CMAC is working with a broad range of drugs for example one research partner runs a specialist oncology division, while other projects focus on large scale pharmaceutical manufacture. It is also a partner in a £23 million Advanced Manufacturing Supply Chain Initiative (AMSCI) project called Remedies, led by GlaxoSmithkline (GSK).

In 2015 researchers from the CIM have been employed by companies such as Johnson Matthey, GSK, Mettler, Eli Lilly and AZ. Likewise CMAC has recruited expertise from outside academia from GSK and Delft. The CIM has started a new MSc programme, and also runs a Centre for Doctoral Training.

The AMSCI project benefits SME suppliers to big pharma by working pre-competitively, sharing information, for the benefit of business as a whole. CMAC is intended to make the pharma industry supply chain shorter and more efficient in a way that the automotive and aerospace sectors in Britain already

are. This has been led by the pharma industry and the government, and CMAC has been part of most of the significant activities, for example Cogent, the skills council for the process industries.

At Strathclyde university, CMAC is working on research projects which are expected to deliver in the short to medium term whilst also being heavily involved in strategic work with research projects that have a 10-20 year horizon. Johnston envisages the CIM operating through TRLs one to nine with equal effectiveness ultimately.

ART ATTACK

The centre has explored novel ways of spreading its message, including having an artist in residence, who exhibited in a national exhibition last year. It is actively targeting specific pharmaceutical products where there is an opportunity to develop new manufacturing technologies that may give greater access to medicines in the developing countries, as well as addressing the healthcare needs of the developed world.. It is working on anti-malarial treatments, as well as new drugs for HIV and cholesterol.

The centre has made major leaps forward in research in 2015. It has 49 research publications conference proceedings and has had a dedicated presence at conferences in manufacturing, crystallisation, flow chemistry and formulation.

The CMAC Doctoral Training Centre, which opened in October 2012, offers a world-class and multidisciplinary four-year training programme that will equip graduates with state-of-the-art skills in pioneering continuous pharmaceutical manufacturing processes.

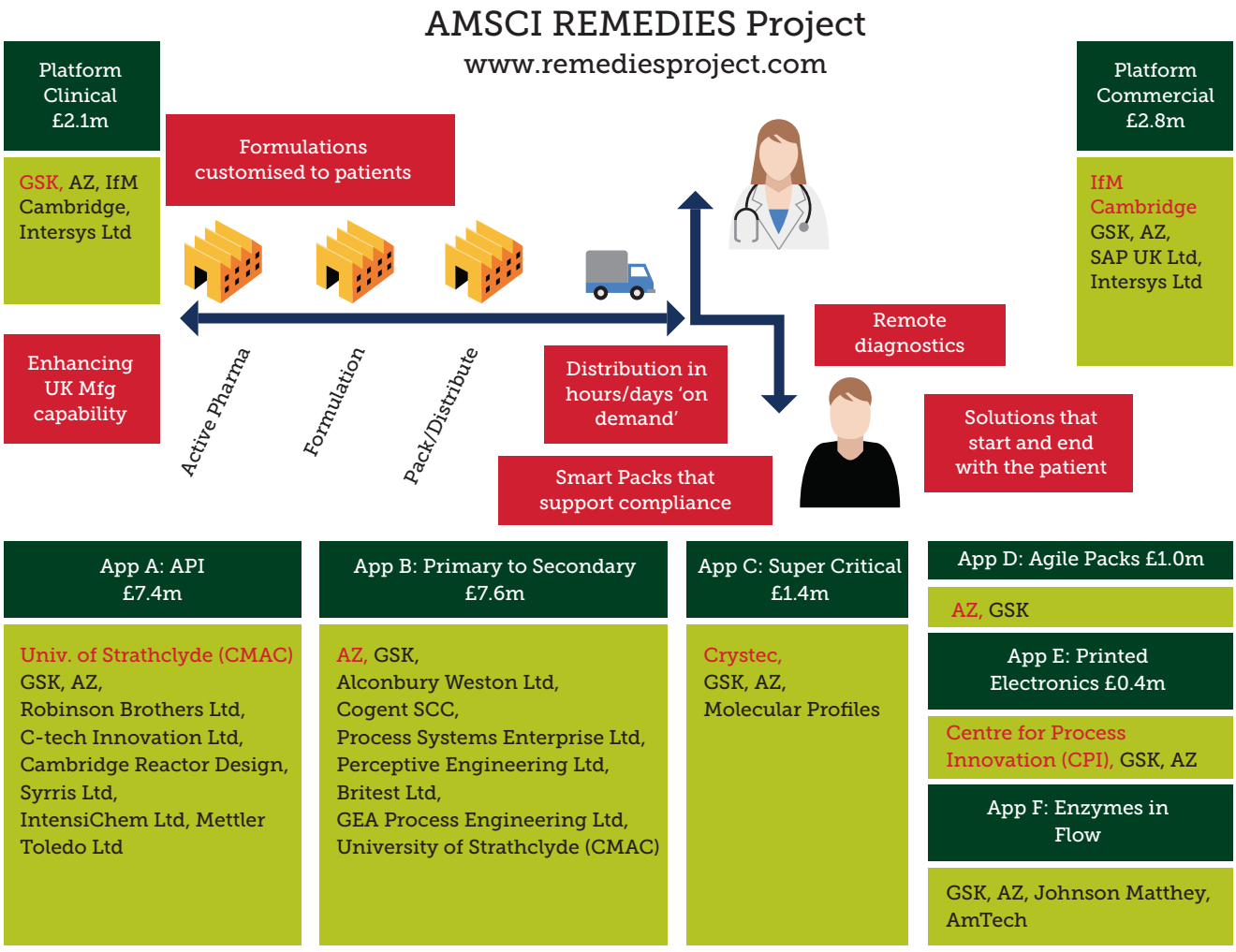
CMAC is part of Strathclyde's Technology and Innovation Centre which has the potential to help transform the city of Glasgow and Scotland. It could attract millions of pounds of inward investment to the city, drive global businesses, and create jobs.

"We believe that this project will be in the vanguard of exciting new investments that fully realise potential to capitalize on academic excellence, contribute to economic development and position Scotland as a major player in key sectors," says Sir Jim McDonald, principal of the University of Strathclyde.

CMAC is part of a vision that could re-position Glasgow as a cutting-edge city for technology and also help resuscitate its reputation as a major player in engineering.

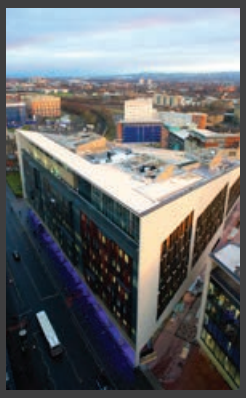
McDonald says: "But beyond that, this is about transforming the way we share knowledge and find solutions to challenges that affect every area of society – including energy, pharmaceuticals, manufacturing, and economics." UKMR-15

LINES OF SUPPLY: REMEDIES HELPS SMALLER FIRMS ACCESS PHARMA GIANTS



Royal flush: HM the Queen opens the £89 million Technology and Innovation Centre, Strathclyde, July 2015

CMAC HIGHLIGHTS, 2015



Bayer Healthcare joins as a new Tier 1 member

PwC, Siemens and Bayer Technology Services join Mettler Toledo, PSG, Perceptive and others as Tier 2 members

CMAC shortlisted for an award by IChemE

CMAC co-founds International Institute of Advanced Pharmaceutical Manufacturing

In September 2015, the first cohort of students from the novel MSc in advanced pharmaceutical manufacturing from Strathclyde. The 4th PhD cohort starts at CMAC, taking PhD numbers to 60

Professor Alastair Florence

CMAC CENTRE DIRECTOR, UNIVERSITY OF STRATHCLYDE

The last year has seen major developments across our centre's programme, spanning industry engagement, research, training, facilities and internationalisation. CMAC's industrial partnerships continue to flourish, underscoring the continued importance of our contributions to the UK innovation landscape.

In particular we welcome Bayer Healthcare, which joins GSK, AstraZenenca and Novartis as Tier 1 members of CMAC.

This highlights the community working together at CMAC to accelerate the adoption of advanced manufacturing technologies in pharmaceuticals, and other high value chemical products.

Our progress is rooted in the manufacturing research carried out by CMAC researchers across our academic partner network. It has been particularly rewarding to see many of these projects mature in 2015, leading to an increasing number of high quality research papers and conference papers emerging, a key step towards delivering impact from the engineering and physical science research at the centre.

We have also continued to develop our international partnerships in the US, EU and Singapore. For example, CMAC is one of the founding partners with C-SOPS (US) and RCPE (Austria) of the International Institute of Advanced Pharmaceutical Manufacturing. The new collaborative training and research projects being developed build on the complementary nature of these centres.

One of the most significant developments this year for CMAC is the move into the new £89 million Technology Innovation Centre for the centre team at Strathclyde. Opened by Her Majesty the Queen in July 2015, the building houses the new CMAC National Facility. This facility benefits from more than £12 million of investment from the UK Research Partnership Investment Fund, the Wolfson Foundation, and EPSRC, in state-of-the-art processing equipment and instrumentation.

We're exploring how these investments can provide benefits to the wider manufacturing research community.
www.cmac.ac.uk

Combining technology and human labour to reshore production

The EPSRC Centre for Innovative Manufacturing in Intelligent Automation (CIM-IA) is taking the idea of automation in manufacturing to a new level. Its work will allow companies that embrace its findings to increase productivity and create more highly-skilled jobs.

While the UK was at the forefront of the original Industrial Revolution, it now lags behind many rival markets in its adoption of a new generation of manufacturing processes including the adoption of mechanised, high-tech equipment such as production floor robots.

The benefits of automation are clear: robots can work faster, more accurately, and with a greater degree of precision than people. The car industry in the UK – led by Japan, which established Nissan's world-class car factory in Sunderland in the 1980s – has relied on robotics for decades in order to compete globally.

But automation has also had its shortcomings historically. While a series of physical actions can be replicated by a robot, the indefinable element of human skill and unobservable intelligence has been harder to imitate.

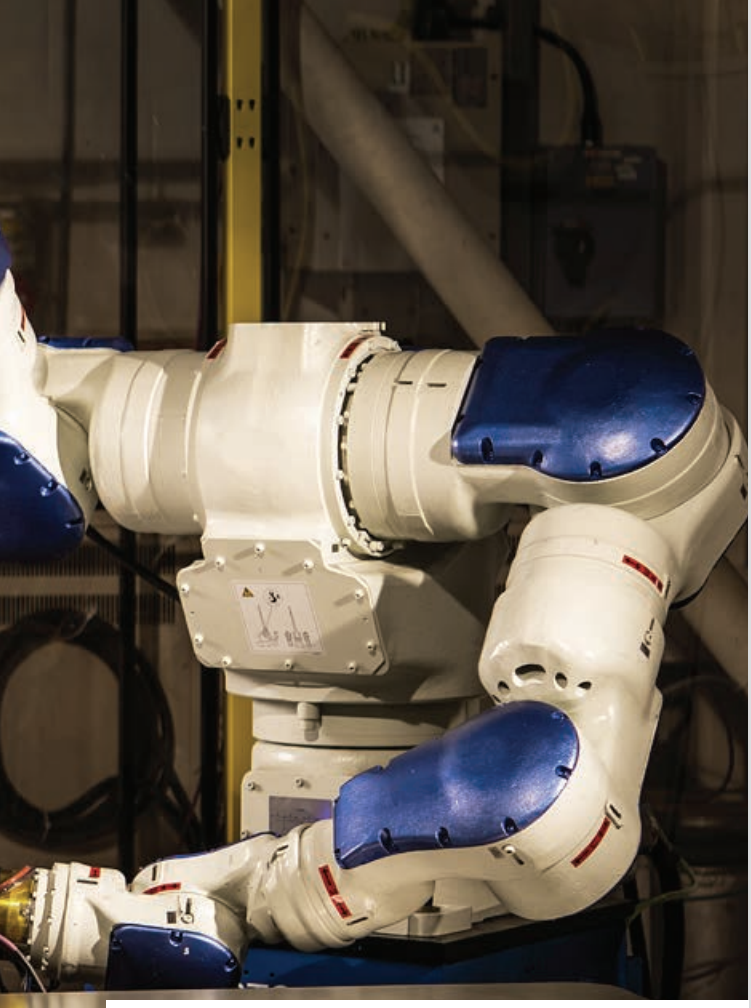
That is starting to change. Today, a new industrial revolution – dubbed Industry 4.0 – is underway. Manufacturing equipment and so-called robots can now be networked over the Internet to other devices.

In Germany, automation is being used to 'mass-customise' goods by linking the design capabilities of the Internet to manufacturing technologies. Higher degrees of automation are necessary here too, most agree, if the UK is to exploit its position as a resurgent, leading manufacturing nation in the next decade.

The Engineering and Physical Sciences Research Council's (EPSRC) Centre for Innovative Manufacturing in Intelligent Automation (CIM-IA), a collaboration between Loughborough University and Cranfield University which also encompasses industrial partners, including Rolls-Royce, Airbus, Controls and Data Services and the HVM Catapult via the MTC, is dedicated to helping ensure UK firms make the most of automation to compete in global manufacturing.

It aims to improve the effectiveness of manufacturing operations in key areas of UK industry, including helping small firms – which may struggle with the costs of adopting automation – determine whether it can help them be more productive.

At the level of cutting-edge research, the CIM is trying to automate manufacturing processes that have been thought of as too difficult to automate in the past. For example, aerospace manufacturers are exploring the possibility of automating highly labour-intensive tasks such as riveting aircraft wings in order to speed up aircraft production with companies such as Japanese automation firm Fanuc, which has its UK base in the West Midlands.



CIM is conducting work to help robots mimic the most sophisticated actions and decisions made by human operatives.

UNDERSTANDING THE HUMAN FACTOR

Robots and humans will increasingly work side by side raising many fascinating questions

Although human issues are critical to manufacturing performance, industry has prioritised development of technology more than it has tried to understand the work patterns and behaviour of humans.

But there is now a greater understanding of the ergonomic and human factors that improve efficiency as manufacturing organisations seek to improve commercially.

The Industrial Psychology and Human Factors Group at Cranfield, led by Professor Phil Webb, provides the expertise needed by individual organisations to address human-centred issues, such as scientific research and cutting-edge technologies to address a wide variety of industrial needs.

It has a designated team that has been set up to carry out human-centred research and consultancy, primarily within manufacturing industry. Most of its research to date has been conducted within the high value aerospace manufacturing sector, as part of the School of Aerospace, Transport and Manufacturing's Aero-structure Assembly and Systems Installation Research Group – of which Professor Webb is the leader.

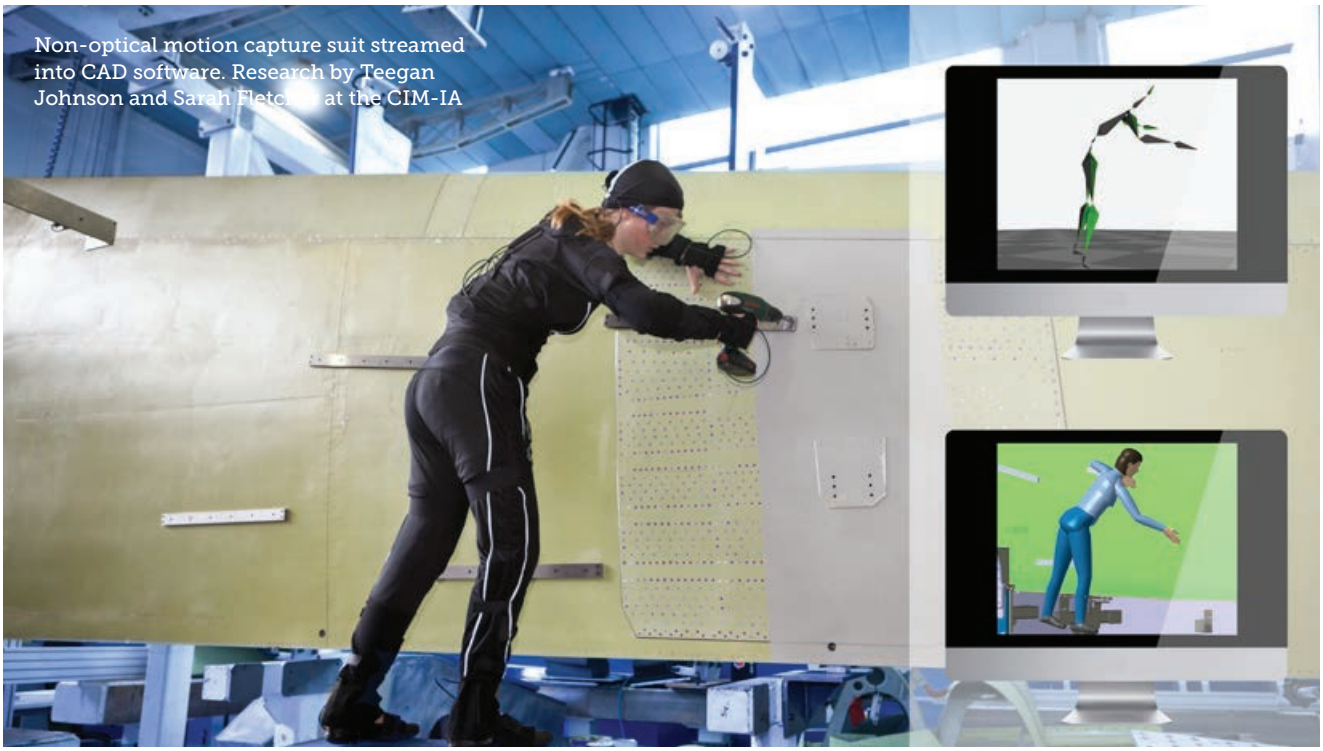
Additionally, the Cranfield group has conducted human factors research work that encompasses two key strands: 'human-robot collaboration' and 'human skills capture'.

The group's work is not restricted to any particular industrial sector, as we are well-equipped to apply a range of state of the art data collection and analysis capabilities in controlled laboratory or industrial settings including: computer aided design with human modelling and ergonomic assessment; eye tracking for analysis of visual behaviour, monitoring and response; industrial laboratory with jigs and tooling for experimental studies of human behaviour with products and processes in realistic shop floor work environments; and non-optical motion capture for measurement of dynamic body activity and static posture analysis in open and occluded environments.

It also looks at interactive physics simulation to impose real physical activities and motion capture directly into computer aided design modelling, as well as robot systems of varying types and sizes for simulation of collaborative industrial work within automated systems and analysis of human-robot interactions.

The programme recognizes that the success of any new technology is highly dependent on consideration of 'human factors' at the design stage and worker acceptance at implementation stage. As such, it is developing a greater understanding of the many physical and psychological issues that are important in the design and operation of shop floor robot cells which will share workspace with human operators.

For example, it has examined the aspects of design that affect human trust, situation awareness, cognitive workload and other important mental processes that need to be fully understood so that it can ensure the best designs are developed.



Non-optical motion capture suit streamed into CAD software. Research by Teegan Johnson and Sarah Fletcher at the CIM-IA

The aim of these big companies is to pass on their expertise to SMEs. “SMEs are benefiting from access to the sort of research they wouldn’t normally be able to get close to,” says Professor Mike Jackson, Director of the EPSRC’s CIM-IA.

He says that intelligent automation is a “combination of skilled worker and robot together”. The human worker gets more output – meaning more productivity – and greater levels of exports, potentially and thus a stronger British manufacturing economy in the long-run.

“It takes a lot of the stress out of the job and frees up the workers to spend more time on the difficult parts of the job,” says Prof Jackson. “The whole job is more productive. The primary reason for doing this is to bring manufacturing back to the UK and encouraging exports - this will have a positive long-term impact on the local economy.

“The jobs that are actually created are high-tech jobs. The robots will not be as intelligent as human beings, but they will be capable of making manufacturing industry much more competitive.”

WORKING WITH ROBOTS

Fully capturing the benefits of automation is not easy, however. The CIM-IA is working on a number of fronts to ensure that the potential of this sector becomes a reality.

For simpler automations, the benefits can be easy to identify in the form of time and cost savings and more consistent outputs. However, the CIM is also looking at ways of evaluating more complex, multi-step activities.

It is trying to help companies better estimate the potential benefit of automation and measure its realisation post-implementation. In addition to effort reduction, it is also seeking ways to better measure and evaluate other factors that can be improved such as human error rate, process compliance and system or service uptime.

The EPSRC Centre has worked with companies including Percussion Plus and Quality Furniture Company (QFC) where they have observed people at work in a manufacturing environment to understand whether their tasks can be enhanced by automation solutions to improve both operator well-being as well as production performance.

This moves the idea of Industry 4.0 into new territory again. Another key area of research lies in allowing robots to interact with humans without compromising safety. Such a mix can offer a combination of ingenuity and brute force that can be extremely useful.

Rt Hon Nicky Morgan MP visiting the lab at Loughborough University, that is part of the CIM-IA

Robots are being designed with special awareness to interact safely around humans

"The jobs that are actually created are high-tech jobs. The robots will not be as intelligent as human beings, but they will be capable of making manufacturing industry much more competitive."

Professor Mike Jackson, Director of the EPSRC's CIM-IA

But most manufacturing systems still rely heavily on human skill for the completion of production tasks. This is because it is very difficult to identify the human skills and activities the automation needs to replace or augment, and those which cannot or should not be transferred.

CIM-IA notes that whilst overt physical actions can be observed and replicated the unobservable and hidden intelligence applied in the performance of production task cannot.

The organisation is attempting to develop a formal methodology to capture both the explicit and 'tacit' skills deployed by operators, particularly during complex task performance, and to classify these skills for automation design.

The ambition strays into other challenges. Forms of automation are also being designed that feature sensory systems that allow robots to continuously monitor the position of shopfloor operators in order to work alongside them effectively, and safely. This means that conventional guarding systems can be removed, opening up new possibilities in terms of production systems.

In fact, for any arduous and repetitive jobs that can strain human workers, robots are an ideal replacement. In this sense, automation has a pronounced benefit in terms of improving manufacturers' health and safety culture.

Advancements in this field raise the interesting prospect of increased human-robot collaboration in the workplace, another area that CIM-IA is studying. It notes that for this to be possible, a deep understanding must first be established of how tasks can be divided between industrial robots and human operators to maximise the capabilities of both.

In collaborative mode, when both are working on the same process, the human can augment the capabilities of the robot or vice versa. However this should not simply be the allocation of the hard and complex tasks to the humans and the simple repetitive ones to the robots. To optimise this process a comprehensive methodology for task analysis and decomposition is being developed.

Such forward-thinking working practices raise other questions around both the design of the robot and the interface and also how humans react and adapt to such a shift in working practices. Research is being carried out within the Centre to establish ways of interacting with robots safely and effectively.

SPREADING THE WORD

Much of the research done by CIM-IA has now reached sufficient maturity for publication. Thirty journal papers have been published to date, a further 13 have been submitted, and around 40 are currently in progress. To date the Centre has attracted over £14.5 million in funding, including over £2 million of European projects.

The CIM-IA has also focused on encouraging young people into STEM, with a particular focus on automation. The CIM-IA provides substantial support through the First Lego League (FLL) programme, hosting local and national events, mentoring schools, providing equipment and demonstrating links between the automation challenges and real world manufacturing applications. With a skills shortage in intelligent automation, as in all other areas of manufacturing industry, work is vital to encouraging potential future engineers.

Secretary of State for Education Nicky Morgan MP presented her own award at the FLL National Final. Visitors are regularly hosted, with more than 100 external visits to date with an established programme of technical demonstrations and presentations to promote intelligent automation and to highlight key research streams to varied audiences from industry, academia and public office. Political engagement and strategy-setting are vital aspects of the CIM-IA role.

Prof Mike Jackson, Director of the CIM-IA, based at Loughborough University has been active in the Robotics and Autonomous Systems road-mapping and strategy workshops with Sir Mark Walport adn has contributed in person to the Dowling Review highlighting the benefits and challenges of working with the Catapult network.

As the UK looks to re-shore greater levels of manufacturing, a trend that has noticeably increased due to quality, cost and logistics issues over the past two years, the CIM-IA and greater levels of automation are expected to help, because they could help make British industry much more competitive.

Many of the technologies developed should enhance and maximise the use of the existing skill sets within the workforce rather than replacing them, thereby significantly increasing their cost effectiveness and competitiveness.

So it's not necessarily the case that increased automation means fewer jobs – in fact, at some small companies in the West Midlands' automotive sector, for example, it is allowing them to expand and take on more staff, because the latest machinery means they can take on work that would formerly have been out of range. This will require more technical apprentices. Here, help is at hand - in 2015 the CIM-IA's partner organisation, The Manufacturing Technologies Centre, recruited 48 engineering apprentices to its new Advanced Manufacturing Training Centre. They will learn skills relevant to this field of engineering, including informatics and mechatronics. UKMR-15

Pushing the boundaries

Printing with electronic links: This "super inkjet printer" can print very fine lines of electronic ink. The lens is part of a camera so researchers can see what the printer is doing

EPSRC CIM in Large-Area Electronics

LARGE AREA ELECTRONICS

Large area electronics provide a means of enabling growth in new high-volume consumer markets, and Britain has an edge when it comes to the technology

Large area electronics (LAE) – including printed, plastic, organic and flexible types – is a new way of making electronics that uses new manufacturing processes and materials to produce electronics with different forms and costs.

For example, LAE approaches can produce devices that emit or reflect light in a controllable manner, for displays or lighting and smart windows, or devices that transduce light, for sensing and photovoltaic energy generation.

It can make devices that sense a variety of physical, chemical and biological parameters, or transistor circuits, both analogue and digital; or energy harvesting and storage devices in a variety of thin and flexible formats. Ultimately, LAE-produced designs could provide the spur for innovation in high-growth markets in healthcare, automotive and wearable electronics.

It's an area where Britain has a lead, according to researchers at the EPSRC Centre in Large Area Electronics, based at the University of Cambridge.

"The UK has been a pioneer in the field of organic and printed electronics for more than two decades, from initial inventions in UK universities. Now we are seeing the leading companies scaling up key materials and processes and new device forms are moving into pilot production and on towards volume manufacturing," says Dr Mark Leadbeater, programme manager at the centre.

The UK has a broad range of companies active in LAE materials, processes and devices. It also has a very large electronic systems industry, in itself worth more than 5% of UK GDP and employing some 850,000 people.

Innovation in the four key sectors identified in an ESCO report – Internet of things, healthcare, robotics and autonomous systems, and industrial automation – will be critical in enabling the UK to grow its economic activity in electronic systems.

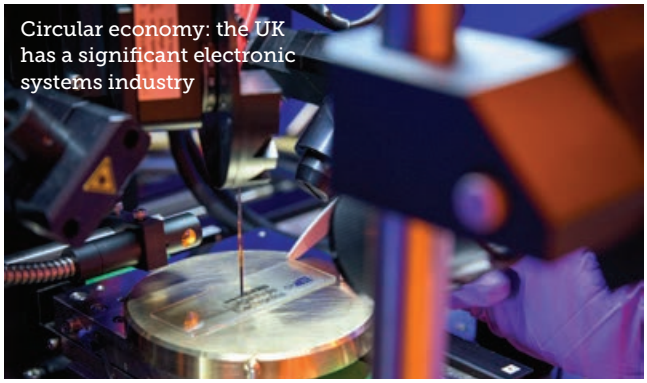
"We see the smart integration of electronic systems combining LAE and silicon as one of the innovation drivers that will enable this to happen," Leadbeater explains. It is the combination of LAE with traditional silicon-based production of electronics that will yield the best results, according to the centre.

MOVING ON UP

The EPSRC Centre for Innovative Manufacturing in Large-Area Electronics was set up in October 2013 with funding awarded by the Engineering and Physical Sciences Research Council to address the challenges of scale-up and

high-yield manufacture of Large-Area Electronics systems, incorporating multiple functional elements, and improving key manufacturing processes for enhanced performance.

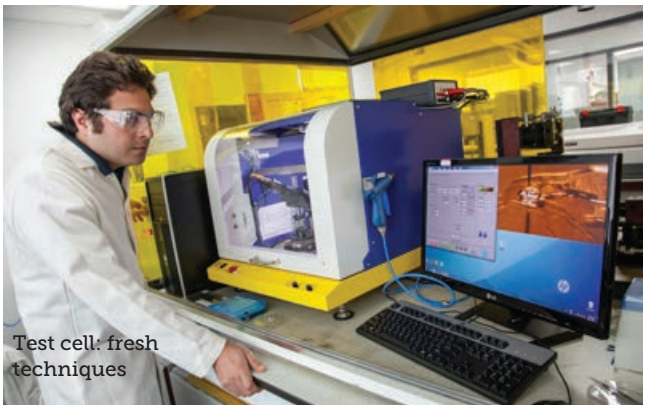
It works with a wide range of companies who are pioneering what could become an electronics manufacturing revolution, and with end-users who see its commercial potential, helping to establish what may one day become a vibrant new electronics systems manufacturing industry. The objectives of the EPSRC Centre are to address the technical challenges of



Circular economy: the UK has a significant electronic systems industry

manufacturing multifunctional LAE systems, and develop a long-term research programme in advanced manufacturing processes, aimed at reducing manufacturing costs and improving system performance. Technologies developed at the centre should be supported in the long-term if adopted by British industry.

The EPSRC LAE centre's operations team has many years' industrial experience in leading research and development teams, protecting intellectual property, setting up research



Test cell: fresh techniques

collaborations and providing technology for commercialisation.

Its researchers bring together diverse expertise and facilities from the four largest academic groups in the field of Large-Area Electronics in the UK, covering materials – organic and inorganic – light-emitting devices, photovoltaics, sensors, transistors, diodes; and manufacturing processes, including contact printing and non-contact digital deposition of all types. Several were among the early pioneers in the field and many have experience of commercialisation through spin-out companies.

Leadbeater says: "We welcome collaborative projects with academic and industrial partners from all over the world.

"Although our core EPSRC funding can only be spent at UK universities, we routinely use other funding mechanisms ,such as those available through Horizon 2020, for European collaborations, and Innovate UK, for British organisations, to enable other collaborations.

"We will also work on directly-funded projects with industry from any country." UKMR-15

INTELLECTUAL PROPERTY

Consultancy McKinsey reported in December 2014 that semiconductor executives believed the Internet of Things would be the most important source of growth for them over the next several year – more important, for example, than trends in wireless computing or big data.

For the LAE centre at Cambridge, the Internet of Things also represents a significant growth opportunity, due to the requirement to move electronics into a range of applications, where new form factor and cost structure become enabling.

This view is supported by global electronics companies. In the LAE sector, for example, we recently saw a major investment in UK company, PragmatIC Printing, by ARM, as part of an investment round led by Cambridge Innovation Capital.

PragmatIC has been a pioneer in demonstrating the use of flexible circuit technology in sectors such as consumer goods, security printing and wearable electronics, working with companies such as Procter and Gamble, De La Rue and Hallmark.

The investment will enable PragmatIC to scale up its flexible circuit production technology to 100 million circuits per year.

"Large-area electronics is now a significant and rapidly growing part of the trillion dollar electronics systems market.

"The UK is home to leading companies with plans to manufacture products across a range of LAE application sectors, including photovoltaics, lighting, electronics and components, displays and integrated smart systems.

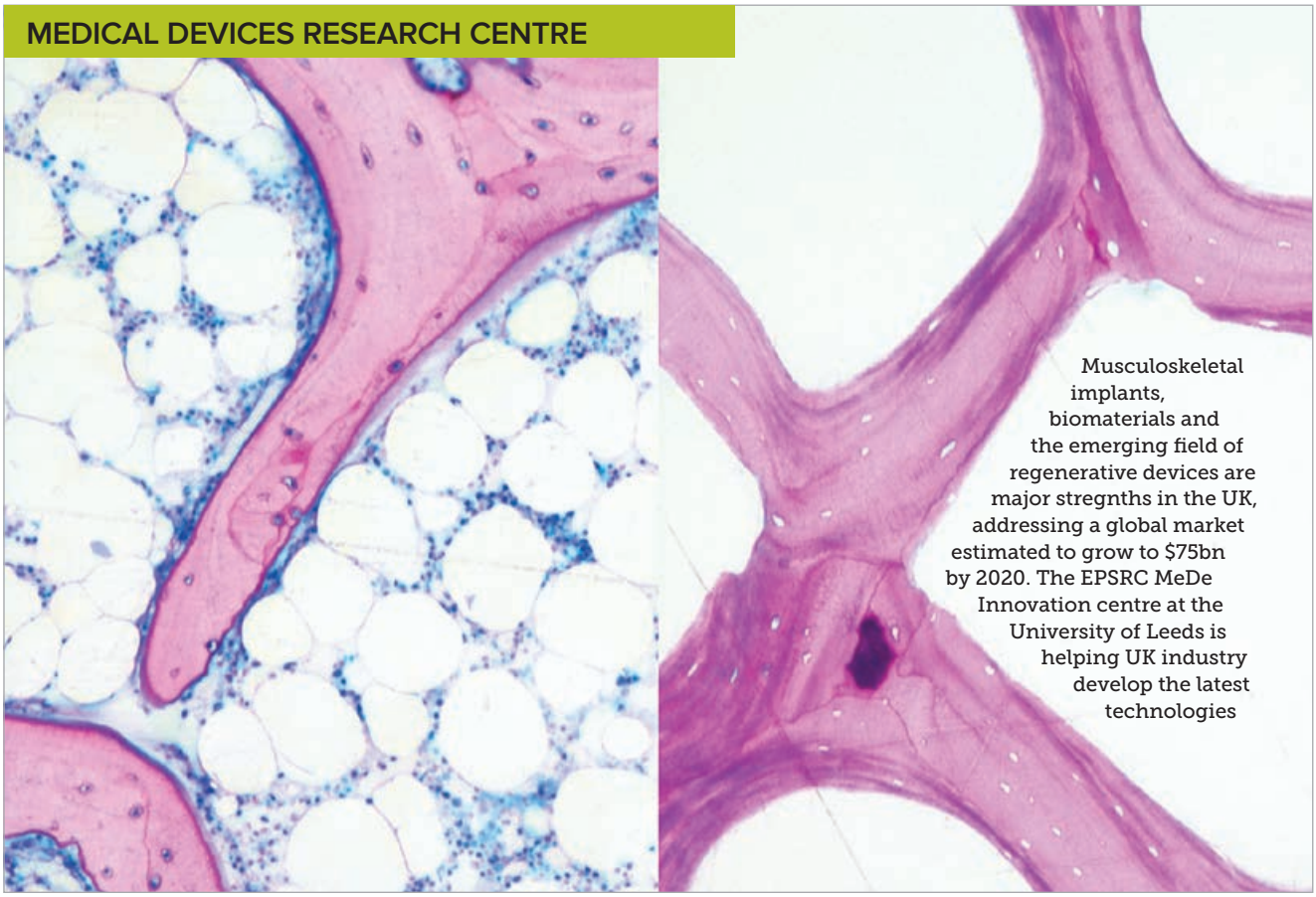
"Britain also boasts an impressive number of process equipment suppliers and materials suppliers, with recent licensing successes for advanced functional materials to global electronics brands.

"Looking forward, we expect to see the profile of the UK LAE industry change as a significant number of companies move from materials and process development into manufacturing"

- Chris Rider, LAE CIM director

Designs on the medical sector: Scaffolds, implants and joints at the Medical Devices innovation centre

MEDICAL DEVICES RESEARCH CENTRE



Musculoskeletal implants, biomaterials and the emerging field of regenerative devices are major stregnths in the UK, addressing a global market estimated to grow to $75bn by 2020. The EPSRC MeDe Innovation centre at the University of Leeds is helping UK industry develop the latest technologies

All photos courtesy of: MeDe Innovation CIM

Stratification and personalisation to help solve challenge of how to keep people fitter, longer

The EPSRC Centre for Innovative Manufacturing in Medical Devices – MeDe Innovation CIM – headquartered at the University of Leeds, is demonstrating how stratified and personalised design and manufacture processes could be used to address future demands on the medical sector. Here, technology will play a crucial role in enabling the healthcare system to cope with the demands placed on it by a growing and increasingly long-lived population.

The CIM is developing engineering solutions for two main areas of medical devices: implants, such as total artificial joints to replace damaged joints and surfaces with orthopaedic prostheses, and regenerative devices – known as scaffolds – that a patient's own cells can bind to, to regenerate and repair damaged tissue. It aims to improve the reliability and functionality of devices and to deliver customised medical devices where they are needed – or at "near patient manufacture".

To deliver this, the centre leads an international network of industrialists, academics, clinicians and regulatory body representatives, working together to translate the successful outcomes of the research into manufacturing practice in the highly regulated market of Class III medical devices.

The Centre was founded by the universities of Leeds, Bradford, Newcastle, Nottingham and Sheffield in partnership with 13 companies that included device manufacturers, simulation companies, materials manufacturing specialists, software companies and design companies. The partners committed a total investment of £1.9m, and since then the Centre has leveraged a further £50m through collaborative investment into its related research projects. There are now over 600 members of the network, with over 200 from industry.

"We have strong industry involvement and have been able to leverage investment and know-how from different sources," says Centre director, Professor John Fisher. "The centre has very strongly focsued strategic challenges that have been developed with our industry partners."

The Centre has launched its National Capability Database, an online searchable tool to connect potential partners to the unique capabilities that support innovative manufacturing of Class III orthopaedic medical devices: implants that require pre-market approval to ensure their safety and effectiveness.

Developing fracture fixation devices that can be reabsorbed over time at the University of Nottingham, part of MeDe Innovaton

Photo courtesy of: MeDe Innovation CIM

EXTERNAL AFFAIRS

Examples of adoption of MeDe Innovation Research by industry include:

> Advanced hip and knee joint simulation sytems that improve implant design and reliability. Collaborators are: **simulation specialists, Simulations Solutions; device manufacturers, DePuy Synthes; Jaiotong University in China; and distribution partners in Gaitech, Shanghai, China.**

> Natural knee simulators for predicting the function of novel regenrative devices. Collaborators are: **Simulation Solutions, NHS Blood & Transplant, and Tissue Regenix plc**

> The manufacture of fracture fixation devices that can be reabsorbed over time. Collaborators are: **Materialise, Promethean Particles, JRI Orthopaedics, and DePuy Synthes.**

Industry partners with the centre include:

- **Invibio**
- **DePuy Synthes**
- **Materialise**
- **JRI Orthopaedics**
- **Simpleware**
- **Simulation Solutions**
- **Ceramisys**
- **Fripp Design and Research**
- **NetComposites**

It has also partnered with high profile national events to access new potential collaborations, including the Arthritis Research UK Marketplace, Med Tech Innovation Expo, and the British Orthopaedic Associations Congress. Regular newsletters and web updates that highlight key achievements keep members engaged between other activities. And the medical technologies sector is growing rapidly - with an estimated 3,268 companies, generating an estimated turnover of £18.1 billion and employing an estimated 88,000 people across the UK – it is one of the nation's key growth sectors.

The methods for design and manufacture which MeDe Innovation has developed are being adopted within medical industry design and development programmes, and are helping to set enhanced international standards. The Centre is also assessing the varying demands of the UK and US regulatory environments with a panel of representatives from industry, regulatory bodies, academics and clinicians.

50:50 JOINTS AND REGENERATIVE DEVICES

MeDe Innovation divides its research approximately 50/50 between the artificial joints and bone structures, including hip and knee prostheses – implants; and scaffolds, or regenerative devices, an emerging and disruptive technology.

The MeDe Innovation centre has a memorandum of understanding with the Cell Therapy Catapult in London, where Hermann Hauser, the entrepreneur who devised the original model for the innovation centres under Gordon Brown's government, delivered his findings on their early stage performance to the media in autumn 2014.

Advances in medical technology can take years to find their way to the clinic and to patients, not to mention the high costs associated with developments, and significant commercial risks.

IN-CLINIC MANUFACTURE FOR PERSONALISED IMPLANTS

Another of MeDe Innovation's aims is to develop processes which are (where possible) minimally invasive and that can effectively deliver bioactive materials.

One of the major factors for novel surgical interventions is to decrease the anatomical injury at surgery, reduce hospital time for patients and accelerate the rate of recovery.

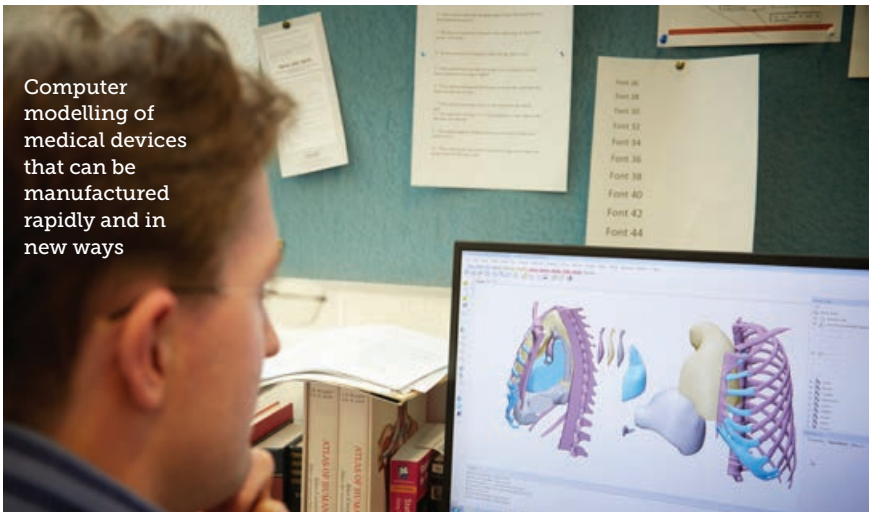
The last decade has seen significant growth in research into biofabrication, and many approaches have been developed. However many of these suffer from limita-

INDUSTRY VIEWPOINT

"We are experiencing a strong demand to innovate faster – the medical device sector is growing, plus patients are demanding earlier interventions and tissue preservation.

"We are working with MeDe Innovation to develop pre-clinical simulation equipment that takes into account patient, surgical and implant design variables that have the greatest influence on function, performance and clinical outcome. If the research is successful, we can offer this novel simulation system as part of our portfolio to clients."

Nick Eldred, Director, Simulation Solutions



Computer modelling of medical devices that can be manufactured rapidly and in new ways

tions, in particular in relation to structural materials being too soft to provide significant support in clinical applications.

The research challenge addresses defects in the musculoskeletal system as early as possible, through two approaches. Researchers are developing implantable devices that can boost tissue regeneration and restore function, which could have huge implications on repairing early stage joint damage. The research focuses on producing bioactive devices that are small and strong enough to be inserted in joints to carry out repairs using minimally invasive techniques.

"We've developed solid plug designs made from bioceramics that have been

Centre Director: Professor John Fisher CBE

"By introducing regenerative devices through the medical devices route, they can get to market with reduced risk, time and cost - and more patient benefit."

Mechanical engineer John Fisher spent 12-years working outside academia, initially in the automotive, defence and healthcare sectors. He holds a first class BSc in Physics from the University of Birmingham and a postgraduate certificate in design and manufacture at Preston Polytechnic. He also has a PhD in bioengineering at Glasgow University, and has received the CBE for services to biomedical engineering.

After 18-months of operation, MeDe Innovation had leveraged around £20 million of additional research income from both public and private sources. This included funding for a Centre for Doctoral Training, and money for equipment. In 2015 the CIM has attracted more than £1 million of direct industry funding.

Professor Fisher says the organisation has come a long way in a short space of time.

It started with five founding partners, all universities. There are now 150 external organisations engaged with the CIM. "The scaffolds we are producing can be used in combination with cell therapy, as part of regenerative medicine. They are translated as medical devices, which means they can get to market quicker," says Fisher.

"You use the patient's own cells to make the repairs, which means there is less risk. If you create new cells and introduce them to a host patient, it could potentially harm the patient. So the regulatory burden is bigger. We make scaffolds that a patient's own cells can bind to, to regenerate and repair damaged tissue."

He adds: "The scaffolds can be translated into commercial use as medical devices, whereas cell therapies are translated as advanced medical therapies and products."

Fisher adds that the translation period for regenerative devices is shorter and costs much less, so if you can introduce regenerative devices through the medical devices route, you can get them to market with reduced risk, time and cost and benefit patients much more easily.

"There is a very clear strategic challenge we are addressing, which is one of the reasons we have been able to leverage so much involvement from the sector. We are producing a lot of good research and we are recruiting a lot of new companies."

There are few large companies involved in biomedical manufacturing in the UK, he adds.

"The medical technology industry is composed of SMEs. We need to ensure they are world-class players, and to help them grow."

MeDe Innovation is working on new simulation methods for the design of knee prostheses

2015: MeDe HIGHLIGHTS

- The MeDe Innovation Centre is using microsphere technology to combat osteoporosis, a disease in which bones lose density and become brittle and fragile, which affects three million people in the UK.

- Researchers are working on a techique to regenerate osteoporotic bone

evaluated in vitro," says Professor Kenny Dalgarno from Newcastle University, the deputy director of the centre. "We plan to carry out further pre-clinical tests during the next 12-months to understand more precisely what happens after the plugs are implanted."

Researchers led by Newcastle University are also advancing bone and cartilage implants that can be adapted for individual patients, to deliver successful and longer-lasting outcomes. Although the technology to do this is already available, the processes are time-consuming and costly.

Through MeDe Innovation, researchers are working on different methods of combining cells and biocompatible materials that clinicians can use closer to the patient, saving time and money.

"We've developed a method of printing cells onto scaffolds to make a device that can be implanted in the patient to promote tissue growth," says Professor Dalgarno. "Our aim is to produce implants that could be adapted to precisely fit in each patient." UKMR-15

BETTER BONES BY DESIGN

One of MeDe Innovation's aims is to deliver new simulation methods for the design and manufacture of hip and knee prostheses, evaluated through two design and manufacture case studies.

The resulting designs are intended to accommodate patient and surgeon variability, delivering greater reliability in a cost-effective manner.

This project has three research challenges: to develop models characterised by variations in geometry, properties, surgical delivery, and activities of the patient population.

It will also develop simulation models predicting biomechanical and bio-tribological function, and apply these new approaches to hip and knee prostheses.

The projects define models of hip and knee anatomy, geometry and properties, compatible with engineering design systems which characterise both the eastern and western patient population, and the variation in surgical positioning of artificial hip and knee joint components in these patients.

The projects will then develop a set of biomechanical and kinematic inputs for hip and knee joint replacements for a variety of different activities – control, standard walking, stair-climbing and descent, and rising from a chair – through collaborations with Leeds, North America and China. Using these inputs, Leeds is developing finite element models to predict the biomechanical and biotribological function of the joint replacements, for a range of activities and surgical positions.

They intend to experimentally validate functional predictions, with evidence from patients and tissue specimens. This work will result in a validated toolkit of stratified pre-clinical simulation methods, which will functionally differentiate the design and manufacture of new prostheses, the application of which will be demonstrated through case studies.

Researchers at Leeds will also define parameterised models for natural hips and knees and characterise variations in anatomy, geometry, material properties, surgical delivery, and patient activities. The ultimate aim is a systematic design methodology consisting of parameterised models, data and simulation systems, to predict function, which can be adopted as an international standard by manufacturers, and their supply chain.

EMERGENT MACROMOLECULAR THERAPIES

Cellular science for growth industry

CIMEMT specialises in developing unique, new biologically-based medicines for patients worldwide, backed by one of the leading research universities in the country

A biopharmaceutical, also known as a biologic medical product or biologic, is any medicinal product manufactured in, extracted from, or semi-synthesised from biological sources.

The UK biopharmaceutical sector comprises 250 companies and a workforce of 10,000 – part of a supply chain involved in research, development and manufacture.

The global biopharmaceutical industry is currently worth more than £90 billion, and growing by 15-18% a year, according to research conducted by BioPlan Associates.

There are more than 300 approved biopharmaceuticals on the market, and seven out of the 10 top-selling drugs in 2014 were biopharmaceuticals.

There is now a clear shift in the focus of medical intervention, with an increasing emphasis on the production of 'stratified medicines', or drugs focused on the treatment of smaller patient populations.

This approach to stratified medicines poses extra challenges to improve the speed and cost of development, as well as the cost of manufacturing.

In 2011, University College London established a Centre for Innovative Manufacturing (CIM) in Emergent Macromolecular Therapies, with funds from EPSRC, and a consortium of companies and trade associations. The CIM is based at the Department for Biochemical Engineering, which won a 2012-2014 Queen's Anniversary Prize in recognition of its 'outstanding excellence'.

The CIM addresses business pressures to contain costs, and increase the uptake of new drugs. Regulators are pushing for biopharmaceuticals to embrace quality by design to achieve greater process understanding, and mitigate safety concerns arising from product variability.

In risk averse regulatory and investment climates, tools to prioritise candidates with respect to clinical efficacy and manufacturability, and aid in determining the most cost-effective production methods, have a major positive impact on investor perception, increasing private sector investment, and sustaining the buoyancy of the industry over a sustained period.

Research at the CIM is directed to delivering tools that enable engineers and scientists to characterise biopharmaceutical candidates for their manufacturability at an early stage in the development lifecycle.

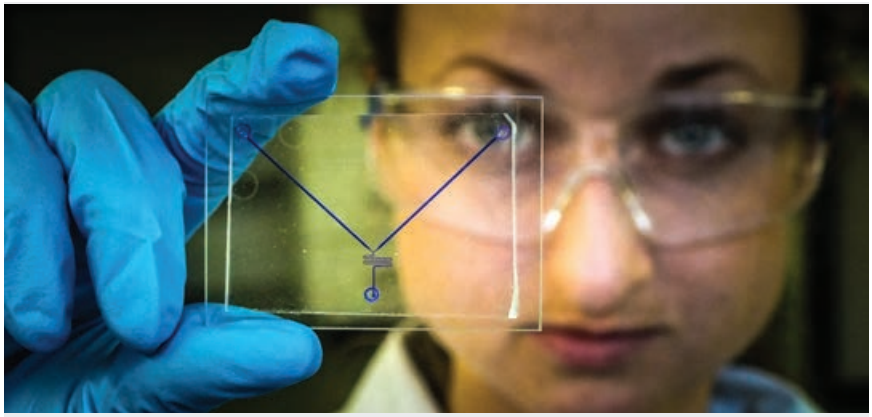
These quantitative methods provide crucial metrics on each candidate drug for example the susceptibility to shear and aggregation.

It also focuses on tools based on simulation and modelling to accelerate and optimise process design, understand facility fit issues and support strategic decision making. Frequently, companies have to select suitable process and operating conditions, reflecting a balance between costs of goods and ease of operation.

The decisional tools provide that framework and a capacity to pose 'what if' scenarios as the candidate progresses towards market. The centre's vision is a holistic one so it considers not only the

"The integration of science, engineering and health economics is vital to develop affordable drugs for the NHS" - Nigel Titchener-Hooker, CIM director

ELISABETH'S STORY



Elisabeth Kastner started her CDT project in September 2012 at Aston, on the formulation design and manufacture of novel vaccine adjuvants, supervised by Professor Yvonne Perrie. The focus of the project is on the development of microsomes for delivery of vaccines, particularly against tubercolosis.

Elisabeth already had good links to the biochemical engineering department at UCL having studied there for her MSc. The potential to use microfluidics for microsome manufacture was recognised early in the project and she subsequently spent time in the lab of Professor Nicolas Szita at UCL to investigate various microfluidic processes.

Nicolas Szita was coopted as the second supervisor on this CDT project, and Elisabeth is a visiting researcher in Nicolas Szita's laboratory while principally based at Aston.

As part of her project Elisabeth has demonstrated the proof of concept of using continuous manufacturing with a microfluidic mixer system for manufacture and purification of nanoparticles. The initial scale has been verified and has high industrial applicability.

Elisabeth spent one month working at Precision NanoSystems in Vancouver, Canada. The company works on the manufacture of novel nanoparticles, or nanomedicines, which are used for cell-specific delivery and targeting to treat diseases.

The work at Precision NanoSystems comprised testing developed microfluidic-devices used for a rapid and controlled assembly of nanoparticles.

The technology was evaluated in a scale-up platform based on microfluidic reactor parallelization in a continuous-flow system. The evaluation of these liposomal systems for tuberculosis vaccines is being carried out by Aston University in conjunction with SSI in Denmark; this work is ongoing.

The collaboration between UCL and Aston has grown stronger and a second CDT project started in September 2015, again under the supervision of Yvonne Perrie and Nicolas Szita.

HIGHLIGHTS 2015

February 2015
VISION briefing: personalised medicine only for the lucky and the privileged few? Likelihood of change?

June 2015
Gene Therapy Viral Vectors and Therapeutic Vaccines Workshop, in conjunction with the Knowledge Transfer Network

August 2015
Centre hosts delegation from the US National Institute for Standards and Technology, and initiates UCL secondment to NIST

issues of manufacturing the active ingredient but also how it is formulated, delivered and administered to the patient.

"This integration of science, engineering and health economics is vital if drugs are to be developed for the NHS at an overall cost that is affordable," explains centre director Professor Nigel Titchener-Hooker.

Dissemination of the centre's work in the community is assisted by user demonstration projects, fully integrated with the centre's research vision. Collaboration is key and includes international links for example with partners in Austria, Mexico, the US and in India.

Closer to home, training and research links are being implemented with the HVM Catapult, and the newly-constructed National Biologics Manufacturing Centre.

An EPSRC centre for doctoral training was established in 2012, closely aligned to the centre to train the next generation of highly skilled bioprocess manufacturing researchers. Sixty-eight per cent of the current CDT projects have been awarded directly to external institutions.

This is a key mechanism for building future collaborations and, ultimately, a stronger UK research base in manufacturing research for biopharmaceuticals. The centre's researchers have developed simulation and modelling tools to include advanced optimisation capabilities based on novel genetic algorithms.

The optimisation framework can search a very large range of potential process combinations in silicon, quickly, and identify the most promising process setups, avoiding the cost of extensive lab/pilot investigations. The function is capable of optimising multiple conflicting objectives, such as the cost of goods and purity targets, by tuning several process decisions. These include the sequence of unit operations and equipment sizing, while accounting for process constraints and uncertainties.

These are challenging problems which are difficult to tackle by standard mathematical optimization approaches. "Two companies from the user consortium, MedImmune and Actavis, have investigated applying the optimisation tool to designing and selecting optimum chromatography configurations, that will yield the most cost-effective manufacturing process," explains Professor Titchener-Hooker.

The results confirm that the optimisation tool provides insights on the trade-offs between different process options and objectives, and can be used to steer process development and reduce experimentation required. UKMR-15

Big industry: enough for everyone?

CIM FOOD

Building the capability for resilient and sustainable food manufacture: the EPSRC Centre for Innovative Manufacturing in Food is providing the food industry with innovative food materials, products and processes

Food and drink manufacturing is the largest manufacturing sector in the UK. With a turnover of more than £76 billion, it contributes £21.5 billion of GVA to the UK economy – almost equivalent to aerospace and automotive combined –with exports worth £12.8 billion and salaries in excess of £10 billion.

Through employment of up to 400,000 people, food manufacturing is a valuable asset for the UK, both through a vital and holistic contribution to the nation's well-being, and through a valuable export contribution.

The EPSRC CIM in Food is a collaboration between the universities of Nottingham, Loughborough and Birmingham, and was established in December 2013 to address these challenges, with a focus on manufacturing activities post-farm gate to supermarket shelf – and more specifically the implications these activities have towards resource efficiency and sustainable production.

Food production is massive but researchers want to make it sustainable

In the food sector, innovation often deals with the adoption of new technologies to respond to different challenges: production of stable food products, new functionality and added value. Recently a great deal of focus has been given to innovation in food and nutrition, enabling the development of advanced materials with unique textural and active properties.

The industrial implementation of such technologies, as with our research into encapsulation, targeted delivery and release systems, led by Professor Ian Norton's team at the University of Birmingham, will require faster translation of scientific results into high-value applications, as well as using scientific advances from other disciplines.

The EPSRC Centre for Innovative Manufacture in Food aims to develop new manufacturing capabilities to deliver on the environmental, economic and social sustainability agendas, an area led by Prof Shahin Rahimifard at Loughborough University.

The Centre brings together expertise in the areas of biomaterial science, formulation engineering and sustainable manufacturing in a unique and multidisciplinary approach to address and stimulate the food manufacturing agenda of the future.

By driving business growth and bringing together the national SME and global food community, the CIM enables the training and development of thought leaders.

OPTIMISING FOR RESILIENT AND SUSTAINABLE FOOD MANUFACTURE

The rapidly increasing world population (the UK population is predicted to grow by around 15% by 2030) changes in demand, and dietary behaviours both within developed and developing countries, and loss of arable land linked to climate change, urgently demand a need to change the way we grow, manufacture and consume our food products.

The Foresight Report (see box-out) clearly highlights the need for new science and innovation for the containment of resource-intensive types of food and minimisation of waste in all areas of the food system, providing long-term sustainability in production and consumption.

One of the most prominent challenges commonly acknowledged by modern manufacturing industries is, 'how to do more with less' – sometimes referred to as the productivity puzzle. Nowhere is this truer than in the food sector, due to well-documented concerns regarding the long-term availability and security of food resources.

Current research activities focus on identifying not only new sources of material, but also reducing the demand on existing resources, through a simultaneous consideration of food products, processing methods, and supply networks.

In this context, therefore, some of the key research questions are: how do we use material currently discarded as waste,

The Foresight Report on 'The Future of Food and Farming: Challenges and Choices for Global Sustainability' says that, "the case for urgent action in the global food system is now compelling.

"We are at a unique moment in history as diverse factors converge to affect the demand, production and distribution of food over the next 20 to 40 years.

"The needs of a growing world population will need to be satisfied as critical resources such as water, energy and land become increasingly scarce. The food system must become sustainable, while adapting to climate change and substantially contributing to climate change mitigation."

HIGHLIGHTS 2015

- **Free membership is introduced for industry interested in engaging with the CIM**
- **Healthier food products are designed and manufactured through new formulations and processes**
- **We are introducing new ways of understanding the fundamentals of food waste and how it can be minimised / valorised**

Material preparation and analysis is critical in food engineering research

such as biomass, as a new source of raw material in food production?; how can we design and prepare food products with the high nutritional values using fewer raw materials?; how do we measure, monitor and ultimately minimise the energy and water consumption per unit across the entire supply chain of a product?; how do we improve the efficiency of food production processes, as through improved automation and smart technologies to consume fewer resources, such as materials, energy and water?; and, how can we eliminate the production and post-production waste caused by inefficient supply and manufacturing activities and or relationships?

It might be thought that 'global food security' is about growing more crops and increasing global production output. However, improving distribution, increasing the productivity, and reducing waste though a range of initiatives such as enhancing food supply, better network planning of outlets and

Professor Tim Foster

CENTRE DIRECTOR

Professor Tim Foster, Director of the Centre for Innovative Manufacturing in Food, says the CIM's approach to redesigning the food supply chain is through producing healthy, nutritious and sustainable food.

"Our Centre aims to develop a fundamental understanding of the soft matter and physics of food structuring, to predict the retention and delivery of key nutrients, including the triggered release of micro-nutrients, in the GI tract.

"The design of low energy density foods, for enhanced food function, is being pioneered by research at the CIM." Foster explains that the nature of the CIM allows the exploration, design and development of novel food structures and manufacturing processes, an activity that wouldn't normally be exercised by industry – to this level – due to the extreme cost: risk ratio associated with challenging existing methodologies and practices.

"In order to engineer sustainable processes to create food structure fit for purpose, be it nutritional value, optimal nutrient delivery, palatability or acceptability, there needs to be a better understanding of the interplay between food components and the manufacturing processes.

One approach we are taking is designing multifunctional particles from supra-molecular structures to provide stabilising, encapsulating and texturising properties for both food and pharmaceutical systems.

These food-safe particles are being produced through the electrostatic complexation of biopolymers from sustainable materials, using whey protein – a co-product of cheese

manufacturing – sugar beet pectin, a residue from the sugar extraction process, and chitosan, a derivative of crustaceans.

Another approach is by challenging traditional food creation processes through modelling and simulation, and unearthing more efficient uses of ingredients and food materials – particularly in the context of novel food sources, food processing, and managing food waste. For example, structuring foods made with novel ingredients to increase their acceptability to the consumer would require multidisciplinary working.

Busy modern lifestyles are necessitating the need to change how we traditionally prepare food; consumers are demanding new ways to make the foods they eat more customised to their own and their household's needs and eating patterns, ultimately reducing the food they need to throw away.

Work undertaken by the Centre into advanced drying techniques in foods, such as supercritical CO_2 and microwave vacuum drying, is a route to a step change in on-demand edible products.

The team is conceptualising and developing new formulations that can be dried to prolong shelf life, that on-demand can be returned to familiar products with the flavour and/or mouth feel that is desired. In the future this technology could be used not only to meet regional variations but also in-home variation, simply by stirring in cold water.

But the CIM is well equipped, says Foster: "Our Centre now comprises a diverse team of nine academics and 20 researchers, with disciplines ranging from materials and particle science, chemical and electrical engineering, food science, nutrition, personal care and pharmaceutics. The culture at the CIM is to encourage cross-team collaborations to stimulate ideas for next generation projects and to develop future leaders in the sector.

"The Centre is making real headway into the resilience of the UK's food manufacturing capability, and our network members are supporting our progress through guidance, direction and collaboration.

"Further areas would include mapping of behaviour drivers, their variability within society and between individuals and how the UK population maps onto a global environment and how these paradigms may change in the future.

"This may include issues related to both access to food, and foods personalised for preference or need, necessitating new manufacturing paradigms and supply chains."

These studies would also complete the circle of the food economy linking consumer and population behaviour to the future challenges of manufacturing.

REDESIGNING BISCUIT MANUFACTURE

Biscuits are baked products made principally from fat, sugar and flour. Some of their important characteristics are long shelf life, their status as convenience food, consumers' liking for sweet foods, and their good value, which contribute to their success. Biscuit manufacture has evolved to reduce the labour input throughout the process; however, no major changes have been made to the baking process itself.

The traditional way of baking biscuits is through oven manufacture. The Food CIM has developed another means of manufacturing biscuits. Instead of using a traditional baking process the researchers have experimented with the use of a heated press. This combines the use of a thermal treatment with applied pressure, enabling the moulding of the product between two heated plates.

The main advantages for making biscuits with a heated press are the potential for removing water in the formulation of the dough, and the reduction in processing time. In this study, the biscuits were made with a variety of recipes and different process parameters, in order to fully understand the effects.

The results have demonstrated the potential use of the heated press as an innovative method of processing a well-known product. More research is required to fully understand the process and efficiency of this new method, but with support from our industry collaborators, we are already starting to apply this technology to some of our favourite household food products.

distribution to maximise efficiency and improved resilience, utilisation of new materials and biomaterial processing, multiple use of crops/waste streams and novel processes to minimise water and energy requirements, are all equally important considerations upon which the future of the food sector must be founded.

MEETING THE CHALLENGES OF GLOBAL FOOD SECURITY

The global food manufacturing model is being reassessed and the UK needs to be at the forefront of the next generation of sustainable production of more natural and healthier foods, where it is important for Britain to develop more resilient supply chains.

There is also additional pressure coming from the use of land and crops for a new generation of biofuels around the globe.

This has led to crops being grown on land not previously used for food production, and intercropping of under-utilised crops. The conversion of these materials into the food we eat is not straightforward, and therefore new processing technologies are needed to both convert the crops into food, and to maximise the utilisation of the biomass grown; this is the bio-refinery approach of valorisation of waste streams.

The Food & Drink Federation's shared vision for the UK food and drink industry is to deliver sustainable growth of 20% by 2020, and food security, by seeking to improve productivity and strip out unnecessary costs in order to stay world-class in product and process innovation, while being proactive in responding to key societal challenges such as obesity and climate change.

"Our vision is for the EPSRC Centre to meet the challenges of global food security through developing world-leading technologies, tools and leaders, tailored to meet the needs of current challenges while redesigning resource-efficient and sustainable, nutritious foods of the future."

Our involvement with the policy influencers such as the Food National Technology Platform (NTP) and the Food Knowledge Transfer Network (KTN) Food Group, our connections with other CIMs (Industrial Sustainability, Additive Manufacturing) and Centres (Centre for Sustainable Energy Use in Food Chains, the National Centre of Excellence in Food Engineering), and our engagement with the translators such as the Manufacturing Technology Centre, the Institute of Advanced Manufacturing, the National Formulation Centre, via the Centre for Process Innovation, and Campden BRI, enables the food CIM to translate its research into technologies needed by industry. UKMR-15

EPSRC Centre for INDUSTRIAL SUSTAINABILITY

The 4th Annual EPSRC Centre for Industrial Sustainability Conference, July 7-8 2015

Prof Steve Evans, Dr Graham Hillier of CPI and HVM Catpult, and Catherine Tilley of CISL discuss policy, leadership and the future of manufacturing

Lively networking and discussion are a feature of the conference exhibition

Delegates have the opportunity for in depth discussion of the Centre's sustainable business tools with the researchers who developed them

An essentially cleaner, greener and leaner industrial future

The EPSRC Centre for Industrial Sustainability is working to make British manufacturing viable in the long-term by eliminating wasted energy, water and raw materials while realising value.

A clothing mountain to climb: One of the Centre for Industrial Sustainability's main projects is working with companies including Marks & Spencer and Elvis & Kresse to reduce the enormous wastage in the clothing industry

Image: Shutterstock

Now and in the long-term, manufacturers face challenges involving the sustainability of their operations, such as access to raw materials, reliable energy supplies, global warming, and developing cleaner technologies and processes. Simultaneously they must find ways to reduce costs and find more value.

The EPSRC Centre for Industrial Sustainability operates from four universities – Cranfield, Cambridge, Loughborough, and Imperial College London, which are leaders in sustainable manufacturing research. It is helping to develop a more resilient manufacturing sector that is also able to meet the needs of future generations without compromising sustainability.

UK manufacturers are facing challenges to the future supply of critical materials, which may threaten national security. Despite some progress over the course of the last Parliament, policy-makers and engineering businesses are often unaware of the use and availability of certain Critical Raw Materials (CRMs) in their supply chain.

NECESSITY: THE MOTHER OF SUPPLY CHAIN INVENTION

These materials are necessary for the production of countless items crucial to the UK economy and maintaining our current way of life, such as smartphones and computers. Indeed, society's basic infrastructure is dependent on such products. But according to a 2012 EEF survey, 80% of senior manufacturing executives consider limited access to raw materials as a business risk and a threat to growth, and many identify it as the top risk they face.

PROFESSOR STEVE EVANS

CENTRE DIRECTOR

The director of the EPSRC Centre for Industrial Sustainability, Professor Steve Evans, champions the cause of sustainability in public forums including an interview on BBC R4's *Today* programme in October 2015 to discuss the planned mothballing of Tata Steel operations in Scotland.

He has also advised the coalition government on industrial strategy and was on the lead expert group for the previous government's Foresight Report, *The Future of Manufacturing*.

"Long term, industrial sustainability is the ability to provide the goods and services that we need, and supply them to everyone on the planet – within the limits that the planet provides. In the short-term, we in the UK have to learn how to do this using less energy, less water, and less materials."

This can involve looking at a manufacturing company's entire value chain, from the way in which a company designs and manufactures goods to the way which it creates value for customers. "Why do we work with companies such as Marks & Spencer? Retailers move products and bring them in front of customers. With M&S we are trying to investigate new ways of ways of getting products to consumers so all the material used by M&S comes back into the supply chain." The Centre aims to rescue 50% of the material that would otherwise end up in landfill through the project.

"I am incredibly excited by the idea that UK manufacturing can be made more efficient and resilient," Evans says. "If we can save five billion in terms of energy costs, water and raw material costs, that is five billion on the bottom line of UK manufacturing.

"If you do that, people have to buy our products because they are greener than anyone else's. If you do that, then UK manufacturing becomes more resilient."

4TH INTERNATIONAL SUSTAINABILITY CONFERENCE, JULY 2015

The EPSRC Centre for Industrial Sustainability held its Fourth Annual Conference at Fitzwilliam College, Cambridge on July 6-7.

The two-day conference, attended by 165 people, included a mix of presentations from industry and academia with an exhibition of tools and research projects developed for industry by Centre researchers and industrial partners.

Keynote presentations were delivered by Ramon Arratia, sustainability director at Interface, Sanjeev Bahl, president at Saitex, Professor Gunther Seliger, chairman at Technischen Universität (TU) Berlin, and the Centre Director, Professor Steve Evans [see profile].

The event also featured presentations by centre members, including Toyota, Unilever, Marks & Spencer, the manufacturers' organization EEF, as well as partners such as the United Nations Industrial Development Organization, University of Ulster, High Value Manufacturing Catapult, Centre for Renewable Energy Systems Technology, IfM Education and Consultancy Services, and many researchers and academics from the universities of Cambridge, Cranfield, Imperial and Loughborough.

Highlights of the conference included:

- Over 40 different business, 15 public sector or industry organizations, and 20 universities represented
- Attendees include representatives from multi-nationals, SMEs and start-ups as well as consultants, policy makers, third sector organizations and academics
- Focused sessions on Efficiency, Systems and Business Model Innovation, Remanufacturing and Recycling Technology, and Industrial Sustainability Policy

The discussion in the evening at the conference dinner included a talk from Barry Sheerman MP, the Labour and Co-Operative MP for Huddersfield. Sheerman is co-chair of the All-Party Parliamentary Design and Innovation Group, and a member of the Design Commission.

According to think tank Policy Connect, China is by far the largest producer of CRMs, and is constantly expanding its control of mining operations around the world. Unlike the US, Japan and Germany, the UK does not have a strategic plan for protecting its own access to crucial resources. In the face of geo-political uncertainty and the internationalisation of vulnerable supply chains, the national security of the UK could be under threat. The sustainability of materials, especially in terms of recycling and waste reduction, is more critical than ever.

In its five years of operation, the Centre for Industrial Sustainability has engaged with a wide range of UK organisations to promote the optimised use and reuse of resources, including Airbus, Toyota and Unilever, as well as many smaller manufacturers. It has developed simulation and modelling tools, which enable engineering firms to analyse ways in which they waste resources including energy and materials, and cut back on expenditure as a result. These tools can help, for example, precision engineering firms to reduce the use of coolant and recycle swarf more effectively.

Efficiency projects based on research by the Centre have increased, with new energy-saving projects implemented in 20 UK SME's , Toyota, and flooring and wall cladding company Altro, as well as utilisation of novel efficiency simulation

PART OF THE FURNITURE IN THE CAPITAL

Photo courtesy of Vitsoe

Vitsoe furniture production at Centric Close, London

One of the companies the Centre for Industrial Sustainability is working with is Vitsœ – pronounced 'vit-soo' – after the name of the company's founder, Niels Vitsœ, who died in 1995. While selling Danish furniture in post-war Germany, he was introduced to leading industrial designer Dieter Rams by fellow designer Otto Zapf. In 1959 the pair founded a company called 'Vitsœ+Zapf' to produce Rams' furniture designs.

Otto Zapf left the company in 1969 and it became known as Vitsœ. A distinguished showroom opened in central Frankfurt that became an important meeting place for the world's design literati. The core philosophy of the company is to recycle not replace its furniture wholesale.

In 1985, Niels Vitsœ and Dieter Rams were introduced to a Briton, Mark Adams, who set up Vitsœ Ltd in the UK. On the retirement of Niels Vitsœ, Mr Adams became managing director of Vitsœ and moved its production and HQ to London in 1995, to serve international markets.

Today, with a growing international team in a variety of worldwide locations, Vitsœ has pioneered selling directly to customers in more than 50 countries.

Vitsœ generates as little waste as possible at all times and in all areas of its business, the company says, and material reuse is essential. For example, wooden stillages are used to transport aluminium parts between suppliers. Many stillages have been in continuous use here for 20-years.

Reuse also applies to customers who are able to take their furniture from home-to-home while adding, subtracting or dividing as necessary.

The company lists the definition of sustainability made in 1987 by the Brundtland Commission as its preferred definition: "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

HIGHLIGHTS IN 2015

- Workshops held in Vietnam, China, Sri-Lanka on industrial sustainability
- Parliamentary enquiry into industrial sustainability launched, report launched in October 2015
- Cambridge University IfM Education & Consulting Services (ECS) enables the delivery of consulting which in six months delivers £50,000 in scoping work
- Training programmes for industry practitioners developed based on research. These continue to be delivered by the Cambridge Institute for Sustainable Leadership
- Schools activities include the Cambridge Science Festival and a pilot with Cardiff schools to place students in local businesses
- Industrial sustainability stands and workshops connect with more than 1,000 people at five industry-focused sustainability conferences

and modelling tools in 12 SMEs and Jaguar Land Rover, and sustainable changeover analysis at Unilever and Altro. Technology projects at Toyota, in end-of-life robotics and at Unilever, in critical materials and manufacturing, are producing step change results for both companies.

University of Cambridge

AT A GLANCE

The Centre has 21 senior academics and nine post-doctoral researchers

30 Active PhDs, 6 completed PhDs, and 5 visiting researchers

It has produced 21 tools to aid industry and worked with over 170 companies

The Centre has added 29 new academic papers in the past nine months. The total is 143 since it started

Overall, £2.9 million of new funding has been acquired for operational activities in the past 12 months

The Centre's sustainable business modelling research is refining models and tools and seeing them applied in many businesses including: Heraeus Noblelight, Marks & Spencer, footwear maker ASICS, Toyota UK, and at members of several industry sector bodies such as the European Plastics Federation and the World Federation of Sporting Goods Industries. Centre Researchers are engaged with a very broad range of organisations, in the UK and abroad, including practitioners and both governmental and non-governmental organisations, including brewer Adnams, M&S, furniture business Vitsœ [see box], Innovate UK, the Government Office for Science, Forum for the Future and the Sustainable Apparel Coalition. UKMR-15

Treasures & measures

ADVANCED METROLOGY

"It is important for us to be a key partner of the EPSRC Centre. The aims of the centre match our research and development aims, and we're benefiting from the specific innovative ideas to address long standing measurement challenges of industry."

Geoff McFarland, group engineering director, Renishaw plc

The advanced metrology centre began researching metrology solutions for machine tools. It is run by a former automotive industry apprentice, Jane Jiang

The EPSRC Centre in Advanced Metrology, based at the University of Huddersfield, is trying to transform the relationship between metrology – advanced measurement techniques – and production.

The centre aims to develop new technologies, methods and capabilities to embed metrology within the manufacturing process.

The centre describes this as 'factory on the machine', in which components are checked in situ, or on the manufacturing line – rather than being manufactured and transferred to a controlled laboratory environment to undertake quality checks.

In theory, moving verification steps and quality control techniques onto the production line improves product quality, reduces manufacturing lead times, and reduces waste, by identifying non-conformance earlier.

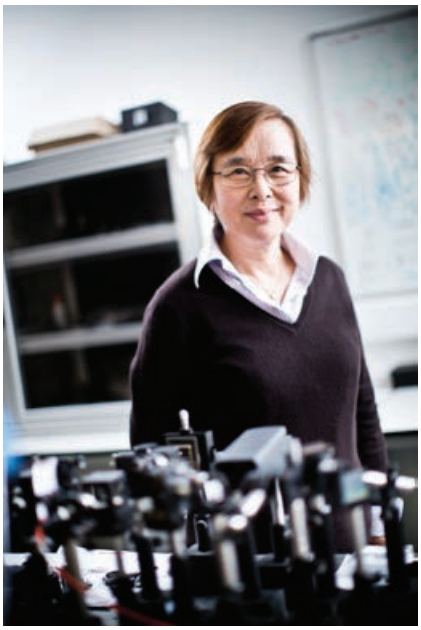
The EPSRC Centre's research priorities were initially focused in two main areas, with the aim of developing metrology solutions for application on machine-tool production platforms.

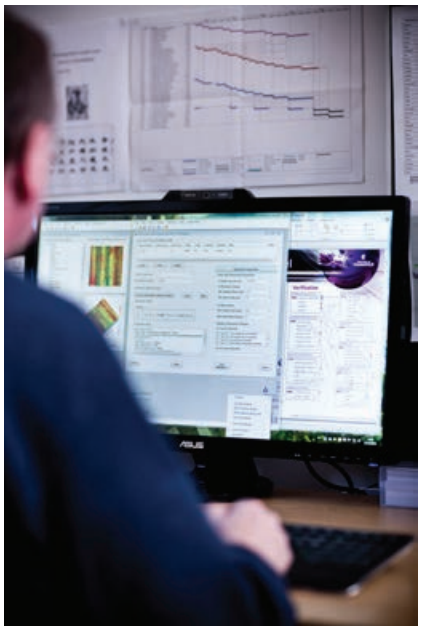
The first area is focused on the machine-tool platform itself, with extensive work on measuring, modelling and reducing the errors inherent in machines, as well as those induced by external factors, such as temperature changes in the factory.

Improving accuracy and repeatability in the production process clearly delivers an immediate quality benefit, but also opens up the option of embedding new measurement techniques, such as the instruments which are being developed at the centre.

This area of activity is researching new optical interferometer-based methods for the development of new instruments for embedded metrology. A number of optical schemes have been developed for different types of application, with the pre-requisites of being fast, small, and robust enough to operate in production environments where vibration and noise are commonplace.

Professor Jane Jiang, centre director, started her career as an apprentice in the automotive industry, before becoming a fully qualified engineer and then embarking on an academic career in measurement science.





"The benefit realised from this work is confidence in machining capability, which reduces variability, reduces waste, and improves quality of our products. These improvements are now being rolled out across our domestic UK plants and shortly into our external supply chain."

Reg Marsden, Company Chief Metrologist, Rolls-Royce

"In high-value manufacturing, up to 20% of total costs are typically associated with product verification." Jiang adds: "Faster, more accurate, and more efficient measurement methods can have a major impact on quality, productivity and profitability.

"Therefore, advanced metrology research is critical, underpinning and enabling discipline for the future success of UK manufacturing."

One of the quality challenges faced by precision engineering companies is maintaining the accuracy and repeatability of the machine tools they use. Standard good practice is to undertake regular calibration, but this is a complex and time-consuming process that can put a machine out of production for up to a week.

By using their in-depth understanding of machine tools, combined with new research in the field of artificial intelligence and autonomous planning, the EPSRC Centre team has been able to develop and deploy methods that reduce calibration times from days to hours.

As the metrology centre has evolved, new opportunities and applications have arisen. Instruments have been demonstrated – such as the WSI [see box] – for metrology for the manufacture of flexible electronics, and there is a growing interest and activity around the metrology challenges faced by new materials and production processes, such as additive manufacturing as it becomes a mainstream production method.

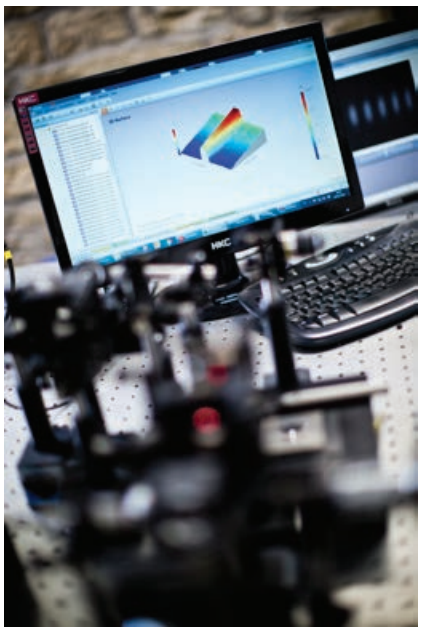
As well as fundamental and applied research programmes, the EPSRC Centre recognises the need for better adoption of existing technologies and best practice by UK industry, and has been working hard to develop new industry-focused training and support programmes.

This work is closely aligned with the National Physical Laboratory (NPL), which has a measurement services laboratory based in Huddersfield alongside the EPSRC Centre team. Joint activities, aligned with NPL's National Product Verification Programme initiative, have seen the piloting of measurement 'health checks' and interventions with a number of regionally-based businesses.

Work has also started on expansion of the EPSRC Centre's research to develop new methods and standards that will start to integrate metrology more effectively into the design process, and to develop stronger relationships with

"Future factories will need measurement systems beyond the current state-of-the-art and this requires a whole new metrology infrastructure," says Professor Jiang (above left).

"Building on our current research, we will be developing smart and connected sensor systems, solutions to integrate design for verification, and control systems to support autonomous manufacturing; we call this 'Manufacturing Infratechnology'."



On the right wavelength with the scanning interferometer (WSI)

The first of a new generation of instruments, the WSI is a great example of how research is being developed and deployed by the EPSRC Centre team.

Based on fundamental science, originally embarked upon as part of another research project, the WSI has been through a process of design, laboratory prototype and pre-production demonstrator, drawing on a number of partner organisations, and working closely with the Centre for Process Innovation, part of the High-Value Manufacturing Catapult.

The technology is now being deployed as part of a new industrial instrument, IBS Precision Engineering's 'Arinna', which was unveiled at the Lamdammap 2015 conference and exhibition in Huddersfield.

research groups specialising in large-scale measurement systems and data science, recognising the need to develop metrology informatics solutions to support future digital and autonomous manufacturing methods.

"Future factories will need measurement systems beyond the current state-of-the-art and this requires a whole new metrology infrastructure," says Professor Jiang.

"Building on our current research, we will be developing smart and connected sensor systems, solutions to integrate design for verification, and control systems to support autonomous manufacturing; we call this 'Manufacturing Infratechnology'."

Working closely with the NPL team, the EPSRC Advanced Metrology Centre is delivering a regional pilot project on metrology best practice for product verification.

The project, supported by European (ERDF) funding, is focused on supporting SMEs in the Leeds City Region by undertaking metrology 'health-checks', advising on best practice, and making recommendations to help improve their use of metrology to support manufacturing.

To date, around 30 small and medium-sized companies have benefited from advice, with about half of these having undertaken the more substantial health-check process – 12 of these 14 companies had no previous collaboration with the EPSRC Centre.

Jiang says: "The project is helping us to engage with a whole new set of companies as well as making a significant contribution to SMEs in the regional manufacturing base.

"This is particularly important in our area, where SMEs dominate manufacturing. Since Leeds City Region has the biggest manufacturing base of all the regions in the UK – around 140,000 employed in the sector – this is clearly as priority opportunity for us now, and in the future." UKMR-15

ADVANCED METROLOGY CENTRE, HIGHLIGHTS 2015

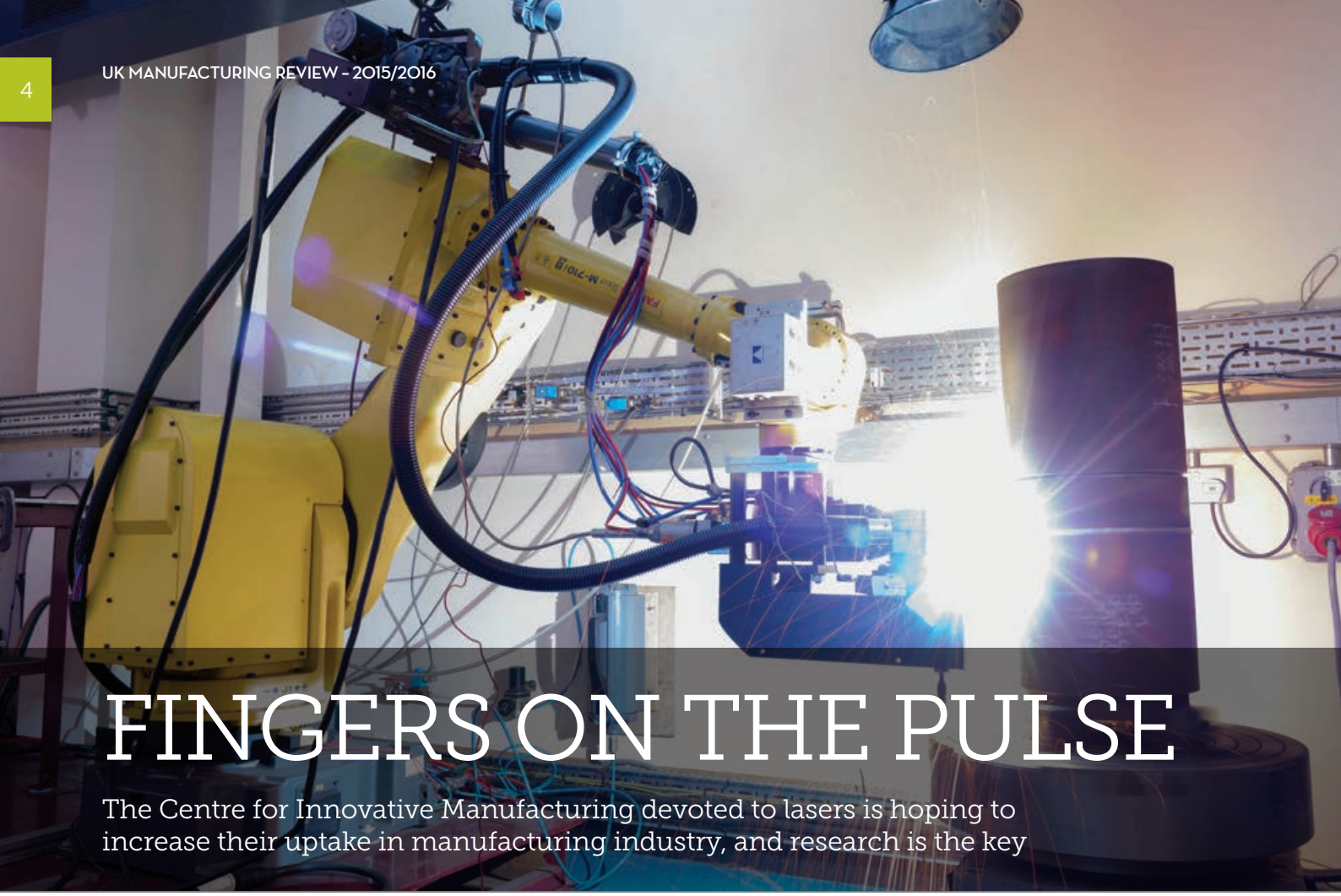
March: IIBS Precision Engineering unveils its new 'Arinna' instrument at LAMDAMAP. This instrument, for high-precision 3D surface measurement, is based on the patented WSI technology

April: Rolls-Royce begins implementation of the EPSRC Centre's CMTrain co-ordinate metrology training framework across its UK manufacturing workforce

June: Regional pilot of NPL-supported product verification programme completes, with 27 regional small/medium companies participating

August: EPSRC Centre PhD student, Christian Young, wins the Euspen student challenge when he and his team design and build a precision 2D measuring device in just nine hours

October 2015: Planning begins for an ambitious new metrology institute in Huddersfield, combining the expertise and resources of the EPSRC Centre/University and NPL, to develop and deliver future ground-breaking metrology research and innovation in the UK



FINGERS ON THE PULSE

The Centre for Innovative Manufacturing devoted to lasers is hoping to increase their uptake in manufacturing industry, and research is the key

Laser-based manufacturing is a global, multibillion dollar industry with significant business opportunities.

The past 25 years have seen industrial lasers replace conventional tools in many diverse areas of manufacturing, enabling increased productivity, functionality – and quality.

The EPSRC Centre for Innovative Manufacturing in Laser-based Production Processes, headquartered at Heriot-Watt University, Edinburgh, is working to increase the uptake of laser-based manufacturing, through a wide-ranging programme of coordinated research and network-building activities.

It enables significant business growth opportunities, stimulates the broader UK community, provides leadership in the development of public policy, and access to infrastructure for SMEs, as well as education and training for industry.

"Our vision is to exploit the unique features of laser light and the experience of our world-leading team, to unlock manufacturing innovation and deliver ground-breaking industrial impact in key areas of the UK economy," says centre director, Professor Duncan Hand.

He adds: "To realise this vision we are focusing on science-based research, drawing on our considerable depth and breadth in physics, materials science, mechanical and electrical systems, and photonics engineering at the five partner universities, to deliver innovative laser process and hardware solutions, thereby enabling the creation of high-impact laser-based production process and machine technologies."

THE LAWS OF LASER INTERACTION

Combining laser material interaction fundamentals with advanced materials science to underpin the development and optimisation of laser-based manufacturing processes, the

VIEW FROM INDUSTRY

"Renishaw has worked with Heriot-Watt University for over a decade. Over the years the collaboration has become deeper and wider with projects in subject areas such as laser processing, metrology, micro-manufacturing.

"With the advent of the EPSRC Centre for Laser-Based Production Processes the talent pool of potential collaborators has become even richer, with the complementary skills of world leading academic partners, as well as commercial partners which represent some of the most innovative companies operating in the UK. These partners represent whole value chains in terms of system design, build, deployment and use of laser-based production.

"The centre's match-making skills mean we now have four programmes under way or due to commence which involve more than one commercial or academic partner. The facilities, organisation and skills deployed make me very optimistic that significant positive impact to Renishaw's business will result from this work."

Nick Weston, General Manager, Renishaw Edinburgh

EPSRC has initiated projects across a wide range of laser interaction timescales, from picosecond pulsed to continuous lasers. These seek to characterise basic laser-material interactions at a fundamental level, while solving specific manufacturing challenges.

A key aim is to enable robust transfer of optimised process conditions between different machines, a capability that is essential for implementing highly-automated, reliable, high-yield component manufacture.

"Our outreach activity is focused on building links to the overall UK industrial and academic communities beyond the cohort of our collaborators, and working with them to develop a National Strategy for Laser-based Manufacturing," explains Hand.

"Building on the work producing the UK Roadmap last year we are now – jointly with AILU, Association of Industrial Laser Users – developing a National Strategy Working group to develop recommendations that will provide a framework for researchers, industry and funding agencies, to increase the exploitation of laser processes, and support UK manufacturing."

SME SEEDCORN PROJECTS

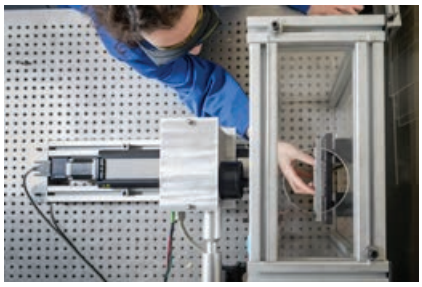
The centre's Seedcorn projects allow SMEs to work with the CIM on two-week feasibility studies or pump-priming projects, at no cost to themselves.

Each project will be awarded up to two weeks' researcher time, with input from members of the centre academic team, to develop or test laser-based production processes that could benefit the SME involved.

For more information on this scheme and details of how to apply please email: lbpp@hw.ac.uk

KEY RESEARCH HIGHLIGHTS THIS YEAR

Key projects include the development of a miniaturised GHz frame rate holographic imaging system and testing of this with ultra-short pulsed laser processes including the welding of glass to metal.



Laser-based manufacturing has traditionally taken an empirical approach. Industrial laser users have access to an immense parameter space consisting of nearly infinite combinations of wavelength, pulse duration, temporal pulse shape, spatial profile and polarisation, not to mention processing parameters

Professor Duncan Hand

CENTRE DIRECTOR, THE EPSRC CENTRE FOR INNOVATIVE MANUFACTURING IN LASER-BASED PRODUCTION PROCESSES

Professor Duncan Hand's work on manufacturing includes laser precision machining; the use of adaptive optics in laser manufacturing processes; and laser joining of microsystems. In this work he collaborates with a range of companies including GE Aviation, Renishaw, BAE Systems and Selex.

"I conduct further research activity on the delivery of high peak power laser light through novel optical fibres, with applications in manufacturing and medicine, including a collaboration with the University of Bath on photonic bandgap fibres, and with the University of Nottingham on IR-transmitting fibres," he says.

Hand also has an interest in optical sensing, with current activities centred on optically-addressed fibre optic micro-cantilever sensors. Hand graduated from the University of St Andrews in 1986 with a BSc in Physics with Electronics, and from the University of Southampton (Optoelectronics Research Centre) in 1991 with a PhD. The PhD was an investigation of different techniques to incorporate permanent phase gratings into optical fibres, 'fibre bragg gratings'. In 1991 he moved to Heriot-Watt University, initially employed as a research associate. In 1997 he was appointed Lecturer in Physics and subsequently promoted to Reader (2001) and Professor of Applied Photonics (2003).

Professor Hand says he "enjoyed physics at St Andrews university but really did not like optics and lasers until I was taught by Malcolm Dunn, and then I realised that 'this is what I want to do'".

He did a PhD "as it seemed more interesting than getting a proper job and meant that I could concentrate on my new-found love of optics and lasers".

He adds: "I was very fortunate in being one of Professor Philip Russell's first PhD students. Philip is now joint director of the Max Planck Institute for the Science of Light in Erlangen, Germany. As one his first students, I got lots of his time.

"The fact that that you can use light to dramatically modify material in such a wide variety of ways continues to fascinate me – and of course this was the driving force behind my research that led to me heading up CIM-Laser."

LIGHT SOURCES: TECHNOLOGY IN DEVELOPMENT

Applying the holographic imaging system to investigate the dynamics of a range of processes

Welding, including of ultra-thin materials – and of non-linear crystals to create novel non-linear optical devices

Laser beam shaping – applications to welding; hybrid welding; cutting

High precision machining of fibre-end components for medical applications

Laser development – 2m short pulsed; high brightness laser diodes

Development of laser-based techniques for optical systems fabrication to replace manual construction and alignment approaches for lasers, and other complex optical components

Hands-on research may yield future stars of industry

such as processing speed, pulse, and overlap.

The centre's research in this area aims to develop in-process diagnostic instrumentation that can be employed to optimise the parameter space for a variety of laser-based production processes and laser systems, such as the manufacture of well-controlled high friction surfaces onto marine engine components. High power lasers can be used to produce many different types of surface structures, including optically absorbing nano-structures; controllably oxidised surfaces (markings of different colours); polished surfaces and self-organised nano-gratings. These different process regimes are dependent on the laser parameters (in particular pulse length, pulse shape, spatial beam shape, intensity).

The development of a phenomenological model for laser powder bed processes, is essential to understand and compensate machine-to-machine variability with powder bed additive manufacturing. The majority of powder bed systems for additive manufacturing use galvo-scanners, which enable fast translation of the laser spot across the working area. However, one of the drawbacks of galvo-scanners is distortion of the projected laser spot on the surface of workpiece, whilst the beam is being translated. This can result in non-uniform build characteristics during the powder bed additive manufacturing process. Furthermore the process is optimised only for one particular machine with a particular optical set-up, which imposes transferability issues when applying the process on different machines.

The centre is working to identify a set of interaction parameters that controls the fusion characteristics and profile of build layers in powder bed systems. The overall goal of this project is to make the selective laser melting process more robust and transferable between different powder bed systems. These fundamental parameters can also be used for optimisation of the laser powder bed system in terms of process efficiency and scale-up to higher powers and build rates. UKMR-15

CIM-LASER PARTNERS

The EPSRC CIM-Laser is a partnership between Heriot-Watt University, Cranfield University, the University of Cambridge, the University of Liverpool, and the University of Manchester.

Industrial partners include:

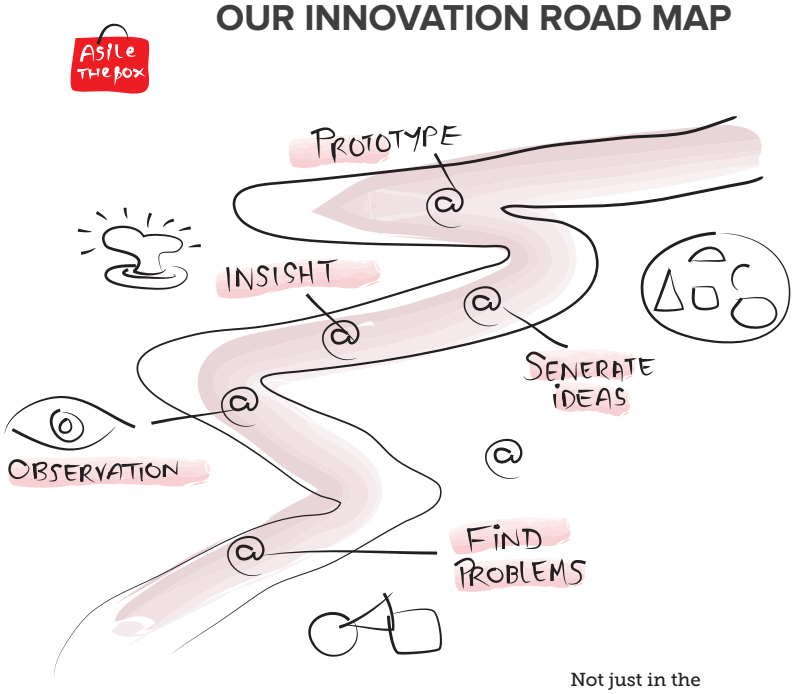
AILU – Association of Laser Users
API Technologies
Airbus
Alicona
Applied Laser Engineering
Attica
AWE
Carrs Welding Technologies
Coherent
Compound Semiconductor Technology
GE Aviation
Gooch & Housego
JK Lasers
Laser Cladding Technology
Laser Expertise
Laser Micromachining
Litron Lasers
MAN Diesel & Turbo
Maufacturing Technology Centre
Menlo Systems
Micrometric
M-Solv
OpTek Systems
OptoScribe
Oxford Lasers
PowerPhotonic
Renishaw
Selex-ES
SPI Lasers
Rofin-Sinar UK
Rofin-Baasel UK
Rolls-Royce
Tata
Trumpf
TWI

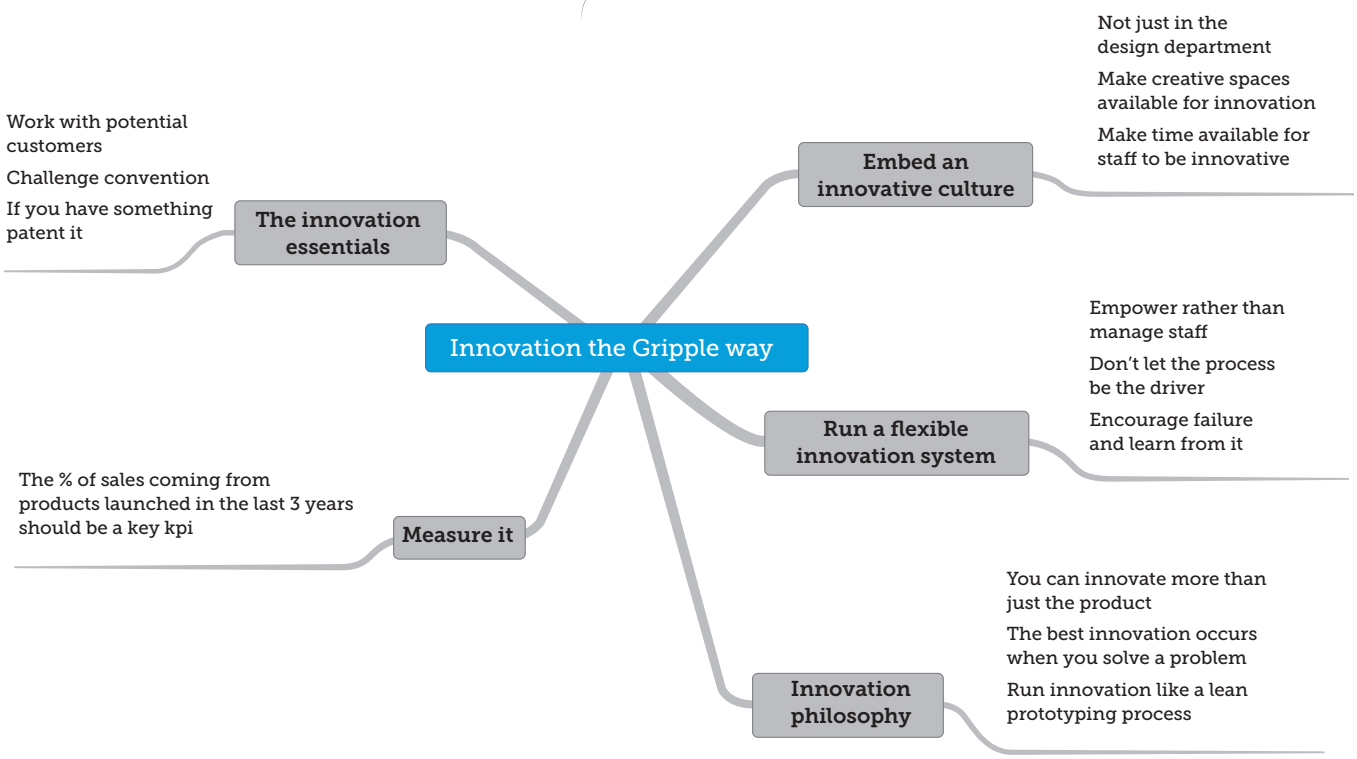
Gripple Innovation Map

"Amidst a plague of useless gadgets and false promises, the Gripple is a true rarity in the modern age - a product that genuinely makes life easier," says Gordon Macrae, Special Projects Director at Gripple.

Innovation has been at the heart of making Gripple a successful business. By embedding innovation in our culture, and by focusing on challenging convention and solving customer problems we have created a world class employee owned wire joining and tensioning business which sells over 85% of its product outside the UK and has grown by at least 10% annually.

OUR INNOVATION ROAD MAP





Contributing Writers

SECTORS

Aerospace

Chuck Grieve writes about aerospace and related sectors for publications mainly in the UK, Middle East and Africa. His stories have appeared in ADS Advance, Airline Business, Flight Daily News, Midlands Aerospace, Arabian Aerospace, African Aerospace and Payload Asia. He is a fellow of the Institute of Internal Communication (IoIC) and the RSA.

Automotive

Ian Adcock Specialist in the motor industry covering road tests, adventure drives, technology and design as well as manufacturing and business. Editor, 'Automotive Design' (UK) European editor Road & Track (USA) and Nikkei Automotive technology (Japan). Past assistant editor What Car?, news and sports editor Autocar, deputy editor and editor Motor. Contributor to specialist automotive design and technology magazines.

Chemicals

Sarah Houlton Sarah Houlton has a degree and PhD in chemistry from Imperial College London, and worked as a drug discovery chemist between the two. As a science journalist, she has been writing about the chemical, pharmaceutical and biotech industries for more than 20 years.

Food and Drink

Paul Gander Paul Gander is a London-based freelance journalist and editor who writes for a range of food and ingredient-related business publications and websites. In the past, he has edited packaging and international confectionery industry titles, International Food Ingredients magazine and currently edits a packaging research newsletter. He has written for the nationals, including the FT and Independent on Sunday, as well as for magazines across a range of industries from hotels and travel to marketing and design.

Metals

Andy Sandford is a writer and consultant specialising in manufacturing technology. He trained as a metallurgist and worked in industry for a number of years before returning to higher education to complete his doctorate, since when he has worked in business media and public relations across a range of engineering sectors. Andy runs his own PR consultancy, edits Engineering Capacity and Quality Manufacturing Today, and is a director of the Engineering Industries Association.

Pharmaceuticals

Zoe Cormier is an author, journalist, and science writer. Her work has featured in *The Times*, *Wired*, *Nature*, *New Scientist*, *The Guardian*, *The Globe and Mail*, *BBC Focus* and other publications. As a broadcaster and public speaker she has appeared on BBC Radio 4's Start The Week, CBC Radio, CTV television, and spoken live at music festivals, arts events and a wide variety of theatrical performances for a decade.

Electronics and Productivity

Peter Marsh is the author of "The New Industrial Revolution: Consumers, Globalization and the End of Mass Production". He is a speaker on modern manufacturing, having given talks on this topic in the past two years in countries including the US, UK, South Korea, China, Italy, Germany and Lithuania. In 2015, From 1983 to 2013 he worked as a journalist at the Financial Times where his most recent job was manufacturing editor.

Power Generation

Helen Knight is an experienced engineering, technology and science reporter. Helen began her career at The Engineer magazine, where she worked her way up to become deputy editor. She then joined New Scientist magazine as Technology News Editor, where she spent five years. She left the magazine in 2010 and began working as a freelance journalist, writing news and features on science and technology research, and engineering.

Rail

Christian Wolmar is a writer and broadcaster specialising in transport. He has written a regular column for Rail magazine for the past 20-years and appears frequently on radio and TV as a commentator on the railways. His latest book is To the Edge of the World, the story of the Transsiberian railway published by Atlantic Books and he is currently working on a history of Indian railways.

SUBJECTS

Manufacturing Tech - Big Data

Malcolm Wheatley Malcolm Wheatley is an experienced writer and editor who writes about information technology, enterprise software, engineering, manufacturing, Big Data and the Internet of Things, among other subjects. He is a visiting fellow at Cranfield University.

Skills

John Pullin is a journalist, editor and writer who has been commenting on manufacturing industry issues for more than 40 years. He was editor of The Engineer from 1984 to 1991, of Construction News from 1991 to 1995 and then joined the Institution of Mechanical Engineers as editor of Professional Engineering and editorial director of its publishing operations. He now contributes widely to reports on innovation policy and industrial management issues, and is also doing an MA in History.

Energy

Jane Gray is assistant editor at Utility Week, and was previously editor of The Manufacturer magazine, where she worked for over five years. She has been a trustee of the Design and Technology Association since 2012. The D&T Association advises government on curriculum development, champions D&T teaching in schools and raises awareness of its significance in shaping vocational talent for the design and engineering sectors of tomorrow.

Industry 4.0

Will Stirling is a journalist and publisher specialising in the manufacturing sector. Stirling Media is the publisher of the UK Manufacturing Review 2015. Will has written manufacturing reports in The Times, The Daily Telegraph and The New Statesman. He has produced two conferences on Germany's Mittelstand with the German British Forum, with a third conference on Brexit due in March 2016.

Industrial Sustainability

Isabella Kaminski is deputy editor of environmental business journal The ENDS Report, where she specialises in legal compliance and government policy on the environment across the UK. She has also contributed to a number of other environmental publications.

Isabella previously covered Welsh education policy for TES Cymru and worked for the European Parliament on media policy.

Trade

Charles Orton-Jones was editor of EuroBusiness magazine, and won PPA Business Journalist of the Year. He covers economics, data analytics and the internet of things for newspapers and magazines across Europe.

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UKMR 2015 Deputy Editor

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Notes

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