

The Future of UK High Value Engineering

An insight into the future of the UK HVE segment

Methodology

This report was commissioned by RBS and produced by The Future Laboratory. Findings were obtained by qualitative research through canvassing the opinions of key stakeholders in the UK High Value Engineering segment through a series of interviews with business leaders, industry and trade association representatives and academics.

Desk research covered extensive secondary sources, including insights into the sector produced by government departments, industry bodies and independent think tanks. In addition, examples of current work, in SME and mid-corporate businesses, as well as academic institutions, were identified which provide glimpses of the future shape of High Value Engineering. The latest available Office for National Statistics (ONS) data has been used in the compilation of this report (October 2012).

A quantitative survey of 286 business leaders and decision makers in UK manufacturing was conducted online and by phone in 2012. Statistics quoted in this report are from this survey, unless otherwise credited, and should be referenced thereafter as ‘RBS The Future of UK High Value Engineering 2012’.

For the purposes of this report, we define SMEs as companies with a turnover of up to £25m and mid-corporate business as companies with a turnover of more than £25m.

RBS would like to thank the following experts for their contribution to this report:

- Graham Chisnall**, Deputy CEO and MD of Aerospace, ADS
- Professor Richard Dashwood**, Academic Director, Warwick Manufacturing Group
- Professor Sir Mike Gregory**, Head of the Institute for Manufacturing, Cambridge University
- Lee Hopley**, Chief Economist, EEF
- Mike McCann**, Head of Business Development and Strategy, GKN Aerospace
- Sir David McMurtry**, Chairman and Chief Executive, Renishaw
- Peter Morgan**, Director of Corporate Affairs, Rolls-Royce
- Colin Paynter**, CEO, Astrium
- Professor Keith Ridgeway**, Head of the Advanced Manufacturing Research Centre, Sheffield
- Tim Roustis**, CEO, Cosworth
- Sir Alan Rudge**, CEO, ERA Foundation
- Dave Shemmans**, CEO, Ricardo
- Professor Paul Shore**, Head of the Cranfield University Precision Engineering Institute

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Forewords



John Cridland CBE, Director-General, Confederation of British Industry (CBI)

As the economic recovery continues to build momentum, it is more important than ever that UK manufacturing, High Value Engineering particularly, plays its full part in securing economic growth and ensuring the UK remains competitive.

As new technologies and processes like 3D printing and composite materials develop and grow, new markets and opportunities for development will emerge. It is crucial that the UK is at the forefront of such change, with a fully functioning skills base and industrial capability that allows our companies to fulfil their potential and remain a key part of the global high value manufacturing marketplace.

The UK's manufacturing heritage is unique and despite growing international competition, we remain home to a number of world class manufacturers and we are a critical player in the global engineering landscape. This report from RBS is a welcome contribution to the wider debate of how we secure our manufacturing future.



Peter Russell, Head of Manufacturing & Industrials, UK Sector Coverage, RBS Corporate & Institutional Banking

I am hugely excited at the outlook for the HVE segment over the coming years. What is evident from this report is just how much knowledge and capability, not to mention success, already exists within the UK.

The challenge for the next decade, and beyond, will be how the UK goes about nurturing the opportunities that new and emerging technologies, such as 3D printing and nano-structured materials will create, not just in terms of their scientific development but also their early adoption and application by HVE companies, thereby helping the UK to take the lead, ahead of other nations who will also be striving to develop these new markets.

Whilst capitalising on new technologies is seen as essential for growth in HVE in the medium term, our survey results indicate mixed views from around the UK in terms of current, or intended, levels of R&D expenditure. At the time of writing, new proposals around capital allowances are being debated as a possible means of encouraging manufacturers to accelerate their investment plans. If implemented, these must surely be welcomed because there will be no shortage of others who will be only too keen to exploit 'innovation made in the UK'.



Mark Catton, CEO, RBS Corporate & Institutional Banking

Welcome to our Future of UK High Value Engineering (HVE) report which is designed to be a forward looking piece of research aimed at identifying and promoting the tremendous opportunities that lie ahead for this important segment of the UK manufacturing sector.

Without wishing to dwell 'in the present' for too long, it may help to position this report by posing a rhetorical question - what is manufacturing and does it matter? Firstly, there is no common, or agreed, definition of what manufacturing means. To many it is still the process of converting materials into finished goods but the reality is so much more than this. Manufacturing companies have developed well beyond this, with a number now working collaboratively with partners and universities in the fields of research & development, product design and innovation, thereby making good use of the strong science and technology base which the UK has to offer.

As a sector, its value to the UK economy has perhaps never been clearer. Exports of UK manufactured goods generate great wealth, and the notion that a sustained increase would be capable of eliminating the UK's trade deficit is a very compelling thought indeed. However, to achieve anything like this growth, our report highlights the pivotal role that HVE has to play. Through embracing 'game-changing technologies', embarking upon, or increasing, 'R&D' and systematically addressing the 'twin time bombs' that will otherwise remain a drag on progress, the segment carries the potential of delivering real sustainable growth, at the same time propelling the UK into leading market positions. It is for these, and a host of other reasons, that manufacturing still matters.

“

As a sector, its value to the UK economy has perhaps never been clearer. Exports of UK manufactured goods generate great wealth, and the notion that a sustained increase would be capable of eliminating the UK's trade deficit is a very compelling thought indeed. ”

Mark Catton, CEO, RBS Corporate & Institutional Banking

Executive Summary

A pervasive narrative about UK manufacturing paints a gloomy picture of gradual decline. It tells the story of a once-mighty industrial heritage in full and inevitable retreat before the might of the emerging economies of Asia and South America. It is a beguiling tale with a fatal flaw: it's not true.

Increasingly, and hearteningly, there is another story to be told – that the UK could once again be one of the workshops of a brave new high-tech world in which High Value Engineering (HVE) plays a pivotal role in both the growth of the manufacturing sector, and the country's economy as a whole.

Nanotechnology, 3D printing, smart materials and a new generation of composites will be a \$1.3trn (£805.8bn) global manufacturing battleground by 2015, and these are technologies in which the UK's High Value Engineering innovators are well placed to excel.

There are formidable hurdles to be cleared and tough decisions to be made, however. A contract between industry and universities is urgently needed to train and retain the next generation of engineering talent and defuse the twin time bombs of a widening skills gap and a depleted supply chain.

The UK government and HVE companies must learn from their competitors in Europe and Asia, and prioritise continued investment in the creation of a dynamic research and innovation eco-system.

Nevertheless, the omens for the next decade are promising, with skilled and experienced UK engineers poised to become world leaders in game-changing technologies from structural batteries to lightweight materials that will change manufacturing forever.

In this report, we examine five vital strategies for growth, from advanced data prediction and technology investment to diversification and customisation, which UK HVEs can adopt to help become the engines of the country's recovery from recession.

And we present a series of recommendations that are a blueprint for success for the leading-

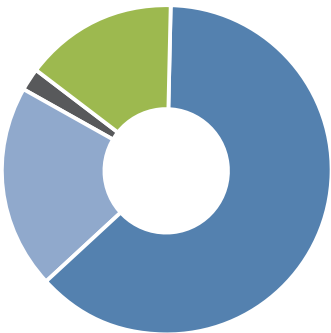
edge engineering businesses that will kick-start the UK's next industrial revolution. These businesses will need to make early changes to their investment, recruitment, and research and development strategies to take full advantage of the huge opportunities to come.

The view from the boardroom

A survey of UK manufacturing leaders for RBS reveals many reasons to be optimistic about the future of UK HVE – but some key areas of serious concern too:

- Eight out of ten (82%) businesses expect their turnover to grow over the next five years, with a bullish 27% of SMEs predicting growth of more than 30%
- Almost unanimous (98%) agreement that research and development is crucial to UK growth, but the discovery that only 10% of businesses plan to increase their R&D spend in the short term
- Birmingham, Sheffield and Manchester are highlighted as the cities that will lead a new High Value Engineering revolution
- Half (53%) of UK manufacturers feel HVE technologies such as composite materials and additive manufacturing will make their business fit for the future – but only 4% are targeting their R&D spend on the technologies of tomorrow such as nanotechnology
- Three quarters (74%) worry that skill shortages will impair future growth and competitiveness, but only 12% are investing in new apprenticeship schemes
- Three quarters (78%) describe their business as equipped to face the challenges of 2025, and yet 88% are not planning to invest in key growth strategies such as improving their supply chain or investing in current staff

Bearing in mind the likely changes to the manufacturing industry in the future, do you feel confident that your business is equipped to be ahead of the competition in 10-15 years time?



Extremely confident	15%
Quite confident	63%
Not very confident	20%
Not at all confident	2%



Manufacturing Britain's Future

UK manufacturing is at a pivotal moment in its history, and the promise and potential of the High Value Engineering segment will determine its future trajectory.

It would be easy to surrender to a sense of despondency. Manufacturing output in the UK has fallen for four quarters in a row, and will drop by 1.7% overall in 2012, according to the British Chamber of Commerce.

To do so, however, would be to ignore the ray of light amid the economic storm clouds: UK HVE companies with their rich industrial heritage, unique production processes, high brand recognition, customised services and rapid delivery times can lead the sector – and perhaps the country – back to sustainable growth.

Some of the world's most innovative and important products – from aircraft and space technologies through to luxury vehicles,

chips for smart phones and life saving drugs – are designed, manufactured and supported by UK companies and the UK subsidiaries of global businesses.

The promise of high economic value that HVE represents to UK PLC is clear. ONS data shows that the High Value Engineering segment of UK manufacturing contributed £151bn to the UK balance of payments in 2010, and accounted for 35% of all UK exports.

It will grow at 2-3% per year over the next five years, faster than the projected growth of 1.5% to 2.5% of the UK economy, according to RBS Group Economics.

“

Manufacturing is not dead or dying. But it is evolving, and this is widely misunderstood.”

Göran Roos, Honorary Professor,
Warwick Business School

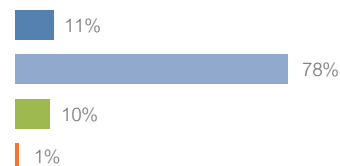
Confidence in growth

Confidence is high amongst UK business leaders that growth in the manufacturing sector will soon return despite the current difficult economic situation.

Eight out of ten (82%) of businesses responding to our survey confirmed they expect their turnover to grow over the next five years. By comparison, less than 8% believe their turnover will shrink.

Interestingly, SMEs are more bullish about their growth prospects than mid-corporate businesses. A quarter (27%) of companies with an annual turnover below £25m expect their turnover to grow by over 30% over the next five years, compared to just one in ten (10%) of companies with a £25m plus annual turnover.

% of surveyed companies' turnover spent on R&D



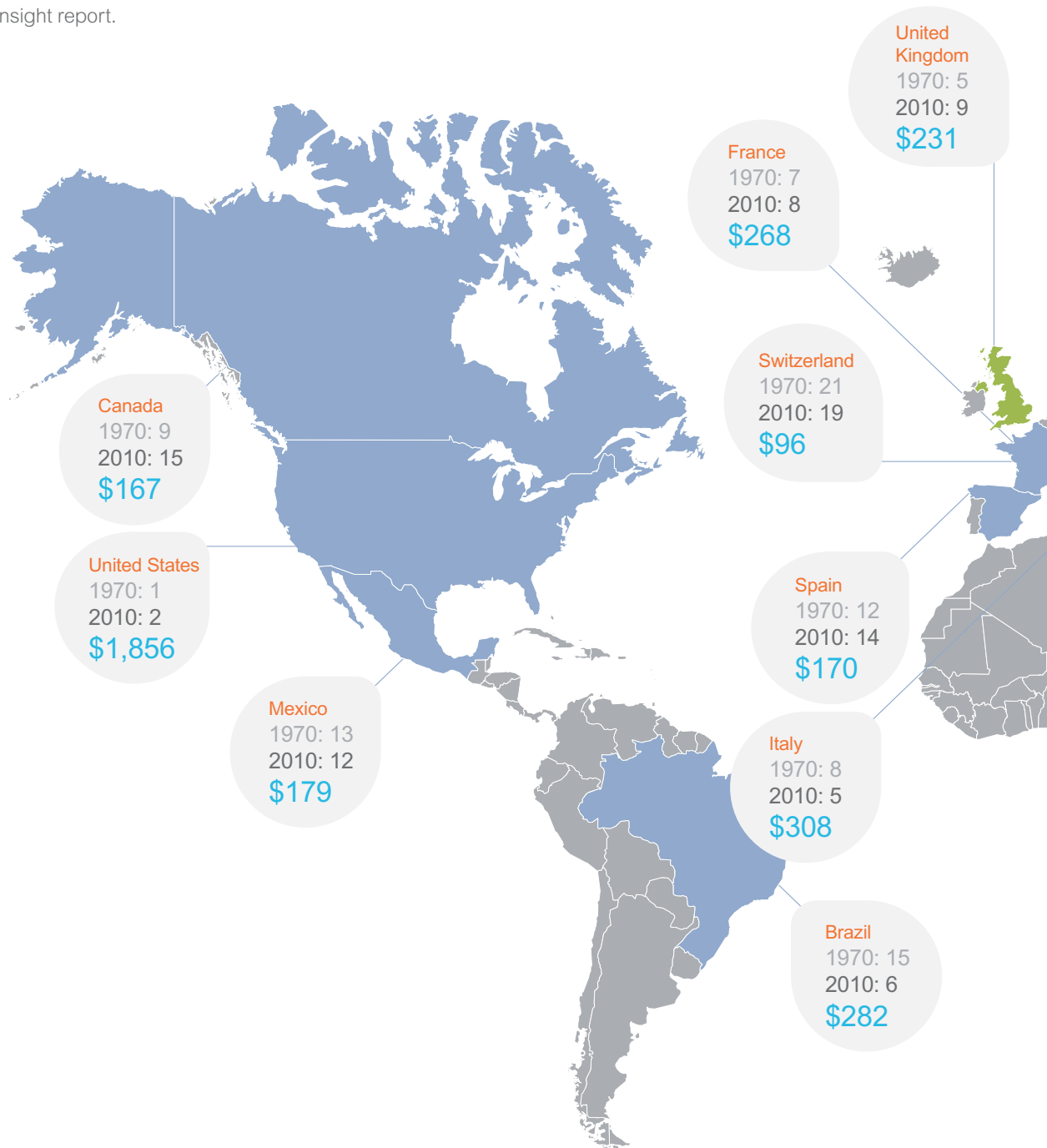
Key

- We don't spend anything on R&D
- 1-19% of turnover
- 20-39% of turnover
- 40-59% of turnover

HVE at the crossroads

Soaring energy costs, resource scarcity, and man-made climate change will be the backdrop, as the UK HVE segment faces up to intense and growing international competition from emerging economies.

Developed nations account for 54% of global manufacturing output in 2012 compared to 73% in 2000, according to the HIS Global Insight report.



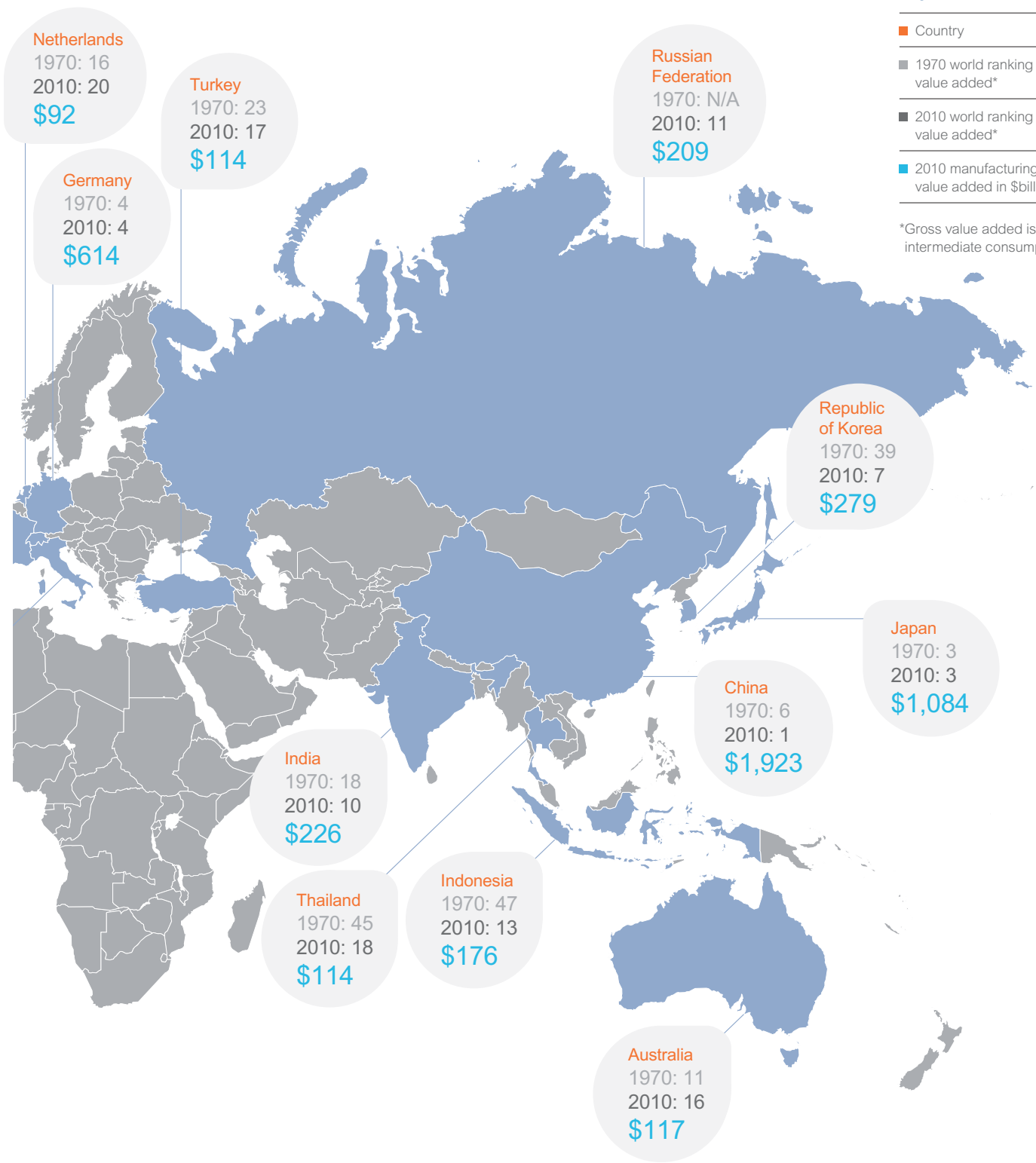
International comparisons of
manufacturing output

Manufacturing gross value added

Key

- Country
- 1970 world ranking by gross value added*
- 2010 world ranking by gross value added*
- 2010 manufacturing gross value added in \$billion

*Gross value added is output minus intermediate consumption



An unparalleled, across-the-board transformation of UK HVE will be needed – from innovation and research and development to training and recruiting the world-beating engineers, who will turn transformational ideas into commercially successful products.

Key strategic market sectors for the UK, as identified by the Technology Strategy Board, combine high growth potential with high levels of R&D. These include:

- aerospace and automotive industries
- computers, electronics and optical products
- electrical equipment
- pharmaceutical manufacturing
- metal and castings
- machinery and equipment
- nuclear industry

There are also opportunities in other high-growth sectors such as food and drink production, plus marine and other components of the transport sector.

UK manufacturing value at a glance

The shape of UK manufacturing has changed fundamentally in the past 40 years. While manufacturing is not the mass-employer it once was, there's an increasing concentration of value in the sector.

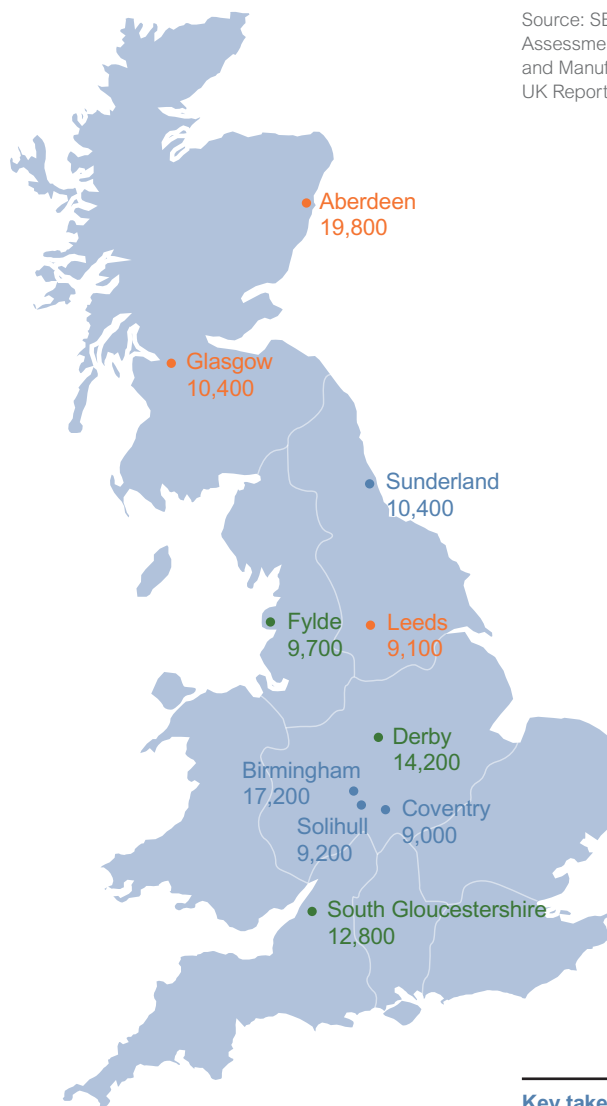
- The 2.5m people who work in the sector contribute 20% more per employee to the economy than average
- The manufacturing sector is an innovation powerhouse, dominating research and development investment in the UK economy. In 2010, 72% of total business R&D was in the sector
- Manufacturing productivity has grown faster than that of the service sector. Output per hour in manufacturing grew 1.9% between 2011 Q1 and 2012 Q1, compared with 0.1% in services

Regional snapshot: growth

Manufacturers in the North of England are the most confident about their turnover for the next 5 years, with 84% claiming it will grow. A fifth of businesses in the North even say their turnover will rise by over 50% in this time period. In Scotland 82% say they anticipate growth, while in the South and the Midlands the proportion is 81%.

Britain's High Value Engineering hotspots

The ten towns and regions in Great Britain with the highest number of jobs in the HVE segment. For each area, total employment in leading technology industries is shown, along with the key sector for each region.



Key

- Science and engineering research and development
- Automotive
- Aerospace

Source: SEMTA Sector Skills Assessment for Science, Engineering and Manufacturing Technologies, UK Report, December 2010

Key take-outs

- The UK is the 9th largest manufacturing nation in the world. The High Value Engineering segment of UK manufacturing accounts for 35% of all exports and contributes £151bn worth of value toward the UK's Balance of Payments
- High Value Engineering is expected to grow faster than the UK economy as a whole at 2-3% per year over the next five years, compared to a projected 1.5% to 2.5% for UK GDP
- Manufacturers in the North of England are the most confident about growth, with 84% predicting an increase in turnover over the next five years, and a fifth saying this increase will top 50%



R&D: The Global Race to Growth

UK manufacturing business leaders understand the need for urgent action in research and development. If they are to keep pace with their international competition, developing new processes and products will be vital.

Encouragingly, UK industry appears to be undergoing a research and development renaissance. Almost all (98%) of those surveyed agreed that R&D is crucial to the growth of UK manufacturing. That figure stood at 100% of mid-corporate businesses, and all companies surveyed in the North and South.

Manufacturers are clearly prepared to back up these sentiments with substantial amounts of capital. Three quarters (78%) spend up to 20% of their turnover on R&D, and nine out of ten (89%) have an R&D budget of between 1% and 59% of their turnover.

Size can be a deciding factor: only 6% of mid-corporate businesses say they have no R&D budget but worryingly more than double that, 14%, of SMEs say they spend nothing on R&D. Our survey also shows a North-South divide with 93% of companies in Scotland declaring an R&D budget compared to 84% of those in the South.

The message is beginning to get through to even the 11% of all those surveyed who do not spend money on R&D. Half (50%) of this group admitted that they worry that their lack of R&D expenditure will damage their international competitiveness.

New production processes are by far the most important focus for UK R&D budgets, with 43% of companies concentrating on this area over the next five years.

There is overwhelming recognition of the global competitive edge provided by the high standard of R&D in the UK. Four out of five (80%) of those surveyed felt that the quality of UK R&D sets it apart from emerging markets, a sentiment that stands at 89% of mid-corporate businesses and 75% of SMEs.

New product development (16%), resource efficiency (13%) and materials integration (11%) are the next three most popular R&D spending targets.

Another note for optimism is the discovery that manufacturers see the need to increase the focus on the training and development of a new generation of engineering talent to help achieve R&D objectives.

However, perhaps one cause for concern is the relatively low number of companies – just one in ten (10%) – who say they are planning to increase their R&D spend over the next two to five years, despite reports of huge planned R&D budget rises in China and Brazil.

“

Every country by accident or design makes choices about which technologies it supports. We need to be a bit more discriminating in the UK. ”

Professor Sir Mike Gregory,
Institute for Manufacturing,
Cambridge University

UK industry's global competitors are gearing up for growth. In 2011, for the first time in history, total R&D spending in Asia Pacific exceeded total R&D spending in the US. Asia Pacific countries, led by China, accounted for 36.7% of the global spend, while US R&D stood at 36% of the worldwide total, and this growth in their R&D expenditure is expected to accelerate in the future.

Traditional rivals are consolidating their positions with national objectives and strategies. Germany's government-sponsored intern system ensures a constant supply of top-quality engineering talent, while SMEs – seen as a vital part of the ecosystem – benefit from specific research programmes and infrastructure.

Governments in both Brazil and China launched manufacturing plans in 2011, with China's 12th five year plan (2011-2015) focusing on developing sustainable, high-tech manufacturing industries while downgrading its low-quality goods production.

Japan and Korea have held their position as suppliers of high-cost capital equipment, which use advanced manufacturing technologies.

UK research and development boost

Encouragingly, the UK is not standing still. The Technology Strategy Board has doubled its direct HVE innovation investment to around £50m a year and, in 2010, announced the establishment of seven HVE Catapult centres (see map). They are designed to support UK manufacturing by allowing companies to access equipment and expertise that would otherwise be out of reach, providing R&D resources and facilitating access to new funding streams.

The first of the institutes of excellence opened in 2011, and the remaining six, focused on cell therapy, off-shore renewable energy, satellite applications, the connected digital economy, future cities, and transport systems, will be fully operational by 2013.

Catapulting into the future

UK manufacturing business leaders predict that key regions of the UK will take the lead in a new High Value Engineering revolution that will hone the country's competitive edge.

Those surveyed identify Birmingham, Sheffield and Manchester as the top three cities predicted to be at the forefront of the country's HVE future.

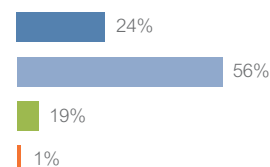
Their judgements showed a clear correlation with the TSB Catapult Centres, including the Advanced Manufacturing Research Centre at the University of Sheffield, and the Nuclear Advanced Manufacturing Research Centre at the Universities of Manchester and Sheffield.

Another Centre of Manufacturing Technology in Coventry would seem to affirm business leaders' decision to pinpoint that city as the 4th best-placed to lead an HVE revolution.

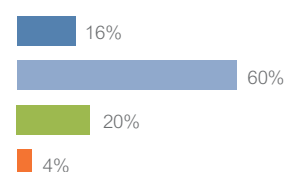
Business leaders also identify Cambridge, Leeds and Newcastle as cities with the potential to help spearhead UK manufacturing's future.

To what extent do you agree or disagree with the following statements?

'The quality of Research and Development in the UK sets it apart from emerging markets.'



'UK universities and research centres give the UK manufacturing sector a big advantage over other economies.'



Key

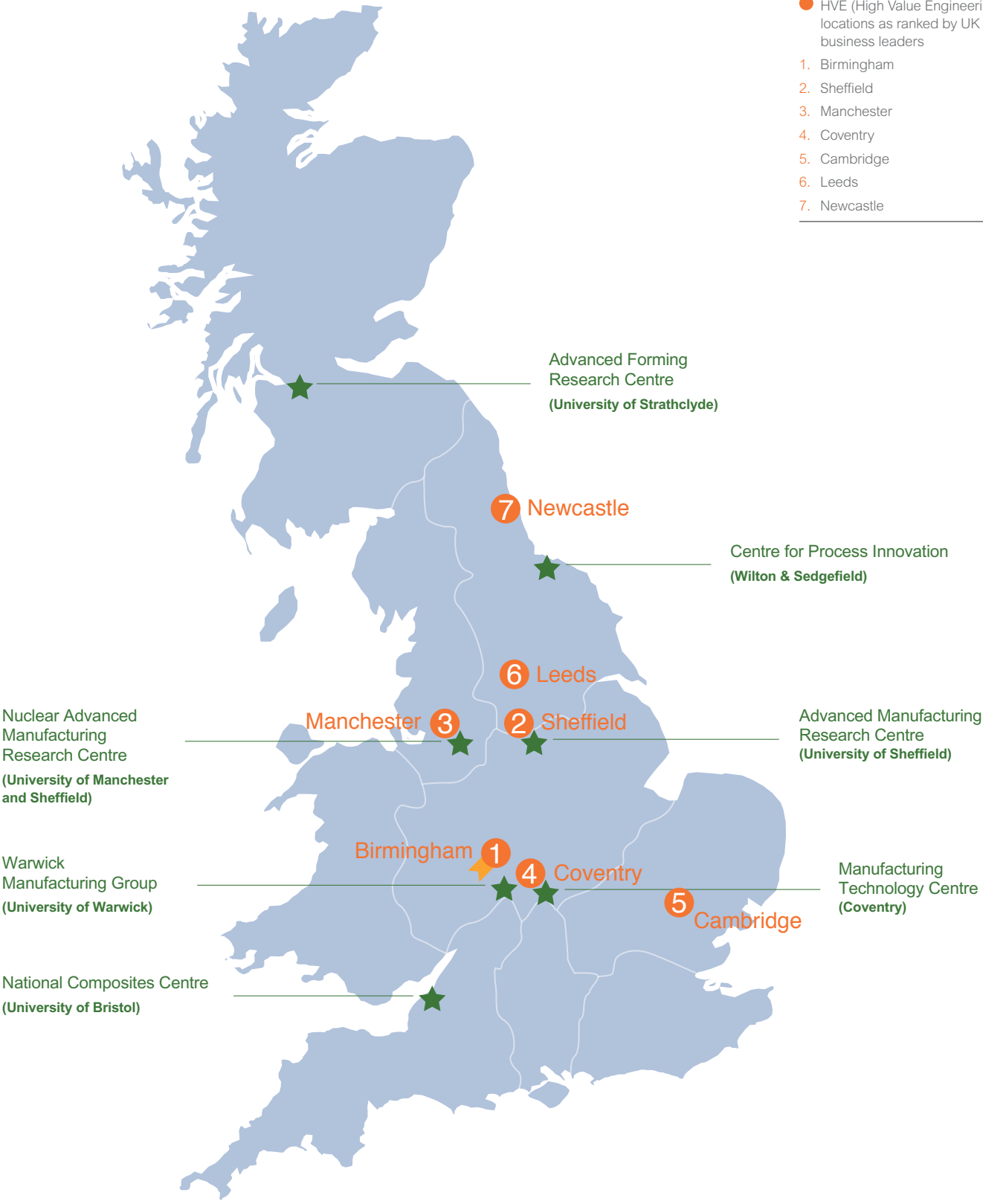
- Agree strongly
- Agree slightly
- Disagree slightly
- Disagree strongly

Key

★ TSB (Technology Strategy Board)
Catapult centres

● HVE (High Value Engineering)
locations as ranked by UK
business leaders

1. Birmingham
2. Sheffield
3. Manchester
4. Coventry
5. Cambridge
6. Leeds
7. Newcastle





You can waste a lot of time in beauty parades to access government research funding. ”

David McMurtry, Chairman and Chief Executive of Renishaw

Regional snapshot: Research and development

Manufacturers in Scotland (93%) and the North (92%) are the most likely to spend money on R&D. 87% of businesses surveyed in the South have an R&D budget, with slightly fewer (84%) in the Midlands making this crucial investment. One thing the North and South can agree on is the importance of R&D to the UK manufacturing industry – 100% of those surveyed in these areas described it as 'crucial'.

R&D shortfall

Research and development is where UK manufacturing looks worryingly behind the curve. Our survey results indicate that 78% of manufacturers spend between 1-19% of their annual turnover on R&D.

Beyond this, industry leaders say UK government funding for R&D compares unfavourably with our European counterparts.

'We believe the French government gives its aerospace sector eight times the funding the UK does, and there is some evidence that Germany does so twelve times as much,' says Graham Chisnall, Deputy CEO and MD of Aerospace at ADS.

A slow and unwieldy funding application process further dulls the UK's competitive advantage. 'You can waste a lot of time in beauty parades to access government research funding,' says Sir David McMurtry, Chairman and Chief Executive of Renishaw.

Key take-outs

- Investment in R&D in the UK must continue to increase significantly to keep pace with countries like China and Brazil
- UK HVE companies must work with government agencies to improve graduate training and boost SME research programmes to remain globally competitive
- Manufacturing must be repositioned in the UK as a high-prestige career path, as in Germany
- Efforts to attract increased government funding to HVE must be redoubled to compete with the likes of Brazil and China
- Business leaders in the UK can learn from Germany and China and work with the government to produce a coherent national manufacturing plan that includes simplified access to grants, accelerated training opportunities, and infrastructure support
- New production processes are the leading target for UK manufacturing research and development spend, the focus for 43% of business leaders who responded to our survey. New product development (16%), resource efficiency (13%) and materials integration (11%) are the next most popular R&D spending choices
- Birmingham, Sheffield, and Manchester are identified in our survey of UK business leaders as the top three cities to lead the further strengthening of the UK HVE segment on the world stage



Game-Changing Technologies

High Value Engineering holds the potential for levelling the playing field as the UK squares off against a pack of global competitors with structural and research and development funding advantages.

Game-changing technologies - micro- and nanoelectronics, advanced materials, industrial biotechnology, photonics, nanotechnology and advanced manufacturing systems – will grow by 54% from its 2008 level of £518bn to more than £800bn by 2015.

That's more than 8% of EU GDP. And the UK's HVE segment has the talent, technology and experience to dominate in each of these.

1. 3D printing

Hailed as the Third Industrial Revolution, 3D printing – a new and emerging technology for building complex, solid objects by tracing out thin layers of material – will revolutionise the fundamental concepts of mass manufacturing.

Able to make more efficient use of scarce materials and produce complex parts without secondary processing, or even assembly, it will increasingly be used to manufacture complex parts that replace multiple individual parts in today's designs.

This so-called 'additive' manufacturing – as opposed to old-style subtractive manufacturing where an object is finished by cutting material away – will mean that UK HVE will be competing for a share of a global market worth \$5.2bn by 2020.

'The old habits of 'design for manufacture' could become a thing of the past, as additive manufacturing can make almost any shape or geometric feature without expensive moulds or tools,' says industry expert Terry Wohlers.

Meeting the challenge

UK HVE companies are leading the R&D charge to find innovative ways around current challenges such as slow material deposition rates, and limits on the size and geometry of parts that can be made.

Researchers at Loughborough University are working on a project that will allow architects and construction professionals to 3D print entire concrete buildings.

At the same time, HVE companies such as EADS are anticipating the advent of a new business model shaped by 3D printing, in which the ability to print parts and components at the site and time of use will drive significant benefits in the form of shorter supply chains and lower operating costs.

'It's a new way of manufacturing,' says Ian Risk, Head of Innovation Works at EADS. 'We could change things significantly, and save money by shortening and simplifying supply chains, and cutting back the amount of warehousing needed.'

Global market growth

Key enabling technologies

54%

EU forecasts the global market for 'key enabling technologies' (micro- and nanoelectronics, advanced materials, industrial biotechnology, photonics, nanotechnology and advanced manufacturing systems) will grow 54% to more than €1trn by 2015.

R&D case studies

HVE futures: High performance, low cost materials

A team at Exeter University is working on a selective laser melting (SLM) technique to print aluminium composite parts – such as pistons, drive shafts, suspension components, and brake discs – for cars and aircraft out of low-cost, metal powders.

The technique is significantly cheaper and more sustainable than other SLM methods, and produces parts that are stronger and quicker to manufacture than those made using traditional techniques.

'Additive layer manufacturing technologies are becoming increasingly accessible, so this method could become a viable approach for manufacturing,' says Sasan Dadbakhsh of Exeter University's Centre for Additive Layer Manufacturing.

HVE futures: print your own aircraft

The world's first 3D printed aeroplane – an unmanned, electrically-powered plane with a 2m wingspan – has been built by UK-based rapid prototyping specialist 3T RPD from only four main components with no screws, rivets or adhesives to hold it together. Using conventional materials and techniques this process would have taken months to complete.

The technology used in the Southampton University Laser Sintered Aircraft (SULSA) allows a highly-tailored aircraft to be developed from concept to first flight in a few days. It promises to revolutionise the economics of aircraft design and the BBC is already planning a larger, more advanced model as a platform for aerial filming.

2. The Nanotech revolution

UK HVE companies are vying for their slice of a global nanotechnology market that is forecast to reach \$48.9bn by 2017, according to US-based BCC Research. The EU predicts that there will be 400,000 jobs in the nanotech sector across the European Union by 2015, up from 160,000 in 2008.

Nanotechnology, already used in sunscreen and strain-resistant clothing, creates materials, devices and systems by manipulating matter at a microscopic level - less than 100 nanometers.

Nanostructured materials, often transparent because their super-hard particles are so small, can bring huge value to the UK's High Value Engineering sector. These can be used in a wide range of products, such as scratch-proof and anti-glare fogging coatings for the automotive sector, anti-corrosion coatings for shipbuilding, more efficient solar cells and self-repairing structural materials.

Graphene is an example to the rest of the world of what can be achieved in this sector – and it was discovered and developed in the UK. Scientists at the University of Manchester won a 2010 Nobel prize in physics for their work in producing the ground-breaking material.

Graphene is the thinnest material known to man and is made up of a single layer of carbon atoms. It out-performs all other materials, conducting electricity as efficiently as copper, and is almost completely transparent.

Clear and flexible smartphone touch screens, hydrogen-powered cars, faster low-power electronic devices, better batteries and low-cost photonic sensors are just a few of the applications in development.

Meeting the challenge

Graphene illustrates the main obstacle that UK HVE firms face in bringing nanotech to market – cost. Not yet benefiting from economies of scale, it costs approximately £1,000 per sq m commercially.

But the University of Manchester team is working to bring down prices and already has some cutting-edge technological developments in their sights: foldable e-paper, display technology that mimics the appearance of ink on paper and can be used to manufacture ultra-thin computer keyboards and as an ultra-fast conductor in next generation high-speed wireless communications.

Harvesting the rewards of innovation for the UK is also problematic in nanotechnology. Graphene research is spread over several major sectors – semi-conductors, biotech and aerospace – across the world, meaning that only 21 of the 2,224 graphene patents filed to date, according to the Financial Times, are held by the UK.

But important steps have been taken to stop the UK losing the graphene initiative to multi-national integrated institutes of technology, such as Samsung.

A £50m Graphene Global Research and Technology Hub was launched by the Department for Business, Innovation and Skills in Autumn 2012 to take the technology swiftly from the lab to the factory floor in the UK.

3. Smart structures

Composite 'smart' materials that can directly store power and integrate communications cable into their structure could lead to the redesign of all electrical technology, and it's an area in which UK HVE innovators have internationally-recognised expertise.

The technology is already being used in aerospace components to stop wings icing during flight, while automotive companies are researching electrical energy storage devices to power the next generation of lightweight hybrid cars. Both uses point to the way in which HVE companies will be able to drive their own growth over the next decade by applying these technologies to the design and manufacture of new products that will offer substantial cost savings to consumers.

Meeting the challenge

The next step forward in this sector can be seen clearly in the UK where Volvo is working with Imperial College London on an EU-funded research project to introduce ultra-strong and ultra-light carbon fibre materials into commercial vehicles. Their sights are set on getting structural batteries into production vehicles within five to ten years.

It is this sort of collaboration that will allow the UK to pool its research capabilities and prosper against international competitors with larger R&D budgets.

R&D Case studies

Structural batteries for soldiers and racing drivers

BAE Systems is also developing the ground-breaking 'smart' batteries which are likely to see their first application as the power source for the zero emission Lola-Drayson B12/69EV, an 850hp Le Mans Prototype car developed in collaboration with race car maker Lola.

Military personnel of the next decade will march into battle with batteries integrated into their composite body armour, reducing the weight of the equipment they need to carry by as much as 76kg.

'This can not only support our military personnel on the frontline, but also revolutionise technology in the consumer market by allowing more efficient, elegant and lighter designs,' says Alex Parfitt, Capability Technology Leader for Materials at BAE Systems. 'Structural batteries can be used in virtually anything that requires electricity, from small gadgets to entire vehicles.'

“

There is a multitude of strong lightweight materials out there and making them is pretty easy. The trick is finding materials you can form, shape and join in a reliable, cost effective way.”

Professor Richard Dashwood,
Academic Director, Warwick
Manufacturing Group



Quantum switches

Sensors and switches that can be printed onto clothing and display screens are being developed by Yorkshire-based Peratech, inventors of Quantum Tunnelling Composite technology to integrate sensors and switches to a wide range of materials. Uses include hospital bed occupancy monitors to warn that a frail patient has fallen out of bed, respiratory monitors for athletes built into chest and wrist cuffs and pressure sensors to improve the comfort of prosthetic limbs.

The company is already reaping the rewards of a £1.1m venture capital investment, and won the 2012 Queen's Award for Enterprise in innovation. Its most recent innovation is a clear force-sensing material that has the potential to create a new generation of touch screens, for which a multi-million dollar license deal with a Japanese manufacturer has already been signed.

4. Composites by design

The UK is a world leader in the manufacture of strong, lightweight composite materials that have helped to revolutionise the aerospace industry. An example of this is the new Boeing 787 Dreamliner passenger jet which is made up of more than half of these materials.

Fibre reinforced composite materials, particularly carbon fibre reinforced plastics, offer many desirable characteristics. They are strong, stiff, light in weight and can be made into large, complicated shapes.

It's a market that will pay big dividends to dominant players. Global sales are estimated to rise to \$48.7bn in 2020 from \$16.1bn in 2012, according to UK-based Materials Technology Publications.

The super-light, super-strong composite lies at the heart of major expansion of the wind energy sector, which is estimated to use 54,000 tonnes of carbon fibre a year by the end of the decade, from 16,400 tonnes in 2011. Carbon fibre is also used in the construction of planes, spacecraft, high-performance race and sports cars.

Meeting the challenge

UK HVE research and industrial development divisions are focusing on accelerating and automating manufacturing processes, reducing the number of man-hours needed to assemble composites, and using innovative heat and infrared systems to cure parts.

'Our development work in composites is less about fibres and more about manufacturing technologies: automatic tape laying and fibre placement technologies, out-of-autoclave curing of resins,' says Mike McCann, Senior VP of Business Development and Strategy, GKN Aerospace.

UK companies are also revising the design approaches they use to make optimum use of the unique properties of composite materials.

'Early composite parts were treated as 'black metal' structures, but now companies are thinking about how to design the parts take full advantage of the qualities of the composite material. Just one example would be designing to reduce the need for mechanical fasteners,' says McCann.

R&D Case study

HVE futures: 3D weaving

New weaving technologies are under development in the UK to allow the creation of 3D shapes from composite materials without the use of curved moulds. The Textile Centre of Excellence in Huddersfield, home to the UK's traditional weaving industry, is one of those at the forefront of this 3D weaving technology and is currently developing a range of prototype parts for customers in the automotive sector.



We have the best cluster for carbon fibre-composite, aircraft wings and components anywhere in the world. People like Bombardier in Northern Ireland, Airbus, GKN and Spirit are doing things that aren't done anywhere else.

Graham Chisnall,
Deputy CEO and MD
of Aerospace at ADS

Key take-outs

- The UK HVE segment needs to focus on nanotechnology, advanced materials and manufacturing systems to take advantage of a global market worth more than 8% of EU GDP - by 2015
- 3D printing will signal a Third Industrial Revolution for the HVE segment, shortening and simplifying supply chains and reducing the need for warehousing capacity. The resulting cost savings will free up capital to be used for vital recruitment and research and development
- New manufacturing capabilities and supply chains will be vital to allowing HVE companies in the UK to harness the competitive advantage of nanotech breakthroughs such as graphene
- Collaboration between HVE companies is essential to provide the level of investment in production, marketing, technical support and recycling needed to take advanced smart materials into new growth markets
- Both industry and government continue to need to make substantial investment in selective technologies to ensure that the UK remains a world leader in the HVE segment



The Factory of the Future

A radical departure from the factory floor of today, factories of the future will be cleaner, leaner and more efficient than ever before.

Skills and innovation advantages in nanotechnology, 3D printing and composite materials will give UK HVE a head start on its global rivals. But that lead will be cemented by the new wave of smart design systems and intelligent machinery that will power the country's factories of the future.

Machines that design themselves

Intelligent machines such as 3D computer-aided design systems are already allowing faster and more efficient production of increasingly complex products.

Exploring design options faster than any human operator, they can 'evolve' optimum parts by testing the performance of different shapes and creating new designs from the best features of existing parts.

But the next generation of systems will go one step further, thinking their way through an electronic catalogue of standard parts to independently select exactly the right combination of control components. These components will then operate the hydraulic systems of, for example, a crane or earth moving machine.

Suddenly, engineers will be freed up from the mundane, repetitive part of product design to spend their time finding innovative ways to

deliver the next generation of product types and ranges, driving the evolution of the HVE segment into the future and producing new and lucrative revenue streams.

Automatic factories

Intelligent factories that move away from the production of batches to a continuous process that offers greatly improved speed, flexibility and reliability – this is the next stage of manufacturing in the UK.

The ability to customise products will be increasingly important in the future. It will be the UK HVE companies that are able to offer a high level of customisation – and deliver this to short timescales – that will see the increase in orders and income needed for growth.

The pharmaceutical industry offers insights with the exploratory use of Process Analytical Technologies (PATs) that analyse the composition of drug products in real time during manufacture. They can then modify process parameters to deliver much tighter control over the specification of the final manufactured drug.

US chip maker Intel uses a similar methodology, Copy Exactly!, to allow plants across the world to produce highly-sophisticated products with equal levels of quality and material yields.

“

The factory of the future will have only two employees: a man and a dog. The man will be there to feed the dog. The dog will be there to keep the man from touching the equipment.”

Warren G Bennis, Founder,
University of Southern
California Leadership Institute



Physically making stuff can be part of your innovation process. ”

Professor Sir Mike Gregory, Institute for Manufacturing, Cambridge University

From factories to Fabs

Fabs – derived from fabrication laboratories or ‘fab labs’ – are general-purpose industrial fabrication hubs located close to where a manufactured product will be used. They will harness advances in 3D printing technology and will mark the next stage in the evolution of the factory.

Changing the shape of UK industry, each Fab will serve multiple customers and markets, allowing manufacturers to print products and parts as needed. This will dramatically reduce the need for large-scale dedicated production facilities and therefore capital investments.

HVE companies like Proto Labs in Telford already provide services similar to that of Fabs. In the future, virtual prototyping and analysis tools will automate and verify machine programming, and companies will use advanced planning and scheduling techniques to dynamically allocate tasks to the right manufacturing resources.

HVE futures: Fabs in space

These advanced, automated, fabrication technologies will allow products to be manufactured much closer to the eventual point of use, whether that's the production of spare parts for military equipment on the battlefield – or even in space.

Leicestershire engineering firm Magna Parva is currently being funded by the UK Technology Strategy Board to develop a process for the production of large composite structures in space.

The company aims to use pultrusion technology – a mix of pulling and extrusion – to create large, lightweight structures containing embedded sensors.

As the parts won't have to fit in the confines of a space launch vehicle, they can be larger than those currently available for the construction of satellites or space stations. They can be thinner and lighter too, since they won't have to withstand the earth's gravity, or the high forces involved in the space launch.

HVE futures: Man and machine

A synergy of more than 70 of today's technologies and enablers – from nano-enabled production to machine-to-machine cloud connectivity for future manufacturing enterprises – will create a future factory floor where man and machine work seamlessly together, according to the European Factories of the Future Research Association (EFFRA).

In the future, it predicts, HVE companies will see major impacts from key technologies:

- Intelligent machines that use enhanced navigation and perception technologies to sense their work environment
- Smart wireless networks and real-time communications that let manufacturing systems adapt, learn and predict performance and energy use
- Intelligent, continuous monitoring technology will adapt manufacturing to optimum performance and energy use on a second-by-second basis
- Smart components in flexible, reconfigurable production systems will maximise safety, efficiency and accuracy

Future technology imperatives

UK industry is firmly backing High Value Engineering technologies such as composite materials and additive manufacturing as business leaders decide on strategies to make their companies fit for the future.

One fifth (20%) of those surveyed felt that embedding sensors and intelligent systems into manufacturing processes and investing in adaptive, knowledge based production systems would play a significant part in increasing UK international competitiveness over the coming decade.

The merits of advances in 3D printing techniques as a driver of competitive advantage are seen by a significant proportion, with 17% predicting improvements in the speed and accuracy of additive manufacturing will have an impact, and 15% expressing the same sentiment about developing advanced automated fabrication to make products closer to point of use.

It's encouraging to see – as revealed earlier in the report – that new production processes, such as additive manufacturing, are a key focus for research and development expenditure for 43% of those surveyed.

A tiny 4% of those surveyed named nanotechnology and nanosciences as the key target of their R&D spend, with only 5% focusing on innovative data interpretation and management.

Regional snapshot: Facing the future

Opposing ends of the UK are the most confident in facing up to the challenges and opportunities in UK manufacturing over the next decade. 81% of manufacturers surveyed in both Scotland and the South of England described themselves as either extremely or quite confident that their business is equipped to be ahead of the competition in 10-15 years time. 77% in the North and 74% in the Midlands shared this confidence.

Key take-outs

- More UK manufacturers need to focus on the importance of the technologies of tomorrow. For example, only a fifth (20%) of business leaders currently feel that investing in technology such as intelligent and adaptive production systems will shape their future international competitiveness
- HVE companies will need to invest in intelligent machines, such as 3D computer-aided design systems, that will allow the introduction of new business models. These models will include production closer to the point of use and the replacement of batch production by a continuous customised process that improves speed, flexibility and reliability
- The growth of Fabs, general-purpose industrial fabrication facilities, serving multiple customers and markets, will change the industrial landscape of the UK by allowing manufacturers to print products and parts as needed, reducing the need for capital investment in large-scale dedicated factories
- Networked, machine-to-machine communication will enable HVE companies to manufacture far more easily across sites, predict performance and match output to demand in real time



HVE's Twin Time Bombs

The potential for HVE to drive growth and create competitive advantage for the UK is threatened by two time bombs lurking within the country's manufacturing sector.

As this report has shown, taking a lead in key enabling technologies and building state-of-the-art factories are vital factors in establishing UK HVE as a world leader.

But two key gaps will need to be addressed now if UK HVE is to prosper in the future.

The first time bomb is training. And it is only by acting now to strengthen the country's skills pipeline and investing in rising UK talent that the HVE segment will be able to benefit from existing competitive advantages.

The second is the UK's supply chain, hollowed out by years of off-shoring, and now in need of urgent remedial action.

Time bomb one: The war for talent

The UK's HVE segment is struggling to find the 1.25m science, engineering and technology professionals and technicians it will need by 2020 to support the country's economic recovery.

'We need clever people with hungry minds to drive innovation. If we stop moving we would disappear into insignificance,' says Peter Morgan, Director of Corporate Affairs, Rolls-Royce.

Retiring boomers

Engineering skills are seeping away through natural wastage as the Baby Boomer generation retires.

The engineering workforce is older than the national average: 14% of its employees are 60 or older, compared with 12% of the UK as a whole. Only 9% is younger than 25, compared to 14% in the rest of the economy.

'We have a lot of experienced people in the last third of their careers, and far fewer in the first third,' says Tim Roustis, CEO, Cosworth.

Graduate gap

Britain's universities are failing to produce the 100,000 STEM (science, technology, engineering and maths) graduates that will be needed each year between 2012 and 2020 by the country's manufacturers, according to The Sector Skills Council for Science, Engineering and Manufacturing Technologies (SEMTA).

Only 90,000 STEM students currently graduate, and over a quarter don't enter the sector, so there is already a major shortfall.

To compound matters, many graduates lack crucial foundation skills needed by HVE companies and the House of Lords recently noted that 85% of students have given up maths at 16.

'The skills pipeline is leaky at every point. Even when students make their initial GCSE choices we are losing people who could be future engineers,' says Lee Hopley, Chief Economist, EEF.

Our biggest ask from policymakers is on education. The more people who study STEM subjects at school and who take engineering at university, the happier we'll be,' says Peter Morgan, Director of Corporate Affairs, Rolls-Royce.

Recruiting for the future

A shortage of skilled workers at both ends of the career pipeline is also squeezing the middle, as top graduates are tempted into non-manufacturing jobs by high wages, and skilled and experienced talent is subject to ever-fiercer, inter-company competition.

To make matters worse, the HVE segment is failing to attract a demographic that makes up almost half the entire workforce – women.

Women today account for only around 20% of the engineering sector's total workforce, and even less in highly-skilled, technical and managerial roles: only 6% of practising professional engineers are women, according to the Institution of Engineering and Technology. Women are also under-represented at board level across the manufacturing sector.

Skills challenge to growth

Research with the UK's manufacturing leaders identifies the need to plug a growing skills gap as the key challenge for the growth of the HVE segment.

One in three (30%) of respondents to the survey feared that recruiting enough staff with the necessary high-level technical skills was a source of potential weakness in their growth strategies.

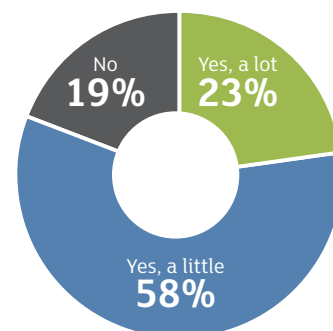
Challenges with succession planning amplified this problem with a quarter of those surveyed (25%) worried that they would be unable to find suitable replacements for retiring experienced workers.

A fifth (19%) of manufacturers identified the third strand of the challenge as the need to re-train current staff with new skills.

However, there does seem to be a worrying disconnect between the understanding that a skills gap exists and the introduction of firm strategies to address it. Only 12% of manufacturers said they are investing in apprentices to ensure they are competitive over the next 10-15 years. A mere 11% intend to spend on higher-level skills during the same period.

Nine out of ten (88%) also feel that their business could do more to work with universities and other research centres.

Do you expect your company to invest in apprentices over the next two years?



Regional snapshot: Skills training

There are clear regional divides in the importance placed upon training the next generation of HVE engineering talent in Britain. Nine out of ten (88%) businesses in the North said they are expecting their company to invest in apprentices over the next two years. This proportion falls to 83% as you move down the country to the Midlands and to only 75% in the South of England.

What this means for the HVE segment

Tomorrow's novel design and manufacturing will demand multi-disciplinary, engineering skills. Focused attention by individual companies, industry groups and government is needed to maintain the right supply of skilled people.

College collaborators

Employers will need to work more closely with colleges and universities to ensure course content includes the theoretical basics of engineering and technology that the industry needs.

'Certain universities and colleges understand they are responsible for one step in the chain of delivering people into the workforce. They actively seek input from employers about what they need,' says Tim Roustis, CEO of Cosworth. 'But that approach is certainly not universal.'

Developing professionals

HVE companies and their supply chains will need to become more systematic in the development of their talent.

Beyond formal education, the development of skilled workers becomes the responsibility of industry. The development of engineers and technicians in the critical early years of their careers is a weak-spot in the UK's production line for engineering talent.

'Developing your own people is good, but it takes five years,' says Dave Shemmans, CEO of Ricardo.

Traditionally, much of the responsibility for this is taken by the large, first-tier suppliers and prime contractors, through apprenticeship and graduate development programmes, with smaller companies and consultancies recruiting staff from them.

As the war for talent intensifies, this natural development process is already reaching its limits.

'I'm concerned that we could [soon] be stealing from each other', says Mike McCann, Senior VP of Business Development and Strategy, GKN Aerospace.

Some are already taking steps in the right direction. Rolls-Royce, for example, is doubling the capacity of its apprentice training academy in Derby to take on around 200 staff selected from companies in its supply chain.

Time bomb two: The hollow supply chain

HVE companies will need to act now to ensure that they are equipped to develop and manufacture products across an extended, more flexible and more collaborative supply chain.

Confidence is high amongst many UK manufacturers. Three quarters (78%) of survey respondents describe themselves as 'confident' that their business is equipped to be ahead of the competition in 10-15 years time.

Competitive strategy deficit

Apparent confusion about the most effective way to drive short-term business growth raises serious questions about whether that confidence has firm foundations.

The survey suggests that a huge majority of business leaders appear to have no plans to adopt key strategies to secure the growth upon which any competitive edge must be based.

Nine out of ten (86%) of those surveyed have no plans to enter new geographical markets and the same statistic applies to those contemplating the launch of new products over the next two to five years.

More worrying still, 88% will not be improving their supply chain or investing in current staff, both strategies that are identified as crucial to growth by industry experts in this report.

'There has been an erosion of the lower supply-chain tiers in some sectors, and that is becoming a pressing issue with some industries struggling with capacity constraints, but it will take a while to turn the tanker around,' says Lee Hopley, Chief Economist, EEF.

It will mean revitalising the UK's 'hollow' supply chain. 'Off-shoring has depleted the UK supply chain. We need to think about how best to rebuild it,' agrees Professor Sir Mike Gregory, Institute for Manufacturing, Cambridge University.

Back in the UK

The allure of high-quality domestic production and supply chains is growing for UK manufacturers as they plan their strategies for growth for the coming decades. More than a quarter (27%) of respondents to our survey plan to keep all manufacturing in the UK, a further 12% are planning to move some manufacturing back to Britain and a fifth (19%) will source more of their supply chain domestically.

This compares to 16% who will move some manufacturing overseas and 14% planning to shift more of their supply chain out of the UK.

Building the supply chain of the future

Workload sharing with partners and suppliers will become a key solution for HVE companies struggling to retain all the in-house skills needed to create the complex consumer products of the future.

Strategy consultants Roland Berger predict original equipment manufacturers (OEMs) and suppliers in the automotive sector will increasingly share resources, allowing convergence and learning from other industries.

Prime contractors and OEMs will have to focus today on developing and embedding the skills needed to manage performance beyond the walls of their organisation. Much of the multi-year production delay that afflicted Boeing's 787, for example, has been attributed to the challenges of coordinating suppliers, after the company chose to radically increase the amount of work outsourced to its supply base.

According to the McKinsey article 'Building the supply chain of the future' (January 2011), it is forecasted that successful manufacturing companies will 'splinter' their supply chains into smaller, nimbler configurations. Restructuring supply chains according to how volatile demand is for products will enable companies to build resilience against the next five to ten years of uncertainty.

For suppliers, there are two areas where immediate action should be taken:

- 1) They will need to invest in stronger technology development capabilities. Fast growing HVE companies need a sophisticated supply base to draw upon. 'Our indigenous supply chain has to be a concern. There is a big growth curve and a level of risk that they won't be able to handle the work load, particularly as access to capital has become tougher for them,' says GKN Aerospace's Mike McCann.
- 2) They will also need to look to the future, to ensure they have sufficiently diverse revenue streams to stay healthy when OEM demand is low. 'We don't want to be the most important customer for our suppliers, because we don't want them failing if we can't give them the work,' says Colin Paynter, CEO of satellite maker Astrium.

Key take-outs

- Urgent action is needed by UK manufacturers to plug a growing skills gap that is threatening to stop the HVE segment realising its full growth potential. Three-quarters of business leaders (74%) identified recruiting and training highly-skilled staff as a key challenge for the future
- HVE companies need to work closely with the education sector to produce workers with the right training, to combat a skills squeeze caused by retirement of older staff and lower numbers of engineering graduates
- Supply chain flexibility should be high on all HVE companies' agendas, alongside new strategies for collaborating with suppliers



A High Value Nation

HVE has the potential to bring growth to all areas of the UK. Yet there are differences across regions in the strategies that manufacturers are employing to realise this potential, and in the confidence that companies show for the future.

Research by the Centre for Cities shows that 33 cities in the UK identify advanced manufacturing as a current or future key strength.

Our survey of business leaders in SME and mid-corporate manufacturing businesses from across the country reveals a varying commitment to the responses identified within this report: investing in research, commercialising new technologies, and defusing the skills and supply chain time bombs.

Northern manufacturers look to new markets

In our survey, manufacturing business leaders in the North of England are confident about the future. Only 16% think their turnover will stay the same or shrink over the next five years, and one in five say turnover will grow by more than 50%.

Looking further ahead, four out of five business leaders are confident that their company is equipped to stay ahead of the competition by 2027.

Northern manufacturers have already identified that they need to work more closely with the UK's world class research base in order to commercialise the technologies that will lead HVE companies to growth. 62% of the region's businesses say they could do more to work with local universities and research centres.

Universities in the region may have to work harder to convince local companies of the benefits of collaboration in research – of all regions, manufacturing firms in the North are less likely to agree that UK universities give the sector a big advantage over other economies.

It's clear that companies in the North are already looking globally, both at new competitors and to new markets. 28% of businesses in the region are looking to new geographical or product markets to drive business growth, while a forward-thinking 7% are already looking to work in partnership with overseas companies.

Closer to home, 26% say they will work to keep manufacturing in the UK over the next five years, while 16% are looking to move off-shored manufacturing back to this country and 18% aim to source more of their supply chain from the UK.

Manufacturers are also investing in staff: 11% say they will take on more staff to kick-start growth by 2017, and 12% will invest more in their current staff, though 29% identify finding staff with the right skills as their biggest challenge.

New markets

28%

of businesses in the North are looking to new geographical or product markets to drive business growth, while a forward-thinking 7% are already looking to work in partnership with overseas companies.

Vision of a low carbon Midlands

Although nearly one in five manufacturing companies (20%) in the Midlands predicts static or shrinking turnover in the next five years, this still sees more than 80% of the region's manufacturers predicting growth. An optimistic 11% see their turnover growing by more than 50% in that time. Three quarters (74%) are confident that their businesses will be able to compete – and win – over the next ten to fifteen years.

Companies in the region know that R&D will be crucial for this – 96% agree – and yet 16% of the region's companies spend nothing on research and development. Encouragingly 11% say they plan to invest more in R&D for the next two to five years.

Some of this investment will be in energy and resource efficiency and products and services for the low carbon economy, which are predicted to be key technologies for the region - one in five business leaders surveyed in the Midlands see these areas as key to growth for UK manufacturing.

To realise this potential, companies know they will have to focus R&D on key areas, and identify new production processes (45%) as by far the most important of these. One in five Midlands companies already predict that intelligent manufacturing will have the greatest impact on UK manufacturing competitiveness.

The region's companies are also addressing the two time bombs identified by this report. 12% of manufacturers in the Midlands identified investing in skills and apprentices and strengthening the supply chain as equally important for growth, second only to finding new product markets (14%).

Yet companies in the region risk missing out on a key area of the workforce, with only 3% identifying the need to bring more women into senior positions in the business as a priority for the future.

Confident South invests in innovation

Manufacturing companies in the South of England show the most confidence about their future in the sector: more than one in five say they are 'extremely confident' about their business competitiveness for 2027.

They are also the most likely to say they will work to keep all manufacturing in the UK (28%) over the next five years.

To do so, they will be investing in innovative combinations of technologies and advanced materials (both 13%) and focusing R&D on new production processes (41%) and new product development (21%).

Strategically, companies in the South are looking to strengthen their supply chains (15%) above entering new geographical markets (13%) although the primary focus remains finding new markets for existing products (16%). One in five companies are seeking to source more of their supply chain from within the UK.

12% say they will take on new staff in the next two to five years, but one quarter of companies in the region say they are not looking to invest in apprentices as part of the drive to recruit staff with the right skills for the future. Perhaps because of the draw of the capital, nearly one in ten (9%) manufacturing firms in the South acknowledge that they are increasingly competing with other sectors for skilled graduates.

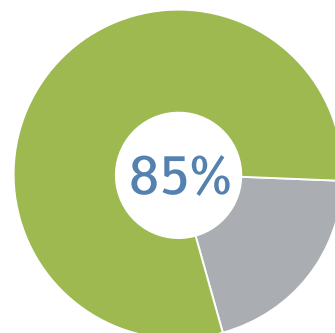
The region's business leaders also know their businesses could do more to work with local and national universities and research centres - 85% see this as a potential path to faster commercialisation of research and increased turnover.

Investing in skills



12% of manufacturers in the Midlands identified investing in skills and apprentices and strengthening the supply chain as equally important for growth, second only to finding new product markets (14%).

Working with universities and research centres



85% of manufacturers in the South see working with universities and research centres as a potential path to faster commercialisation of research and increased turnover.

Scotland's supply for the future

R&D and supply chain readiness will be the engines of growth for Scottish manufacturing companies. 94% of companies in Scotland invest annually in research and development, and for an impressive 11% this is between 20 and 39% of their turnover.

New production processes are the main focus for this research and development, with 52% of companies seeing this as a key area for the next five years. Scottish manufacturers risk missing out on the rewards offered by new ways of managing and interpreting data, however – none of the companies in the region in our survey were putting R&D budgets into this area.

Scottish manufacturers are also the most likely to champion UK supply chains, with 22% planning to source more of their supply chain from the UK. The region is also the only one in the UK where strengthening supply chain ranks top among the strategies companies are already employing in order to remain competitive into the next decade: it rates just above exploring new markets and developing new business models.

Despite this forward-looking approach, almost one in five (19%) Scottish business leaders say they are not confident about their company's chances in a rapidly changing sector and 18% think their company turnover will shrink or remain static in the next five years.

Companies in the region know that a key challenge here, one which must be met if they are to reverse this prediction, is skills. Recruiting people with the right skills, succession planning for retiring workers and retraining current staff with new skills are the most pressing concerns. 11% say they will take on new staff in the next two to five years, however, and 79% of companies plan to invest in apprentices by 2014.

Companies investing in Scotland

94%

of companies in Scotland invest annually in research and development, and for an impressive 11% this is between 20 and 39% of their turnover.

Strategies for Growth

Speed, agility, and stamina will be the key requirements of tomorrow's HVE companies as they make the strategic decisions necessary to maintain a global lead over competitors from developed and emerging markets.

From managing information to enabling diversification, HVE companies must invest today in order to ensure growth over the next decade.

Our expert panel has pinpointed five urgent discussion points for the agenda of every manufacturing boardroom in the UK:

- Investment in data management capabilities
- Accelerating commercialisation of innovation
- Diversifying for growth
- Understanding customers and customisation
- Identifying long-term growth markets

HVE companies need to embrace these strategies, making use of new technologies, such as 3D printing and composite materials, and revolutionary Fab facilities. Their adoption will produce new business models, benefitting from short, agile supply chains and lower fixed cost and working capital needs, permitting further investment in research and development.

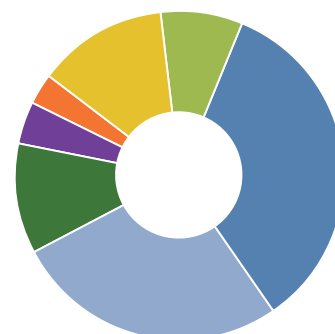
The data imperative

In a global marketplace, companies in the UK HVE segment must be able to outspurt their competitors.

Lightning-fast changes in production volume and mix to meet evolving patterns of demand and advanced analytical capabilities will form what Accenture describes as 'agility on the shop floor and beyond' in their article 'What's your plan for 2025?' (2010).

Essentially, this will mean that future HVE success will hinge on an ability to aggregate, analyse and communicate Big Data. The capability to handle a new level of storage, computing power and deep analytical expertise will allow UK manufacturers to harvest valuable insights into the efficiency of their supply chains and end markets and make cost-saving real time adjustments whenever necessary, according to the Mckinsey Global Institute publication, 'Big data: The next frontier for innovation, competition, and productivity' (June 2011).

Do you believe your company's turnover will grow or shrink over the next 5 years?



Key

Grow by over 50%	13%
Grow by 30-49%	8%
Grow by 10-29%	34%
Grow by 1-9%	27%
Stay the same	11%
Shrink by 1-9%	4%
Shrink by 10-29%	3%

Innovation giants

Size will matter for successful UK HVE companies in this decade and beyond. A new type of company will need to emerge – a giant with the agility and hunger of a business start-up.

They will need to commercialise innovation and new technologies faster than both established markets such as the US and Germany, and emerging economies such as China and Brazil, which are currently investing heavily in HVE.

UK HVE companies will need to continue to invest in research and development, work closely with universities, patent new ideas efficiently and strive for excellence in design and production.

‘There are some sectors where small entities can be a real engine of innovation, but most of our industries are not in that category,’ says Graham Chisnall, Deputy CEO and MD of Aerospace at ADS, when describing HVE companies.

‘We need sustained investment of human and financial resources over the long term - and that calls for big companies.’

Only these HVE giants will be able to sustain the high capital and knowledge intensity of sectors such as aerospace, where product development cycles are measured in years rather than months.

‘We are still enjoying the benefits of significant investments in past technologies. The Airbus A320, for example, was a stunning success. 5,000 have been built or ordered so far,’ adds Chisnall.

‘All the wings were built in the UK and the majority still will be, and that project was the direct result of government and industry investments 30 years ago.’

‘We need to get innovations out of universities more quickly. Today it takes years instead of months or weeks,’ says Professor Paul Shore, McKeown Professor of Ultra Precision Technologies, Cranfield University.

‘This risk of going too slowly is much bigger than the risk of getting things wrong.’

High value diversification

The hunt for long-term return on investment in technologies and manufacturing capabilities will drive HVE companies to seek out more diverse markets for their core skills and technologies.

Accepting that it’s hard for companies to perform well across multiple markets with little in common, HVE companies must acknowledge that the markets that built them will not necessarily be the ones that sustain them.

Diversifying now is one way to gain a foothold in the markets that are capable of offering them sustained growth over the coming decades.

‘We have diversified on the back of our mechanical engineering and electronics expertise,’ says Tim Roustis, CEO of Cosworth, whose company has built on its motor sport background to carve a niche in the development of products for the aerospace and defence markets, including engines for military unmanned aerial vehicles.

Case study: From rocket science to brain surgery

Sir David McMurtry developed the first high-precision industrial measuring probe in 1973, to measure the complex shapes of components in the engines of Concorde, which was commercialised in 1973 by Renishaw, the company he co-founded with John Deer.

Nearly 40 years later, it uses the same expertise to produce neurosurgery robots used for the spatial positioning of surgical devices deep inside the brains of patients.

The company has continually diversified its activities, entering new markets that allow it to make use of its expertise in flexible, high precision manufacturing and on strong patent protection.

The key, says Sir David McMurtry, Chairman and Chief Executive of Renishaw, is finding solutions to issues that cost customers a lot of time and money. ‘We make whatever our customers do more cost effective. How much we do that is what gives us the ability to penetrate a market.’

Customisation 2.0

If HVE companies are to exploit the game-changing opportunities offered by digital manufacturing, they will need to adopt a new approach to product design. Putting Beta versions quickly into consumers’ hands and ironing out flaws in future models will become much more important than spending years designing a perfect product.

“

Our members worry about being able to capitalise on opportunities faster than their competitors. Their focus is on building the internal capabilities they need to take an idea and make it happen.”

Lee Hopley, Chief Economist, EEF

This will alter the balance of power between manufacturers and their customers: companies prepared for this now will be far better placed for future growth.

‘We are not going to grow faster than everybody else just by boosting efficiency, we need to invent and make the things that people will want in the future,’ says Professor Paul Shore, McKeown Professor of Ultra Precision Technologies, Cranfield University.

Future generations of products will evolve faster, with rapid iterations in design and far tighter collaboration between designers, manufacturers and their customers.

Manufacturing flexibility will allow companies to tailor their products to suit the needs of niche user groups or individual customers.

Engineers and designers will need ways of generating deeper insights into the real issues their customers face and of allowing them to evaluate potential solutions faster.

Techniques developed to increase the speed and efficiency of software development show how this can be done. Agile software development, an approach pioneered in 2001 by a group of US-based software engineers, emphasises rapid, iterative product development and prioritises getting a working, if limited, product into the hands of customers above attempts to deliver a comprehensive and fully-documented solution.

From its inception in the software sector, the agile philosophy has crossed over into engineered products too. Apple’s now ubiquitous iPhone was launched with a far smaller number of features than customers currently enjoy, or even than that offered by rival products at the time, but the radical user interface it did offer drove rapid adoption and created pull for future iterations of the product’s hardware and software.

Eric Ries, entrepreneur and author of ‘The Lean Start up’, promotes the concept of the Minimum Viable Product (MVP) as a way for companies to enter and test new markets in order to start gathering essential user feedback that will allow them to refine and improve their offering, or even inspire them to tackle a totally different user issue.

Long term growth markets

For many established HVE companies, the search for long-term growth will involve geographical diversification. The automotive and aerospace industries already rely on wealthy customers in the fast-growing BRIC economies for their growth.

By 2020, 1.2bn people across the globe will move out of subsistence poverty according to World Bank’s report ‘Global Economic Prospects’ (2007). The report also states that these new consumers will have annual disposable incomes surpassing \$5,000 for the first time, and this new pool of discretionary spend is a huge opportunity for consumer goods firms and the manufacturers who supply them.

A number of the key trends identified in Bain & Company’s report ‘The Great Eight: Trillion-Dollar Growth Trends to 2020’ (September 2011) show where there are opportunities for UK HVE companies. Overall, the report sees the global economy expanding at a 3.6% annual rate and world GDP swelling to \$90trn by 2020, 40% larger than today.

This means more nations will demand more efficient processing of resources – from oil and wind, to rare earth metals or even corn.

And defence companies should look to the growing defence spending in China and its neighbours, and the global demand for products and technologies to meet the new challenges of cyber and electronic warfare.

Accessing such markets will require HVE companies to produce a new generation of ‘frugally-engineered’ products that offer high levels of functionality at a fraction of the cost of their predecessors.

Changes in established markets will provide new opportunities too. The transition to a low-carbon economy will call for significant investment in renewable energy technologies, while the ageing population of the developed world will continue to grow the market for healthcare technologies and create huge new markets for ‘accessible’ consumer products designed to meet the needs of elderly and physically impaired consumers.

Bain & Company predicts that changes in payment systems to make healthcare spending more efficient will spur innovation and estimates the global contribution to GDP of healthcare spend will be \$4trn by 2020.

Key take-outs

- UK manufacturers are not yet addressing some of the key issues that will allow them to grow and compete internationally over the next decade. Only one in ten (10%) are planning to increase their R&D spend over the short term, and only 11% plan to invest in higher-level skills across their business
- HVE leaders in the UK must invest now in data prediction and analysis talent to stop their competitors scooping the most skilled people and gaining significant competitive advantage
- The UK needs to accelerate its percentage of R&D expenditure, relative to GDP, for this segment if it is to outpace HVE rivals such as China and Brazil in long-term technology development. This will be essential if it is to achieve sustainable competitive advantage
- Diversification strategies must be a core part of HVE companies’ business plans over the next five to ten years if they are to realise the full potential this segment will generate
- Lessons must be learnt from software and consumer electronics companies to allow UK HVE companies to provide the level of customisation that consumers demand
- Understanding the demands of the ‘next billion’ consumers in emerging markets, and an ageing population at home, will be vital for penetration in future growth markets



Recommendations for Businesses' Manufacturing Strategies for 2027

Turbulent times lie ahead as UK PLC tries to balance the challenges of resource scarcity, energy insecurity and increased international competition against the consumer demands of a rapidly growing global population.

High Value Engineering is the ace up the UK's sleeve. It represents a very real opportunity to leverage the country's competitive advantage in highly skilled design and manufacturing techniques into a position of genuine global leadership.

At a time when the UK's competitors are single-mindedly targeting research and development and the identification and nurturing of new talent as they gear up for growth, UK HVE companies must plan today to meet the commercial challenges of tomorrow.

Across the UK, 28% of manufacturing business leaders say they plan to drive business growth over the next two to five years by entering new geographical or product markets.

Yet, just 11% are actively developing new business models, only 8% say they are investigating a move to Higher Value Engineering and only 3% are working to commercialise technologies from the UK's world-renowned research base.

To ensure they can compete, HVE leaders and innovators should consider adopting this blueprint for future success:

- Britain's world-beating High Value Engineering companies need to act now to secure growth for their business – and the UK as a whole – by taking their slice of a global market in nanotechnology, 3D printing, smart materials and a new generation of composites that will be worth \$800bn and encompass 400,000 high-skill jobs in the EU by 2015.
- To do so, expenditure on research and development must increase substantially – and soon. Only one in ten (10%) of UK HVE businesses are planning to increase their R&D budget in the short term while their competitors in China and the Asia Pacific are outspending the US in this area for the first time in history.
- Research and development spending must be focused on the technologies of tomorrow. This report demonstrates how technologies such as composite materials and additive manufacturing will be key global growth areas for manufacturing in the next decade and beyond. Half (53%) of business leaders agree these are crucial for making their business fit for the future.

- HVE leaders in the UK must encourage government to further increase their funding of the segment and simplify the current funding application process. Despite recent initiatives, government funding, relative to GDP, is still perceived by parts of the UK HVE segment to be significantly lower than other competing countries.
- Britain's manufacturers must learn from their rivals in China and Germany and work with the government to produce a coherent national manufacturing plan that simplifies access to grants, launches accelerated training initiatives and provides infrastructure and logistical support.
- Launching apprenticeship and systemic reskilling schemes, and forming skills partnerships with universities to produce many more STEM graduates to plug the UK's widening and worrying skills gap must top the HVE agenda. Three quarters (74%) of manufacturers worry that skill shortages will impair future growth and competitiveness.
- Collaboration, not competition, must be the aim of UK HVE companies aiming to capture market share from global rivals. Defence giant BAE's ground breaking work with race car manufacturer, Lola, on a new generation of 'smart' batteries demonstrates how UK engineers can pool their talents and resources across sectors with world-class results.
- To secure growth and competitive edge, manufacturers must build extended, more flexible and more collaborative supply chains to compensate for the 'hollowing out' caused by years of off-shoring. Three quarters (78%) describe their business as equipped to face the challenges of 2025 and yet 88% are not planning to invest in improving their supply chain despite 19% of respondents confirming their intention to source more through the UK.
- UK HVE companies must become giants with the agility and hunger of start-ups. They need size to sustain the high capital and knowledge intensity of long development cycles, but must be agile enough to commercialise innovation and technology faster than established markets such as the US and Germany, and emerging economies such as Malaysia and Singapore, says Graham Chisnall, Deputy CEO and MD of Aerospace at ADS.
- Diversifying into new long-term growth markets must become a core part of UK HVE segment strategy in order to harness the spending power of the 'next billion' consumers who will escape from poverty in emerging economies by 2020. Nine out of ten (86%) manufacturers currently have no plans to enter new geographical markets over the next two to five years. The same is true of manufacturers planning to find new product markets.
- HVE companies need to create an imaginative national plan for patents to reap the full benefits of innovation. Graphene is a revolutionary nanostructured material with a wide range of commercial applications that include flexible smartphone screens, better batteries and low-power electronic devices. It was discovered by a research team at the University of Manchester and yet only 21 of 2,224 graphene patents filed to date are held by the UK.
- Plan, prepare and invest for the game-changing structural transformations in manufacturing that will be wrought by the factories of the future. Intelligent computer-aided systems will free engineers from more mundane aspects of the design process to spend their time creating the lucrative next range of products. Fabs, general-purpose manufacturing hubs using 3D printing technologies and sited close to where a product will be made or assembled, will shorten supply chains, and help to liberate vital capital for increased R&D spending and the recruitment of top talent.

About the Royal Bank of Scotland PLC

At RBS, we recognise the great weight of responsibility that has been placed upon the manufacturing sector as a whole to help lead the UK back to economic prosperity and there is no shortage of challenges to overcome on the journey to achieving sustainable growth.

We are committed to help our manufacturing customers achieve their strategic objectives and help the sector invest for growth. Our dedicated team of Relationship Directors can provide your business with tailored solutions to suit your specific needs, both in the UK and when trading internationally.

Your dedicated Relationship Director will maintain a thorough understanding of your organisation and strive to provide you with the support you need to achieve your goals. Our Relationship Directors also coordinate the skills and expertise of product specialists across the RBS Group to help your organisation succeed.

For more information or to discuss any of the insights highlighted in this report, please contact Peter Russell, Head of Manufacturing & Industrials on peter.russell@rbs.co.uk

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