160 years of innovation
theengineer.co.uk
January 2018 | £3.70

the ENGINEER

FIRST FOR TECHNOLOGY & INNOVATION

plug + play

The next generation of bionic limbs

prosthetics

Frost report

Providing Arctic inhabitants with real-time ice data

»24

Corridor of power

ABB boss Ulrich Spiesshofer on why we shouldn't fear the robot

»26

Car of the issue

Ariel rewrites the supercar rulebook with its HIPERCAR project

»30

Advanced manufacturing

News, opinion and in-depth analysis of the latest manufacturing and production technologies

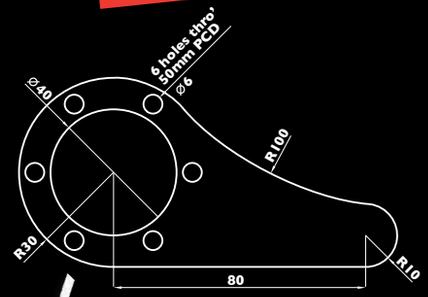
»40

PROTO TRAK®
ON THE MILL

FROM ONLY **£99** A WEEK
+VAT SUBJECT TO STATUS

The ProtoTRAK®Mill can increase manual production up to 6 fold

drawing to component in only minutes



comes with free training

Call today to arrange a 30 minute ProtoTRAK SMX desktop demo at your place.

FROM ONLY **£29,450** +VAT

XYZ 500 LR	XYZ 750 LR	XYZ 1000 LR
18 HP SPINDLE	18 HP SPINDLE	18 HP SPINDLE
580x400 mm TABLE	830x410 mm TABLE	1060x500 mm TABLE
510x400x450 mm TRAVEL	750x440x500 mm TRAVEL	1000x500x500 mm TRAVEL
8000 RPM SPINDLE	8000 RPM SPINDLE	8000 RPM SPINDLE
(12000 RPM optional)	(12000 RPM optional)	(12000 RPM optional)
SOLID CASTING 2400 KG	SOLID CASTING 3500 KG	SOLID CASTING 4600 KG

Options on spindle speeds and tool changer capacities are available.

For many this will be an ideal opportunity to upgrade and modernise their workshops.

All **XYZ** CNC machine tools come with free training, full 12 month warranty,

XYZ Machine Tools

To learn more please call 01823 674200

MACHINE TOOL DEMOS ARE AVAILABLE AT ANY OF THE XYZ UK

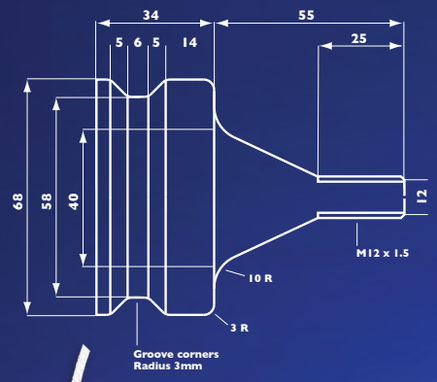
PROTO TRAK®
ON THE LATHE

FROM ONLY **£99** A WEEK
+VAT SUBJECT TO STATUS

The ProtoTRAK® Lathe can increase manual production up to 15 fold

Both available with DXF file convertor

Visit the web site to see the 3 1/2 minute DXF video



comes with free training

Call today to arrange a 30 minute ProtoTRAK SLX desktop demo at your place.

XYZ UMC-5X

FROM £149,150 +VAT

- **Siemens 840DSL ShopMill (iTNC 640 HSCI Heidenhain optional).**
- **Front loading 600mm diameter trunnion rotary table *90 rpm*.**
- **High accuracy rotary axis direct drive high torque motor *90 rpm no worm and wheel*.**
- **Comes with fully dedicated 5 axis XYZ Service, Programming and Sales Engineers.**

DIRECT DRIVE HIGH TORQUE MOTOR **90 RPM** NO WORM OR WHEEL

In its price bracket, this is at the forefront of five-axis machining.

extended warranties, free programming helplines, nationwide service engineers.

sales@xyzmachinetools.com **www.xyzmachinetools.com**

SHOWROOMS DEVON BLACKBURN NUNEATON SHEFFIELD & LONDON

30 YEARS OF XYZ EXCELLENCE

MSC | BUILT TO MAKE YOU BETTER®

Request your FREE Engineers Pocket Guide and Conversion Chart

Email: sales@mscdirect.co.uk

MSC IS A LEADER IN THE SUPPLY OF METALWORKING, MAINTENANCE, REPAIR AND OPERATIONS PRODUCTS AND SERVICES.

We will save you time and money by transforming the way you operate. The manufacturing world is split into two, those who love MSC and those who haven't tried us yet.

GIVE US YOUR TOUGHEST PROBLEM

Email: tech@mscdirect.co.uk

It can be very time consuming when trying to find the most efficient yet cost-effective way to run your production line. Having additional engineering and technical support to improve your operations can increase your productivity and exceed your customer's quality expectations and deadlines.

At MSC we're here to help. On-site and at the spindle or over the phone, our Technical and Engineering experts will help you tackle the toughest technical application and product challenges to cut costs and drive productivity.

- Over 90,000 Metalworking and MRO products in stock
- **Technical and Engineering Application advice and support**
- Save time and order online with real time inventory
- Keep your production line running with next day timed delivery
- Manage your supply chain with our Inventory Management Solutions

0800 66 33 55 | mscdirect.co.uk | sales@mscdirect.co.uk

this**issue**

Volume 298
Issue No.7894
Established 1856

news

opinion

features

our**opinion**

Hand of history

Medical history was made earlier this month, when Almerina Mascarello, an Italian woman who lost her left hand in an accident over 20 years ago, became the recipient of the world's first portable prosthetic hand with a sense of touch.

Developed by an international group of engineers, scientists and surgeons, the device uses sensors to detect information about the hardness of an object, which is then relayed to the brain via electrodes implanted in the upper arm.

While the capabilities of this prototype system are limited, it nevertheless represents a genuine advance in neuroprosthetics. Indeed, Mascarello reportedly described wearing the device as almost like having her hand back, while the team behind the technology claim that the breakthrough could represent a key step along the road to prosthetic devices that equal or even improve on the performance of a natural hand.

The news marks the latest development in a field that's surely one of the most inspiring examples of how engineers are working with specialists from other disciplines to change people's lives for the better. And, as *The Engineer* has frequently noted – from the low-cost 3D-printed hands pioneered by Bristol's Open Bionics, to the world-leading lower-limb prosthetics produced by Hampshire firm Blatchford – it's an area of considerable expertise for the UK.

> "From low-cost 3D-printed hands to lower-limb prosthetics, the UK is playing a leading role in life-changing technology"

In this issue's cover story (p20), we explore this fascinating field of research in greater detail and take a look at the role UK engineers are playing in advancing the performance and utility of this life-changing technology. Of particular note is a surgically implanted prosthetic interface described by its Cambridge-based developer as a USB for the body.

Elsewhere in this issue we return to a number of themes that will surely continue to dominate industry discourse over the next 12 months: from the challenges of implementing the government's industrial strategy (p42) to the role technology will play in closing the UK's productivity gap. Indeed, mounting a compelling case for the societal and economic benefits of automation, ABB boss Ulrich Spiesshofer (Interview, p26) argues that with Brexit looming, increased investment in automation and robotics has perhaps never been more important for UK industry.

Jon Excell Editor
jon.excell@centaurmedia.com

UK subscriptions £75 pa UK/£117 pa overseas. Order online at www.theengineer.co.uk/subscribe or by telephone on +44 (0207) 292 3705. All rights reserved. No part of this publication may be reproduced in any form without prior permission from the publisher.

ISSN 0013-7758. Printed by Stones Ashford Ltd, Ashford TN24 8HH
Visit www.theengineer.co.uk for constantly updated news, products and jobs and to sign up for our FREE weekly email newsletter and tailored job alerts

the ENGINEER Centaur Media Plc, 79 Wells Street, London, W1T 3QN

Direct dial 020 7970 followed by extension listed Advertising fax 020 7970 4190 **Editor** Jon Excell (4437) jon.excell@centaurmedia.com **Features editor** Stuart Nathan (4125) stuart.nathan@centaurmedia.com **Senior reporter** Andrew Wade (4893) andrew.wade@centaurmedia.com **News editor** Jason Ford (4442) jason.ford@centaurmedia.com **Recruitment advertisement manager** Michael Maunsell (020 7970 4678) michael.maunsell@centaurmedia.com **Business development manager** Jason Padam (4677) **Commercial director** Sonal Dalgliesh (4487) sonal.dalgliesh@centaurmedia.com **Senior account manager** Richard York (4942) **Production** Lyndon White, Wendy Goodbun (4807) te.production@centaurmedia.com **Publisher** Simon Lodge (4849) simon.lodge@centaurmedia.com **Subscriptions & Customer Services** tecirc@centaurmedia.com

The Engineer is available for International licensing and syndication. For more information please email simon.lodge@centaurmedia.com

NEWS 020 7970 4442 | DISPLAY 020 7970 4487 | RECRUITMENT 020 7970 4110 | SUBSCRIPTIONS/CUSTOMER SERVICES HOTLINE 020 7292 3705

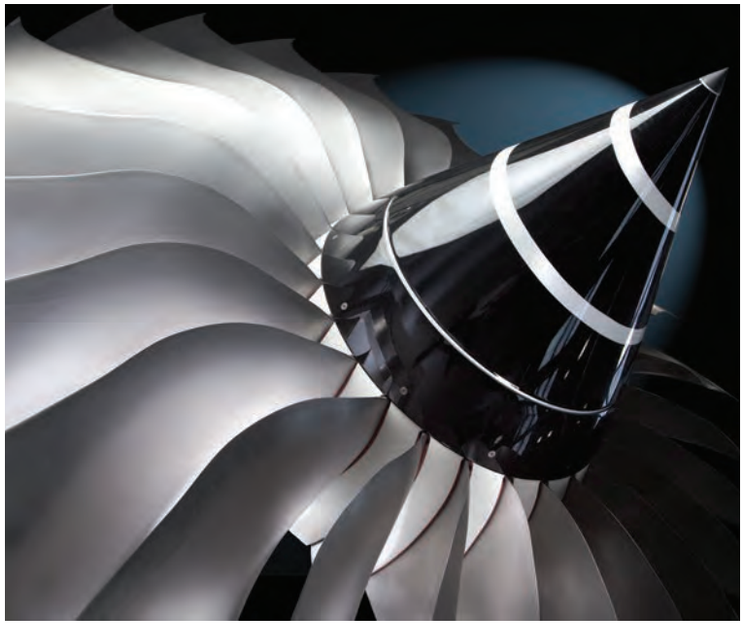
CENTAUR MEDIA

AEROSPACE

The mechanics of all-electric flight

New project will focus on six key areas of mechanical engineering

HELEN KNIGHT REPORTS



A major new research partnership between Rolls-Royce and three UK universities is aiming to develop the technologies needed to allow the aerospace industry to switch towards all-electric flight.

The aerospace industry has been investing heavily in the search for alternatives to combustion engines in a bid to cut carbon dioxide emissions and reduce its dependence on Earth's decreasing fossil fuel reserves.

But the great distances aircraft must travel between refuelling stops has made this a considerable challenge, with battery technology not yet sufficiently developed to cope with long-range journeys, for example.

The new £6.1m EPSRC-funded project, called Cornerstone, which includes researchers from Nottingham University, Imperial College London and Oxford University, will undertake research into areas of mechanical engineering that will help the industry move towards electrification, according to the project's principal investigator Seamus Garvey of Nottingham University.

"There is an assumption that moving towards electric flight requires electrical engineering only, and that is utterly wrong, some of the biggest challenges are in fact mechanical engineering challenges," he said.

The project will focus on six areas of mechanical engineering research. These include an attempt to better understand high power-density contacts, or those locations within an engine where there are very high stresses occurring between two surfaces, such as gear teeth.

"The whole area of understanding how long those contacts will last before cracks start to develop, then those cracks propagate and result in fatigue failure, is as yet an incomplete science, and one of the things we will do through Cornerstone is try to complete that science," said Garvey.

The researchers will also investigate the effect of impacts, such as a bird strike, on engines, and attempt to better understand the load and vibration dynamics of aero-engine assemblies, as well as the way in which air interacts with structures such as fan blades, turbine blades and compressor blades.

Of particular importance to hybrid-electric and all-electric aircraft will be an investigation of new ways to manage heat without increasing the mass or complexity of the system, said Garvey.

"That is particularly relevant for all-electric flight, because all electrical machines are fundamentally limited by the ability to get heat out of them," he said.

This will build on work the research team at Nottingham has previously undertaken to investigate the use of oil as a coolant in gas turbines, he said. "We want to upgrade our methods for analysing thermal management with oil, but we also want to develop some new methods for removing heat from engines."

So, for example, the researchers will investigate the use of fine oil mists for thermal management, as well as cooling components using internal heat pipe elements. The team will also consider the use of materials such as graphene and diamond-like carbon within aircraft components. These materials have extremely high thermal conductivity, he said.

"If we can build those into our engine components, the heat can pass through the parts much more easily than it would do otherwise."

Finally, the researchers will investigate the interactions between the electrical and mechanical machines within the aircraft, which can be a considerable advantage of electrification, said Garvey.

"When we design a rotating machine one of the things we worry about a lot is whether the machine will shake itself to pieces through vibration."

By putting an electrical machine on the rotor, it can help to take vibration out of the system, preventing damage, he said. ■

Readmoreonline

Aerospace
Reaction Engines starts work on US high-temperature airflow test facility

Automotive
London's black cabs go electric and Japan embraces autonomy

Civil & Structural
Six archive snapshots from history of bridges

Defence & Security
DSTL's synthetic ceramic armour could reduce weight by 35 per cent

Electronics & Communications
Brain-mimicking 'neuro-morphic' computer chips for robot insects

Energy & Environment
Syngas process boosts economic feasibility of carbon capture and storage

Medical & Healthcare
Smartphone case delivers blood glucose readings in one device

Manufacturing
Project looks at gecko grip for handling in high-precision industrial settings

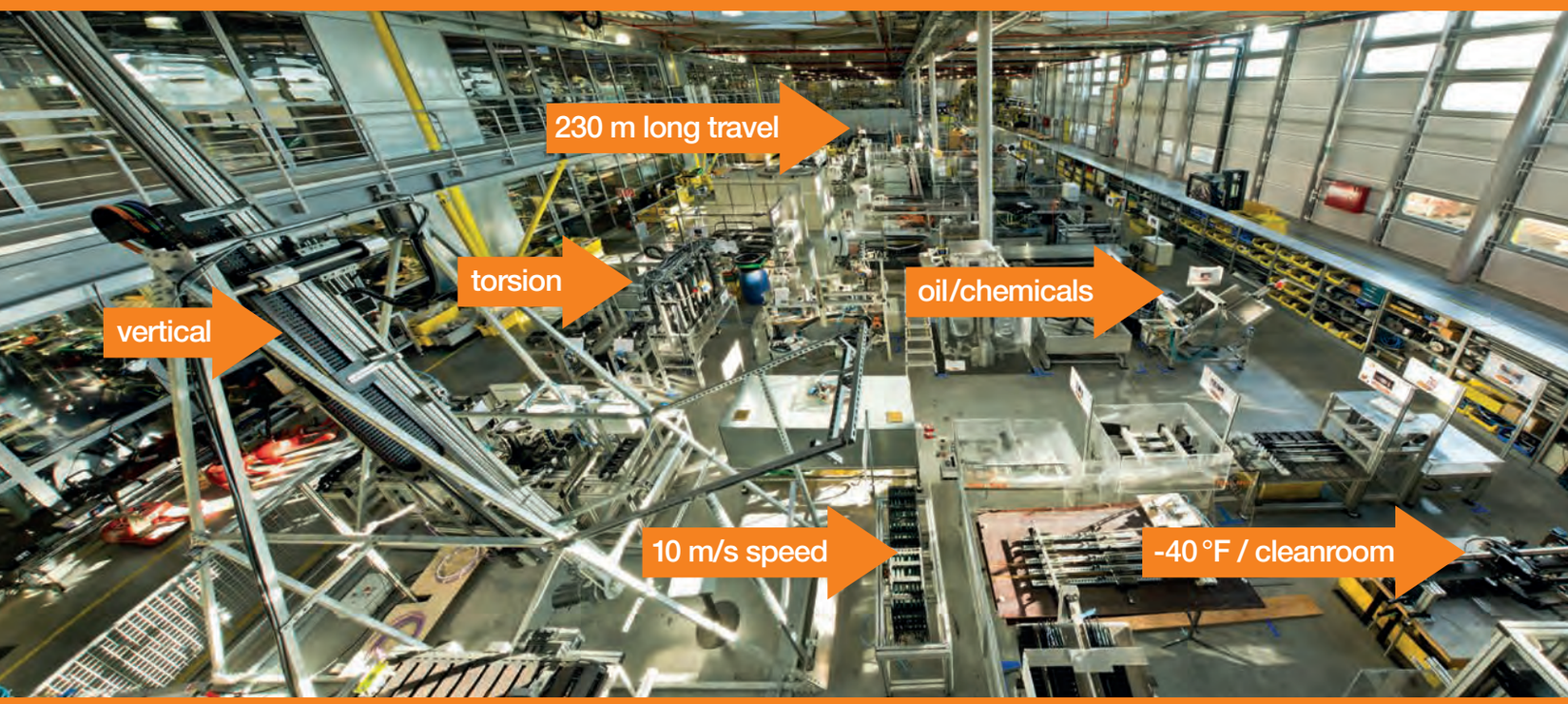
Policy & Business
Engagement is key to realising the Industrial Strategy

For news and jobs theengineer.co.uk

Largest test lab for continuous-flex cables

#1

... number one in moving cables



Widest selection. Unmatched Testing. 36 Month Guarantee.

Guarantee igus chainflex 36 month guarantee

Reduce downtime with chainflex®
- Developed & tested in the 2750 m² lab
- 600 tests run in parallel
- 1.4 million electrical measurements/year
- 2 billion test cycles/year

Shop now: www.igus.co.uk/chainflexshop
Free samples available: www.igus.co.uk/cf-sample

igus®
plastics for longer life®

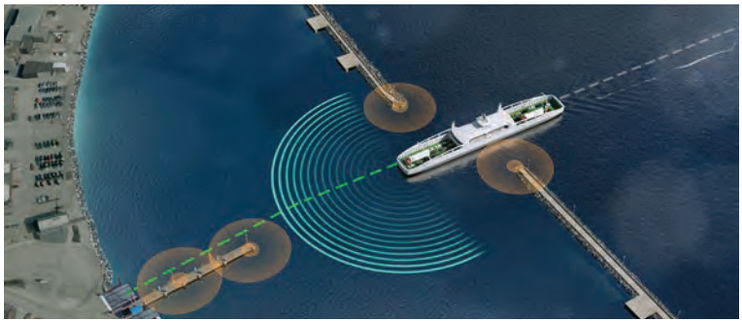
sales@igus.co.uk
Tel 01604 677240

SHIPPING

Space-age tech could aid shipping

Investigation into using satellite-based technology for remote control

HELEN KNIGHT REPORTS



Rolls-Royce and The European Space Agency have signed an agreement to investigate use of space technologies for remote-controlled and autonomous shipping.

Operating vessels remotely is nothing new to the space industry, so the collaborators will explore the possibility of software and satellite-based technologies developed by the sector being used in the maritime field. This includes developments of wireless networks, including satellite carrier systems, to allow vessel-to-shore and ship-to-ship communication.

The commercial shipping industry could benefit from technologies that provide continuity of communications, according to Antonio Franchi, Future Projects, Telecommunications and Integrated Applications Directorate at ESA.

This could lead to the development of smart logistics systems, with seamless communication with cargo from the warehouse, through its transit in port and the ship crossing, to its final destination, he said.

The organisations will also investigate the idea of developing satellite-based positioning for smart ships, based on ESA's Earth observation system. This would give those operating the ships better spatial and situational awareness, while allowing satellites to capture and share information from different vessels simultaneously.

"The upcoming challenges for satellite-based positioning for smart ships in a marine environment are quite unique," said Franchi.

Whatever the satellite-based positioning system in use, autonomous checks must be performed by the on-board receiver to protect users from local sources of error, such as interference, he said.

In its new navigation research and technology programme - Navigation Innovation and Support Programme (NAVISP) – ESA is studying and testing technologies for smart ships and for a variety of nautical tasks, said Franchi.

"The combination of multi-source navigation – including satellite-based – coupled with additional situational awareness devices and weather sensors, and the integration of advanced data links will provide the required system reliability and integrity to enable smart ships and make autonomous shipping a reality," he said.

The partners are also planning to explore the use of big data in shipping, including technologies such as machine learning and artificial intelligence, and data analytics. This could help to improve operational efficiency and safety.

Information from sensors can be used in augmented and virtual reality systems, and to create a so-called digital twin of the ship, or an AI copy of the vessel and its on-board systems in the form of a hologram, which could then be used as a virtual testbed. ■

NUCLEAR

Call to address Brexit effect on nuclear power

IMechE concerns over the pathway of future policies

STUART NATHAN REPORTS

The UK urgently needs to address the implications of Brexit on the nuclear sector and ensure the future pipeline of nuclear technologies, according to the IMechE in a new report. *Nuclear Power: A Future Pathway for the UK* assesses the state of nuclear policy in the wake of the announcement on 7 December 2017 of more support for the development of small modular reactor (SMR) technologies.

The pathway set out in the IMechE report rests upon three main objectives: replacement of all old nuclear capacity with new plants by 2030; building and deploying a fleet of SMR-based power stations by 2040; and developing Generation IV technologies and fusion plants to come on-stream after 2050.

"The key challenge is to reduce costs and delays," commented Dr Jenifer Baxter, IMechE's head of energy and environment.

The three roadblocks that the institution sees in the path of immediate progress are the issue of 'Brexatom' – the UK's still-unresolved exit from the Euratom treaty as a consequence of leaving the European Union; the absence of a firm timetable and plan for the delivery of the long-mooted Deep Geological Disposal facility for high-level nuclear waste; and the fate of Britain's stockpile of 112 tonnes of plutonium. ■

Newsinbrief

Boiling point

Hitachi-GE's UK Advanced Boiling Water Reactor (UK ABWR) has been approved for construction following a mandatory Generic Design Assessment. The Office for Nuclear Regulation has issued a Design Acceptance Confirmation and environment agencies have issued a Statement of Design Acceptability to Hitachi-GE. Horizon Nuclear Power is proposing to build and operate two of these reactors in Wylfa Newydd on Anglesey and Oldbury-on-Severn near Thornbury in South Gloucestershire.

Ups and downs

North Sea oil and gas production is up but greenhouse gas emissions in 2016 were down against 2015, claims Oil & Gas UK's latest Environment Report. Although CO2 emissions rose by four per cent between 2014 and 2016, this was against a background in which production increased by almost 16 per cent.

Power cuts

Up to 1,100 positions are at risk at General Electric, which is looking to make savings across its UK GE Power business. The company said it needs to 'remove cost substantially' as a result of market conditions that have 'had a significant impact on GE's economic performance'.

Battery charge

A 100MW Tesla battery system, which Elon Musk promised to install in less than 100 days, has come online in South Australia ahead of schedule. The facility uses a scaled-up version of Tesla's Powerpack technology. It is paired with French energy provider Neoen's Hornsdale Wind Farm and will help balance the South Australian grid.

GRUNDFOS iSOLUTIONS

INTELLIGENT CONNECTIVITY

IN COMMERCIAL BUILDINGS

SEIZE THE FUTURE OF INTELLIGENT CONNECTIVITY TODAY

Intelligent connectivity is set to transform the future of building applications, utilising new technology to create fully connected, autonomous systems. And with Grundfos iSOLUTIONS, you can seize the opportunities this offers right now. Grundfos iSOLUTIONS brings intelligent connectivity to advanced pump solutions to help you achieve a new level of system performance with greater energy efficiency, reduced complexity, low life cycle costs and more.

See how Grundfos iSOLUTIONS can help optimise your commercial building at: **www.grundfos.co.uk/intelligent-connectivity**

be
think
innovate

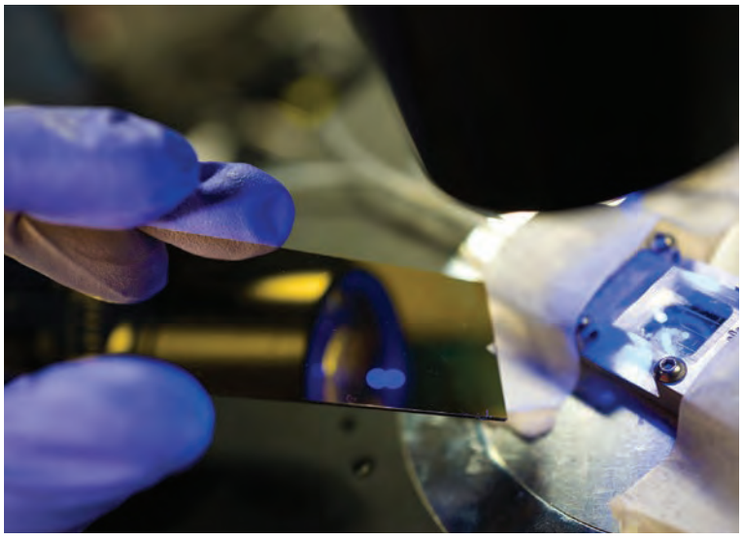
GRUNDFOS

MEDICAL

Wireless technology could block cancerous tumours

Device simulates electrical signals produced by body

HELEN KNIGHT REPORTS



Wearable technology that could one day fight cancer by cutting off a mechanism that allows tumour cells to proliferate is being developed in the UK.

The device, which uses wireless technology to produce an electric field that controls the behaviour of targeted cells inside the body, could stop cancerous tumours growing.

Electroceutics are medical devices designed to treat disease by stimulating and controlling electrical signals produced by the body. However, fitting such devices, including deep brain stimulators for treating Parkinson's disease, requires invasive surgery, according to Dr Frankie Rawson, of the Division of Regenerative Medicine and Cellular Therapies, School of Pharmacy, at Nottingham University. The wireless technology, in contrast, which is being developed by a team led by Rawson in an EPSRC-funded project, can be placed on the skin to control electrical signals remotely.

Research by Rawson and his colleagues has shown that when cells undergo genetic changes that cause them to become cancerous, the way in which the cells expel electrons to their immediate surroundings also changes.

"We have evidence that cancers do this to try to increase their cell proliferation rate," said Rawson. "So we believe that by using an electrical input to stop that external electron transfer, we can stop or slow the cells proliferating, and stop the tumour growing."

Working with Prof Richard Hague, director of the EPSRC Centre for Additive Manufacturing at Nottingham University, Rawson is using 3D printing to develop electronic devices with precise geometries. These devices can in turn generate a carefully controlled electric field that can be used to target the cell's electron transfer.

By applying this external electric field in conjunction with conductive nanoparticles to the area of tissue, the nanoparticles become polarised, said Rawson. "That means the electric field provides the thermodynamic driving force to drive chemical changes, both inside and outside cells," he said.

The two-pronged approach uses the external electric field to change the oxidation state of the cells, inducing cell death, said Rawson.

"And by self-assembling conductive nanowires with cells we have the ability, on application of an electric field, to get enhanced inhibition of cell proliferation by interfering with... mitotic spindle formation, which cells use to divide themselves," he said. ■

SPACE

Future bright for weather satellites

Miniaturised systems are going into orbit

The cost of deploying weather satellites could be cut by 95 per cent following the signing of a contract to put miniaturised weather observing and forecasting technology into space.

The Satellite Applications Catapult signed the contract to put Orbital Micro Systems' technology into orbit at the STFC RAL Space Appleton Space Conference, which was held on December 7, 2017.

Consisting of a 10 x 10 x 15cm-sized instrument in a 3U CubeSat satellite, the payload will be launched in autumn 2018 by Webster, Texas-based NanoRacks and put into low earth orbit via its CubeSat deployer (NRCSD) on the International Space Station.

Innovate UK, which supplies business funding, has invested £1.5m in the IOD programme, which offers a CubeSat platform from Clyde Space and associated launch for four missions. **JF**

AEROSPACE

Flapless flight off the ground

Jet plane tests out blown-air system

JASON FORD REPORTS

Efforts toward flapless flight have taken off with BAE Systems and Manchester University successfully completing initial flight trials of MAGMA, a jet-powered UAV that aims to use a blown-air system to manoeuvre.

Seen as informing the design of future stealth aircraft, the new concept for aircraft control seeks to eliminate complex, mechanical moving parts that move flaps to control aircraft during flight.

BAE Systems said this could give greater control as well as reduce weight and maintenance costs, allowing for lighter and faster military and civil aircraft.

Wing circulation control and fluidic thrust vectoring are the key technologies to be trialled first using the jet-powered UAV. The former takes air from the aircraft engine and blows it supersonically through the trailing edge of the wing to provide control for the aircraft, whilst the latter uses blown air to deflect the exhaust, allowing for the direction of the aircraft to be changed.

According to Brian Oldfield, lead technologist, Advanced Structures, BAE Systems Military Air & Information, MAGMA is a 4m wingspan vehicle weighing 40kg in its conventional control state and is a low-speed vehicle for demonstrating novel technology. It uses a modified Hawk 240N gas turbine engine and will weigh 45kg when modified to have novel flow control devices.

The first phase of flight trials took place at Snowdonia Aerospace Centre in September, 2017. According to Oldfield, MAGMA has flown twice with conventional controls only with a cruise speed of 30m/s. ■

RENEWABLES

The heat is on to improve solar power generation

System being developed to provide electricity and high-temperature heat for high-rise buildings

HELEN KNIGHT REPORTS

Thin-film solar panels can be fitted to external walls of high-rise buildings

With demand for clean and affordable energy ever-increasing, a huge global effort is under way to improve the efficiency of solar power generation.

The most efficient solar photovoltaic (PV) devices, however, are typically designed to use only part of the light spectrum to generate energy, so most of the infrared element is wasted.

Now a UK collaboration, funded by EPSRC and the Department for International Development through Innovate UK, is developing a system that can generate electricity and high-temperature heat from solar energy. The devices could be fitted to the external walls of high-rise buildings to provide electricity plus heat for air-conditioning, heating and refrigeration.

The project, which includes London-based Palliser Engineers, Swansea University and Cambridge-based Polysolar, will use thin-film cadmium telluride solar panels to capture infrared frequencies, which will then be concentrated to provide energy for heating and cooling.

Unlike existing solar panels, the device will allow infrared radiation to pass through the Cadmium Telluride photovoltaic cell to a thermal collector behind it, according to Prof Stuart Irvine, director of the Centre for Solar Energy Research at Swansea University.

"That normally would not happen [in conventional PV] simply because there would be a metal film on the back acting as the electrode," said Irvine. "But it doesn't have to be an opaque metal film, it could be transparent, or transparent in the right part of the spectrum."

The project – Optical Transfer of Heat with Electrical and Light Output (OTHELLO) – is due to begin next year. The researchers initially plan to focus on determining how much infrared light they will be able to allow through the solar cells to the thermal collector.

The Cadmium Teluride cells will consist of different films of material with mixed optical and electrical functions, said Irvine.

"If you have any stack of optical films, where you get differences in the refractive index you will get reflections, and we don't want reflections of infrared radiation," he said. "So we need to optimise the system to get maximum transmission of infrared." ■

AEROSPACE

WheelTug noses ahead

Company to deliver system for Boeing

Bristol-based Stirling Dynamics has been awarded a contract to deliver an electrical system for a powered nose-wheel for Boeing's 737NG (new generation) family of single-aisle aircraft.

The contract is from WheelTug, a company based in Portland, Oregon, which has been developing the system for over a decade, and in 2017 began to seek certification from regulatory bodies in Europe and the US to deploy the system on aircraft in commercial service.

Stirling says it is the UK's leading independent specialist in aircraft landing gear.

"Our engineering team will draw on the company's core capabilities in reverse engineering, wheel analysis, landing gear analysis, safety analysis and structural stress analysis," in order to help WheelTug in its efforts to achieve certification, the company said. **SN**

HEALTH

Radar sensing to monitor the elderly

Radio waves could analyse movement

HELEN KNIGHT REPORTS

UK researchers are investigating the use of radar sensing and artificial intelligence to monitor vulnerable people, including the elderly and those with cognitive or physical impairments.

The EPSRC-funded system will be designed to monitor activity levels over long periods of time, to pick up on early signs of cognitive or functional decline, and to detect falls or strokes.

In this way it will provide family members or carers with information on the person's health and wellbeing, and allow people to remain in their own homes for longer, preserving their quality of life, said Dr Francesco Fioranelli, the project leader at Glasgow University.

The radar system – a small box like a Wifi router – will transmit and receive radio waves across rooms within the home, and then use machine learning to analyse the echoes to understand how and where the person moves.

"The system would build up a map of the individual's usual routine, and then try to spot any anomalies," said Fioranelli. "The classic example is if someone crosses the corridor to go to the toilet once per night, and then all of a sudden they do that three or four times, it could be a sign that they are unwell, and they could be referred to a nurse or GP for a visit," he said.

Unlike wearable sensors and video cameras, radar is contactless and non-intrusive, said Fioranelli. ■

ELECTRONICS

Hot electrons and the need for speed

Quantum effects produce a controlled stream of light

HELEN KNIGHT REPORTS

A nanoscale device developed in the UK could help to synthesise new chemicals and improve the speed of electronics equipment.

The device, developed by researchers at King's College London, and published in *Nature Nanotechnology*, uses quantum effects to convert electrons flowing around a circuit into a controlled stream of "hot electrons" and light.

Hot electrons are highly energetic, making them very useful in chemical research, said Dr Pan Wang, the paper's lead author. "Hot electrons can allow chemical reactions to occur between two molecules which would not normally react," he said.

> "Hot electrons allow chemical reactions"
>
> Dr Pan Wang
> KIng's College London

The device consists of two materials, eutectic gallium indium and gold nanorods, which are separated by an air gap of less than 1nm.

When a voltage is applied across the device, it causes a flow of electrons from the eutectic gallium indium electrode to the gold nanorods.

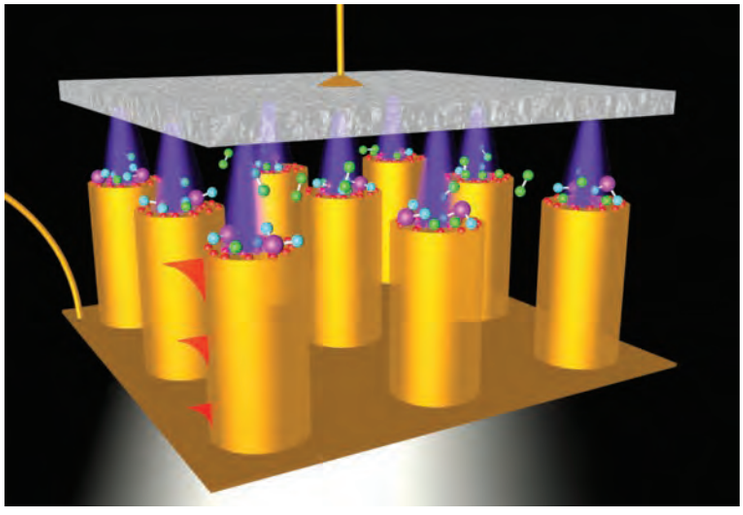
Although an air gap would usually prevent the electrons from flowing between the two materials, at distances of less than one nanometre quantum mechanical rules apply, meaning the electrons are able to 'tunnel' through.

This tunnelling means that the electrons arrive at the nanorod tips in the form of hot electrons. A small number of the tunnelling electrons also excite plasmons in the material, emitting light.

This process is typically very inefficient, said Wang. "But by using a gold nanorod array for one of the electrodes, we can provide billions of tunnel junctions, improving the electron-to-plasmon conversion efficiency," he said. "This makes the emitted light visible to the naked eye."

The device could be used in electronics to optically transmit binary information by rapidly switching the light on and off. In this way it could be used to replace semiconductor lasers, which are becoming too bulky as the size of electronics equipment shrinks.

As well as chemical research, the hot electrons produced by the device could also be used in sensing. Since the tunnel junctions in the material are very sensitive to change, any new substance produced by a chemical reaction will alter their properties, changing the flow of electrons through the device. In this way it could be used to detect the presence of hydrogen leaks in fuel cell production, for example. ■



Gold nanorods provide billions of tunnel junctions, improving efficiency

AEROSPACE

Drone to detect toxic gases

Super-laser will find tiny concentrations

A multi-million-dollar, multi-partner European drone project is using photonics to detect toxic gases in the atmosphere following events such as wildfires, chemical explosions and volcanic eruptions.

Dubbed FLAIR (FLying ultrA-broadband single-shot Infra-Red Sensor), the fixed-wing drone will be able to reach speeds of 120km/h, an altitude of 4,000m, and cover a radius of 80km. On board will be a super-continuum laser capable of detecting tiny concentrations of a range of gases, including carbon dioxide, methane, sulphur oxides, and nitrogen dioxide.

The drone project, which is expected to deliver a prototype in 2018, has already received over €3m from the EU's Horizon 2020 fund via the Photonics Public Private Partnership. It features partners from across the continent, led by Portugal's Tekever Autonomous Systems. **AW**

AUTOMOTIVE

Technology key to better road network

Highways England sets out its strategy

JASON FORD REPORTS

Highways England believes technology will play an increasingly major role in keeping people moving, and the country connected.

In its vision for the strategic road network, Highways England said an intelligent network coupled with connected vehicles would improve how efficiently roads are maintained and simultaneously improve safety.

In another development, drones could also be used to fly overhead and report back on incidents, and cars could be programmed to spot potholes on motorways and automatically transmit the information to Highways England to schedule repairs.

In its *Strategic Road Network Initial Report*, published on 13 December 2017, the government company also stressed the importance of keeping existing roads properly maintained in a way that minimises disruption.

"We are delivering... £15bn of government investment to give people safe, efficient and reliable journeys, and provide businesses with the links they need to prosper and grow," said Highways England chief executive Jim O'Sullivan.

"Because people's journeys are important to us we are setting out our high-level aspirations which will help ensure the network continues to drive economic growth, jobs and prosperity, and keeps traffic moving."

The report will help inform the government's next road investment strategy, which begins in 2020. ■

HEALTH

Making moves on hip replacement

Simulator looks at shape and motion to improve patient outcomes

HELEN KNIGHT REPORTS

An anatomical hip simulator is being developed in the UK to advance the understanding of hip shape and motion and improve outcomes for hip-replacement patients.

Around 80 million people worldwide suffer from hip osteoarthritis, of whom an increasing number require a replacement joint.

In England and Wales alone, 90,000 hip replacements are carried out each year.

While the majority of these replacements are considered a success, an increasing number of people are finding they do not regain the level of movement they were hoping for after surgery. What's more, some replacements fail in the early stages due to mechanical problems with the artificial hip.

> "We need to understand what is happening to the materials"
>
> Dr Sophie Williams, Leeds University

The simulator, being developed by a team led by Dr Sophie Williams at Leeds University with £1m funding from EPSRC, will allow the researchers to investigate the mechanical performance of hip joints – both "phantoms" designed to mimic real hips and artificial replacement components – when pushed to extremes of motion.

"Computer simulations are great, and they enable us to go through lots of different variables very quickly, but we need to understand what is physically happening to the materials," said Williams.

"This project will look at mechanical performance when you go to extremes of motion, so not necessarily gymnastics, but maybe just bending down to tie your shoe laces, which can cause impingement in the joint."

Williams will work with Prof Russ Harris and Dr Rob Kay, both advanced manufacturing engineers at Leeds, to develop materials and structures designed to mimic human bone and tissue.

One issue that can lead to osteoarthritis is when a patient's hip is not as round as it should be, which interferes with the smooth motion of the ball within the socket.

"Part of the project will look at whether we can use additive manufacturing techniques to produce material properties like those you would see in the natural hip, so we can start to understand how the natural hip, when it is not quite the shape it should be, performs in those extremes of loading and motion," she said.

Ultimately, Williams hopes to be able to advise surgeons on how best to position artificial hips, depending on factors including a patient's shape and gait. ■

HEALTH

No sweat to use sensor system

Miniature chip reveals a person's health

Researchers in Switzerland have developed a tiny, portable sensor system that can encapsulate and analyse biomarkers in sweat, an advance that could help provide insights into a person's health.

The miniature chip was developed by researchers at EPFL's Nanoelectronic Devices Laboratory (Nanolab), headed by Prof Adrian Ionescu, working in association with Xsensio, a start-up specialising in so-called lab-on-skin technology for next-generation wearables.

The system, which can be placed directly on a person's skin or integrated into a bracelet, can determine variables such as levels of sodium and potassium in sweat, body temperature and pH. The data can then be sent to a smartphone. The system uses capillary action to draw minuscule amounts of sweat into the chip, where it is analysed. **JF**

MATERIALS

Columbia's advances in graphene

Method creates 'quantum wells'

STUART NATHAN REPORTS

It may be possible to engineer nanoscale-patterned semiconductor material to produce exotic electronic properties.

The research, at the engineering department of Columbia University in New York City, centred around an attempt to reproduce the electronic structure of graphene in a synthetic semiconductor device.

The Columbia team, led by physicist Prof Aron Pinczuk, used the technology normally employed to manufacture microprocessors to engineer graphene-like behaviour in gallium arsenide, a common industrial semiconductor.

They devised a method using nanothithography and etching to create a hexagonal pattern of "quantum wells", which confine the movement of electrons to a lateral direction, onto a sheet of GaAs. The dots were placed about 50nm apart, which is much further than the atoms in graphene but close enough for them to interact quantum mechanically, effectively sharing their electrons like atoms do in solids.

To confirm that electrons behaved like those of graphene, the team illuminated the quantum dot sites with a laser, and measured how the light was scattered. This scattering showed a loss of energy in the light that corresponded to the transitions caused by electrons dropping through quantum energy levels, as they do in atoms.

"This work is really a major advance in artificial graphene. Since the first theoretical prediction that systems with graphene-like electronic properties may be artificially created and tuned with patterned 2D electron gas, no one had succeeded until the Columbia work," said Prof Steven G Louie, a physicist at the University of California, Berkeley. ■

Peer-to-peer energy trading in prospect

Blockchain technology has the potential to transform the traditional infrastructure for distributing and tracking electricity, enabling real-time energy trading

When they flip a light switch or charge their electronic devices, consumers rarely think about the extensive and complex system that enables electrons to flow their way and power their homes and businesses. But more and more of the brightest minds are doing just that: conceiving of ways that the digital economy may transform the traditional infrastructure that distributes and, crucially, tracks electricity through the system.

Blockchain technology has the potential to achieve this. It has the power to connect energy consumers with producers via new markets, enabling real-time energy-trading transactions to revolutionise the energy market.

While it has primarily been applied in the financial sector for applications such as bitcoin, blockchain's decentralised ledger system records transactions in a verifiable fashion. Core capabilities of security, resilience, consistency and accuracy mean it is easy to envisage its application to energy trading markets, enabling disparate suppliers and consumers to trade distributed energy resources. These transactions could take place among commercial and industrial facilities, microgrids, owners of renewables like wind, solar and energy storage, and even residential consumers.

No doubt a transformation of this magnitude will take time to develop. After all, consumers take power for granted and, as a result, the UK power industry has minimally changed structurally in the past 50 years. But we can't ignore the revolutionary changes this technology could offer by enabling energy to flow back and forth between suppliers and users in multiple trades.

Reliable service and stable prices for electricity remain vital to customers and are the foundation of our economy. But change is now the order of the day and innovation is vital to keep pace.

The biggest catalyst for this is the realisation that fossil fuel-based energy has a huge environmental cost and cannot be sustained long term. As renewables are introduced, demand patterns are changing rapidly. Distributed energy resources such as rooftop solar, combined with battery storage and fleets of fully charged electric vehicles, can now contribute power back to the grid. These are only a few of the changes that will fundamentally reshape the energy sector and increase momentum towards a more flexible network based around a new model of distribution system operators (DSOs), as the next stage in the evolution from distribution network operators (DNOs).

Big questions remain about the role of DNOs as the market transitions towards two-way power flow. Some could be answered through blockchain-based technologies that would serve to underpin this digital grid economy. DSOs will need to take an active management role and serve as unbiased arbiters of electricity flowing through the network.

Equally, blockchain can eliminate some common overheads and inefficiencies in financial transactions. It removes errors and ineffectiveness inherent in most human interactions, enabling market participants to trade in a peer-to-peer, machine-based environment based on rules, contracts and real-time system conditions. The system allows tracking and logging of mutual transactions and set contract or payment obligations in a secure and distributed way.

Cyber security has also become a top priority of the energy industry, but the nature of blockchain enables us to build in natural security through ledger distribution, minimise systemic risk and ensure the authenticity of transactions. The cryptography available in blockchain technology means that we can resolve many security issues in peer-to-peer transactions, enabling district grids or microgrids in the future electricity network.

In making this a reality, perhaps the industry's first focus should be on the many thousands of charging points that will be required for universal use of EVs. Imagine a scenario in which a community of energy consumers seeking to use clean and renewable sources of power contracts to purchase energy produced by fully charged EVs plugged into the distribution network.

Achieving scale and critical mass will be key to promoting blockchain adoption in the energy sector. The current lack of regulation, and pending changes to regulation globally that blockchain adoption may usher in, also pose risks for all stakeholders. But these challenges can and must be overcome through disruption preparedness and the development of supporting regulations.

With smart digital energy transformation, the application of blockchain will surpass our current projections for the future of the energy network and open our minds to limitless possibilities. Success will be measured by whether the right balance can be struck between risk and reward. ■

Jeffrey Casey is a business development director at Burns & McDonnell, based in the UK

Core capabilities of security, resilience, consistency and accuracy make blockchain technology ideal for energy trading markets

Mailbox

Thehottopic

Brexit? Time for a grown-up discussion

Our online poll asking how readers would vote in a second referendum sparked a furious debate

A democratic result, yes – but also, undeniably, the result of a single, very narrowly won referendum fought between two campaigns reliant on clickbait, baseless rhetoric, factually meaningless calls to patriotism and the whims of careerist, political, pseudo-celebrity egos....

One has to wonder whether modern hyper-partisan, left vs right, liberal vs conservative 'democracy' really works for enormously complicated, far-reaching issues such as Brexit. Or anything, for that matter...

How can we, as a nation, make informed, objective decisions about the good of the country when we're all slaves to whatever we're told to think by whichever of the two insulated, profit-centred media bubbles we happen to be in? Bottom line: we Brits need to stop labelling ourselves Leavers and Remainers.

Let's all commit to growing up a bit, binning the tabloids and having honest, fact-based discourse about how best to move forward on the path we've set for ourselves.

AH Sprite

Nice idea, this flexible democracy. The vote is done, the decision has been taken. Now let's get on with it, power forwards and stop this constant debating.

Paul Gray

Surely democracy is an ongoing process; if people have changed their minds, how on earth would it be democratic to ignore that?

Further to this, though, we now need to make a decision based on what Leave will actually look like. We didn't know what Leave would look like, but we did know about the single market.

If the choice had been 'Stay in the EU', 'Leave but remain in the single market (similar to arrangements with other countries)' or 'Leave and leave the single market' – 'Stay in the EU' would have won by a mile.

The reason the vote was so close was that no one on either side knew what Leave meant. Each had their own and very different view of Utopia.

Sooners

I voted Leave and would do so again. I also don't believe we should be paying to leave. We should honour whatever financial arrangements exist up to the exit point and not a penny more.

The EU is not in the business of making it attractive to leave and so is playing hardball. This country of ours is a wealthy one in comparison with many in the EU block; I am sure they will miss our financial input to the EU coffers.

If the EU imposes harsh tariffs post Brexit, that works both ways.

David Anderson

You are correct in saying that the UK can, theoretically, walk away without paying any future financial settlements it clearly committed to under David Cameron.

The only slight problem would be that the UK would become, overnight, a pariah state among the international community when it came to paying their bills. It is lucky for this country that this dangerously incompetent government has at least recognised this and is prepared to settle the bill.

John Sally Swigglebottom

Although I'm a passionate Remainer, then and now, I think another national referendum would produce a similar result. Only if our departure heralds a complete collapse of our economy will some change their minds and then only a few; most will blame the EU for our troubles.

I have no doubt we will make a go of leaving but feel we would have done so much more if we'd stayed. We were just starting to shape the EU to our way of thinking and now we're just giving up and walking away, leaving others to finish the job and reap the rewards.

Matt Davies

No prudently managed business would sanction a project like Brexit. The financial and social benefits have not even been agreed and publicised by the Cabinet, let alone by MPs.

Many of David Davies' "about 57" risk assessments don't exist [Ed: since this comment was posted, David Davies has confirmed that no impact assessments have been carried out]. The lack of due diligence combined with gross wishful thinking is staggering and only exceeded by the ego of the foreign secretary. There is no clear case for the project and it is causing paralysis, preventing the government from making progress in improving the lives of those less well off.

A leader would spell out the harsh realities and explain why it's time to pull the plug. An opportunity for a courageous politician!

If EU regulations have such a terrible effect on the UK, why aren't the worst 10 being excluded in the 'Great Repeal Bill'?

Mark Harrison

It seems that the EU has been taking a critical look at itself recently – perhaps because one of its biggest members chose to leave – and it may well make substantial changes.

The irony of this is that, when all the dust settles, the EU of the future may well be one that the UK would be happy to be a member of. (Perhaps we will be able to rejoin and get our divorce money back.)

In the meantime, we need to stop looking backwards (with votes like this) and put our time and energy into making a success of our new situation: outside the EU, yes, but with the freedom to manage our own affairs and to trade anywhere in the world. I voted Remain but, in the extremely unlikely event I'm ever asked again, I'm not sure I would a second time.

Alan Benn

Thesecretengineer

War has driven some of our biggest technological leaps. If only we could innovate with such purpose in peacetime, writes our anonymous blogger

Engineering could possibly lay claim to being the profession with the closest link to warfare, beyond the armed forces themselves.

You could argue that throwing rocks and sticks is merely the application of our innate ability to use our environment. However, when our ancestors first selected a tool, and then used it to sharpen one of those sticks, they stepped on to the first rung of the armaments engineering ladder.

Sadly, it is the nature of humanity to use weapons to assert our dominance, also establishing a need to defend. A stalemate creates the conditions for further developments, which then have to be countered in turn. Situations with an imbalance of power coupled to mobility go further and lead to the creation of empires.

Of course, technology alone does not produce empires, but it is a key part. Roman tactics and political will would have achieved very little without the short sword and roads. Would England ever have been more than a damp little island above Europe without superior arms and shipping?

A lot of military-led developments have gone on to benefit mankind in a wider context. Flying in your jet-powered aircraft, kept safe by radar-informed air traffic control, at high subsonic speeds, is testament to this. Who can say if, in a purely civilian world, we would have had these capabilities anyway? But the fact remains they were born of the near-constant

state of being in an armaments race. There are also plenty of civilian-led advances, but the necessary acceleration of our level of technical sophistication during times of war is notable.

I suspect that the classic triangle of cost/quality/time provides the answer. It is a basic tenet that you can only ever achieve two of the three. If you are in a war with a roughly equal enemy, you do not have the luxury of compromising on either delivery dates or quality; you need better weapons than your enemy and you need them immediately. Therefore you are compelled to spend the money to get them.

Come peacetime — largely free of either 'hot' or 'cold' wars — the use of money to advance science and technology is questioned. The impetus changes from the preservation of freedom or ideology and focuses instead on the protection of wealth. I do not know how this can be changed, but I feel failed by the optimism shown immediately after the first and second world wars.

Looking at the popular culture of the 1920s and 1950s, you see a hope that the strides made forward in the sciences would continue. It may be naïve and unrealistic but there is something incredibly uplifting about the belief that the continued arc of research and investment would cure all the world's problems.

A lack of hunger and disease, along with the provision of a comfortable life for all, may bring its own concerns but, without the pressures of noted inequalities across the globe in these respects, surely the drive for conflict would be reduced?

Utopia may be unobtainable but, while that most selfish act, 'self-preservation', can lead to the advancement of human-kind as a whole, it seems that when we can look at investing in the wider vision we become more insular.

One man notably bucked this trend and saw his inventions as being for the betterment of all, to his own detriment. Yet, as is the way, he was to be eclipsed by those who sought to build empires and accrue wealth instead.

The engineer's contribution to a world without wars surely lies within what he does in peacetime, and for that he need look no further for a role model than Nikola Tesla.

Inyouropinion

Industrial strategy

Without all-party support, it will fail

Is it possible to have an industrial strategy at the same time as Brexit? That's a bit like announcing your decision to play for Chelsea on the same day you decide to feed your legs into a woodchipper.
Mickey Padgett

This is a very welcome and much delayed attempt to support 'disruptive' technologies and innovation in general. However, is the government really talking to the SMEs that need this funding urgently? I think not. It has chosen, as always in its business council, to talk to the usual members of various committees, rather than stretch out to the smaller SMEs that need these new funding streams urgently and are being held up in their development because of this.
A Duncan

The strategy doesn't do enough for SMEs. It will require more funding, it will require a stronger watchdog and it does not meet most of industry's needs. That said, it provides an interesting framework and we should not just stomp all over it!
David Oliver

The only way out of the debt morass (nearly £2tn) is to invest in productive assets. Our politicians would not recognise a productive asset if it stood up and hit them in the face.
Brian O'Connor

Any strategy is better than no strategy. However, at this stage the strategy is just words and it is only a strategy until the next party gets into power and derails it, with ideas from yet more politicians who, as so aptly pointed out above, have never worked in a productive environment in their lives.
Ivan Taylor

Any so-called strategy put forward by a single party is doomed from the outset. A strategy for the UK should be developed, agreed and championed by ALL parties, with an agreement to implement it regardless of who is in power.
Another Steve

Join the debate
theengineer.co.uk

2018: a year of opportunities

The coming year will be one in which engineering will be firmly in the societal spotlight

I feel privileged and delighted to be starting this Year of Engineering as the new chief executive of the Royal Academy of Engineering. It is – of course – my dream job and I am especially excited to be taking on the role in a year in which engineering will be firmly under the spotlight.

I have written on several occasions about the shortfall in engineering skills and diversity. The Year of Engineering – and our associated profession-wide digital marketing campaign This is Engineering – provide an unprecedented opportunity to bring about a step change both in perceptions of engineering and the attractiveness of engineering careers to people from all backgrounds.

The timing of the year reflects many causes for celebration, including the fact that 2018 will see the first passenger journeys made on the Elizabeth Line: an enormous feat of engineering that has demonstrated the quality of project management that is possible in the UK and the power of visionary leadership in ensuring that such projects deliver maximum benefit through innovation, local capacity development and community engagement.

This year is also the 200th anniversary of the founding of the Institution of Civil Engineers and the 100th anniversary of the creation of the RAF. Both anniversary programmes will provide additional opportunities to showcase how engineering has transformed the world around us, and highlight how it can continue to do so in the future.

By contrast, Dame Judith Hackitt's review of building regulations and fire safety in the wake of the deeply shocking Grenfell Tower fire means that engineering and allied professions will come under great scrutiny in the next few months. We pride ourselves on our professionalism within the engineering community and we will need to play our full part in ensuring that lessons are learned and all necessary steps are taken to ensure that such disasters cannot happen again. The systems approach that underlies engineering must surely be of value in helping to create a more resilient framework of controls, even where vulnerabilities do not stem directly from the work of engineers.

Another major theme in 2018 will be the UK's preparations for Brexit and, linked to this, the implementation of industrial strategy, which remains a crucial component of the UK's post-Brexit risk-mitigation strategy. Engineering is a critical contributor to UK jobs and growth and it's important that our voices are heard in the debate. The academy is building on the very positive experience of the last 18 months of increasingly close collaboration with the other bodies representing UK professional engineering by creating a new Engineering Policy Centre to drive greater connectivity between policy makers and engineers, better-informed policy development and implementation.

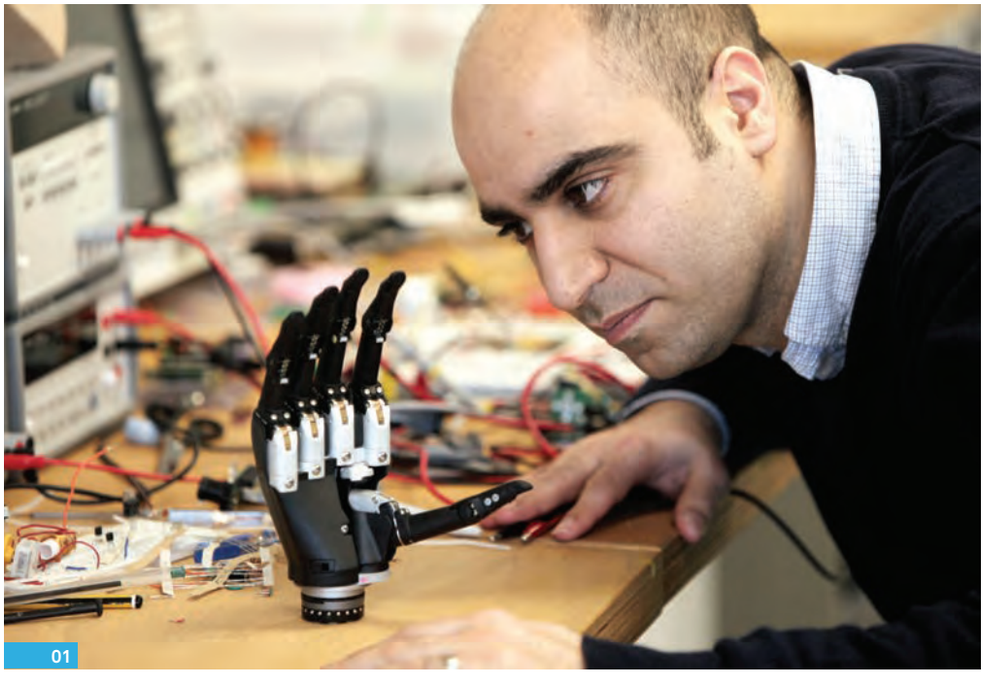
Commentators and politicians are increasingly focused on the impact of automation and technologies such as AI on the UK economy, with the BBC News website identifying AI as the most significant tech trend for 2018. UK research has enormous strengths in areas such as AI and robotics and I hope that 2018 will see greater investment in raising digital skill levels right across the workforce. It is equally important for engineers and technologists to engage with the public, the media and social scientists to help frame a responsible debate about the future of work and the societal impact of digital technologies, and ensure that public trust is built. Failure to do this could jeopardise the UK's ability to benefit fully from these technologies in the long term. The introduction of the General Data Protection Regulation in May 2018 will provoke further debates about data privacy as well as posing practical challenges for those organisations who are preparing for compliance.

Significant change for engineering is also expected within the research and innovation landscape. UK Research and Innovation (UKRI) will come into being on 1 April, while both the Engineering and Physical Sciences Research Council (EPSRC) and Innovate UK will be recruiting new leaders. Many of the senior roles within the research and innovation funding and policy community are currently held by biomedical scientists – including both the CEO of UKRI, Sir Mark Walport, and his successor as government chief scientific advisor, Dr Patrick Vallance. Effective leadership can of course be provided by people from any discipline, but it would be encouraging to see more influential engineering voices at the top table within policy-making circles in the future.

It is tempting to end this column with some reflections on what I might be saying in a year's time. I have given up attempting to predict the political weather, but I very much hope that we will be looking back on a year in which UK engineering made significant strides in supporting wider society and contributing to national life. I was very encouraged to see that the second Create the Future survey of public perceptions across 10 countries, published in December by the Queen Elizabeth Prize for Engineering Foundation, showed that 84 per cent believed that engineering can make a difference to addressing major global challenges and 87 per cent said they trust engineering businesses to make the world a better place. I look forward to playing my part in making sure that we live up to these expectations. ■

Dr Hayaatun Sillem is chief executive of the Royal Academy of Engineering

Bionic stric



01

02

03

01 Kianoush Nazarpour of Newcastle University inspects a prototype prosthetic hand

02/03 Off-the-shelf machine vision can improve functionality in prosthetics

There is a recurring theme in engineering of trying to match or copy nature. It's hardly surprising. The world and its biological systems have had millions of years to evolve solutions to the various problems posed by the environment; civilisation, by contrast, has had mere centuries. It's always a challenge, and humanity's successes in matching nature are relatively rare.

One of the biggest challenges comes in medicine, where engineers literally have to match nature. Engineering some device that will have to fulfil the same function as a natural part of the body or coordinate with natural processes is about as difficult as it gets. And replacing missing or lost limbs provides some of the most striking examples of the progress we have made.

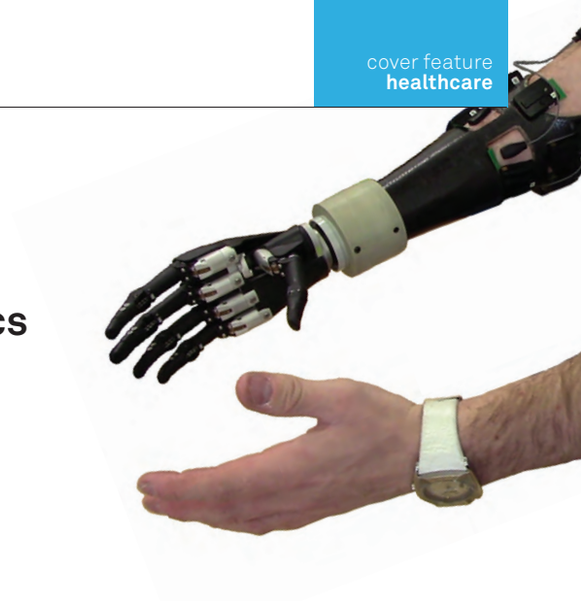
Archaeologists have found examples of replacement body parts from ancient Egypt, Greece and Rome. These range from the crude – wooden peg legs and strap-on toes – to primitive, but still impressive, attempts at limbs with hinged joints. Fast forward to the 19th century, and we find fully articulated prosthetic hands, which might not have been particularly effective but certainly look impressive.

Today, our expectations have been raised – unfairly – by science fiction. The 1970s television series *The Six Million Dollar Man* introduced us to a triple amputee whose legs and arm were replaced with robotic limbs that gave him superhuman abilities (running at 60mph, lifting impossibly heavy weights, and seeing acutely with an implanted electronic eye); the series' enduring legacy is in popularising the term 'bionic' for a motorised prosthetic. A decade later, and we saw the right hand of *Star Wars* hero Luke Skywalker lopped off and replaced with a cybernetic hand that was visually and functionally indistinguishable from his natural extremity, even down to reflexes and sensation.

But neither the Bionic Man nor Luke are realistic reflections of what is possible with prosthetics. We still talk of 'a hand like Luke Skywalker's' we want to evoke an advanced prosthetic, and under examination they still fall well short in functionality, no matter how impressive they look. So, 40 years after we learned to talk about bionics, what is the shape of prosthetics to come?

There are two main challenges involved in developing prosthetics. The first is in designing the mechanical limb itself. With increasing miniaturisation of electric motors and advances in computing power, this is becoming less of a challenge than the second, still-towering difficulty; finding ways to interface the machine with the amputee's body. How can somebody who has lost a limb control a prosthetic? Is it possible to think about moving a prosthetic arm and move it with brain power alone; or to get even closer to the natural condition, and move it without barely any conscious thought? Can the sense of touch be replicated by a machine, even with today's advanced sensors? And how about the sense that we rely on but is so fundamental that we are barely aware of it: proprioception – knowing exactly where our limbs and extremities are

des



The sci-fi vision of prosthetics that can be controlled by the brain is moving a step closer to reality. Stuart Nathan reports

without having to look? How close can an amputee be returned to natural function with technology? And how is that technology likely to develop in the coming decades?

It's useful here to look at the present state of the art. Current prosthetics have sockets that are made to fit precisely onto the amputee's stump by a specialist prosthetician. It is absolutely vital that the fit is precise, and most prosthetics have to be adjusted regularly, which is, like all custom-making processes, expensive, time-consuming, and often inconvenient. There aren't that many prosthetics, and travel to clinics is a problem (this is, of course, even more acute in the developing world and conflict zones, where amputation is disproportionately common and debilitating). Even the best-adjusted sockets are not ideal; the stump can slip against the surface, become sweaty and uncomfortable, and prolonged wear can be painful. This is particularly a problem for lower-limb prostheses, as the body's weight bears down onto the socket; sores and resulting infections are a constant danger.

The most advanced prostheses available today do have some degree of mental control, but no sensory feedback. Control is achieved thanks to a phenomenon called myoelectricity. The remaining muscles of the stump still respond when the user 'moves' the missing limb, resulting in electrical signals on the skin that can be detected by sensors installed into the socket. Although these signals may not correspond exactly to the movements the missing limb would have made, the user can learn how to make the prosthetic move in the desired fashion. Myoelectric sensors are quite inexpensive, and the signals can be processed by off-the-shelf chips and sent to motors in the prosthetic. Companies such as Open Bionics, which *The Engineer* has covered, use such technology in their prosthetic arms and hands, which are designed to be open source and can be built from parts made on commercial 3D printers.

Myoelectric control depends very strongly on the fit between stump and prosthetic, because the sensors that detect the muscle signal have to be precisely placed on the correct area of the skin.

Moreover, this technology is best suited to arms and hands. Legs present a different set of problems, as the movement of knees, feet and ankles in normal walking are more autonomous and less conscious than those of hands, arms and fingers; they also have to deal with different types of stress and perform a more mechanical and supportive function. Because of this, in general, the prosthetics field is sharply divided between upper- and lower-limb specialisms.

Advanced lower-limb prosthetics tend to contain more passive systems, based around mechanical joints whose stiffness, in the most advanced cases, can be adjusted automatically during walking. Known as active joints, these often use pneumatics to help create realistic movements of knees and ankles, controlled by electronic actuators.

The most advanced lower limb available is generally accepted to be the Linx system, produced by UK company Blatchford's, whose joints adjust automatically to changes in posture and that can be used even on soft and uneven surfaces.

Costing around £20,000 per unit, the Linx is, ironically, not currently available on the National Health Service in England because the equipment purchasing policy only takes into account the initial cost. In Scotland, where through-life costs are considered, the system has recently become available.

This reflects an unfortunate fact faced by lower-limb amputees: because of the unbalanced gait resulting from using a prosthetic leg and the stresses this imposes on the skeleton, many amputees eventually have to undergo a replacement of the hip on the opposite side to the missing limb. The cost of this operation, post-surgical care and monitoring, will in most cases outweigh the extra cost of purchasing an expensive prosthetic leg (even though even the Linx needs regular attention from a prosthetic).

Development of prosthetics largely divides into two camps; those working to refine current socket-based technology and those working on new systems more directly integrated into the body. The most basic requirement of the latter is some system that is grafted onto the skeleton using a process known as osseointegration. This requires developing metal systems that can be inserted into or attached to the shaft of a bone, whereupon the body's innate healing processes grow living bone directly onto and into the metal. 3D printing and advanced coating techniques have helped develop the technology considerably in recent years, as they allow the custom manufacture of textures and shapes suited for bone tissue to grow through.

> "Some people might feel tickling, others feel scratching"
>
> Kianoush Nazarpour, Newcastle University

Indeed, prostheses using such technology have become relatively common, such as hip and knee implants. The important thing about these is that they remain entirely inside the body. For a replacement body part, a section of the implant would have to protrude through the skin. Breaking the skin permanently is potentially dangerous, because it could create a pathway for infection. Until relatively recently, the accepted wisdom was that very few amputees would even consider the risk of a protruding implant.

This perception may now be beginning to change, and the difference has come from a surprising source: veterinary science. Readers in the UK may be familiar with Prof Noel Fitzpatrick, an Irish vet whose clinic in Surrey has been featured in several popular TV series that show off his specialism in replacing lost paws of small animals with protruding prostheses. Socketed prostheses are not practical for animals, but regular viewers will be familiar with Fitzpatrick's frequent struggles to encourage the skin of amputated limbs to adhere to his custom-made implants and the fight against resulting infections. Fitzpatrick is, however, an advocate of these "amputation prostheses" for humans, and works with surgeons on advancing the technology into human clinical practice.

Kianoush Nazarpour, a bioengineer from Newcastle University, is one of those researching ways of improving existing technology. It is understandable that amputees wouldn't want to risk implantation, especially when this technology is not fully developed, he told *The Engineer*. "By definition, if you need an amputation, you've already had a very traumatic experience, and the surgery to remove a damaged limb is even more trauma and risk. You can see why people wouldn't want to expose themselves to another extreme

procedure when they might end up with something no better – or even not as good – as something they can already have, and that's before you consider the risk of infection."

Nazarpour is an upper limb specialist, and all his work follows one philosophy. "We try not to overcomplicate the prosthetic itself, especially with on-board computing," he explained. The thinking behind this is that the human brain can already outperform any kind of synthetic processor, and its potential has not been fully explored. "Think of a blind man with a walking stick," he said. "Does that stick restore his sight? No. But the simple sensory feedback he obtains by tapping it in learned ways allows his brain to reach a relatively sophisticated impression of his surroundings; or at least the small part of his surroundings that he needs to understand to take a next step safely."

Nazarpour's research, in which he is working in collaboration with Imperial College London and the universities of Leeds, Keele, Essex and Southampton, is focused on giving prosthesis users sensory feedback. For this, he uses relatively simple sensors in the fingers of the prosthetic to detect temperature, pressure and shear (the last of these is detected by a sensor that responds to force lateral to the surface rather than perpendicular). Their output is translated into small electrical currents that are applied to the stump's skin. "Everybody might feel the sensations differently," he said. "For some people, it might feel like tickling, to others scratching. The sensor density cannot possibly be as great as that on a real hand, and the feedback isn't as rich. But the brain can learn to interpret the sensation on the remaining flesh as though it were on the hand."

Similar research in the blind has had some success in devices that stimulate the skin of the back in response to the output of a forward-facing camera, he added. "In these people, the sensations on the back are translated into an impression of what is in front of them through the brain's learning process."

Part of this, he added, results from neuroplasticity: the brain's ability to develop new connections between neurons, effectively 'rewiring' itself to develop new functions. "It's not fast or easy," he admitted. "People who get myoelectric limbs can typically start to learn to control them in about five minutes, because the visual impact of being able to see what your hand is reaching for, for example, is very powerful. Learning to interpret sensory input is an order of magnitude more difficult, and takes corresponding longer."

One intriguing direction the research has taken is in integrating machine vision into prosthetic hands. An off-the-shelf camera is attached near the wrist facing the fingers, and when the user moves the hand towards an object a processing algorithm assesses how best to position the fingers to grip the object. "It's not a difficult algorithm to decide whether a tripod grip or forefinger and thumb would be best, so as the hand approaches the object the fingers move into the best position. All the user has to do is close the hand when it reaches the object."

This is a transition technology, Nazarpour added, but is achievable with current equipment. "The point is that we shouldn't be afraid to use different sorts of inputs if that will help us," he said.

A similar system could conceivably be used on a prosthetic leg, he added; a camera monitoring ahead of the foot could manoeuvre the prosthetic foot into the best position to help the user climb steps, for example.

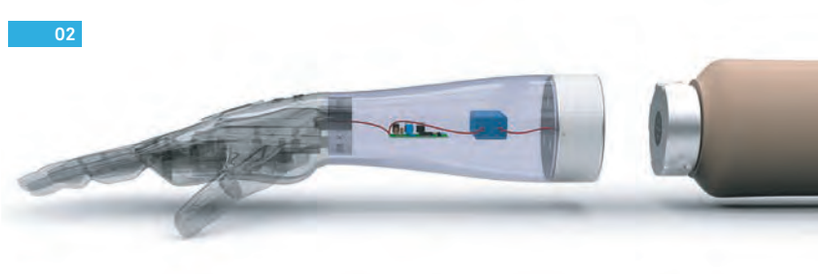
Cambridge Bio-Augmentation Systems (CBAS) is one of the most ambitious of the new technology school of prosthetic development. CBAS is developing a standardised interface that could be surgically implanted into the stump of an arm or a leg, where it would integrate with bone and also connect directly to nerves. A robotic limb would then plug in to the interface, and also clamp securely onto the section protruding from the body to fix it into position. "Think of it as a USB port for the body," explained co-founder Oliver Armitage.

CBAS is focusing on developing the interface rather than the limb, Armitage said. The system would be open source to allow robotics specialists to develop the prostheses themselves. "It gives us the best chance of developing technology, reducing the cost and letting other experts play their role," Armitage said.

Armitage is a bioengineer specialising in the junctions between dissimilar tissue such as bone and tendon, which has led him to work on how synthetic materials can be integrated into the body. One innovation he has been working on is a method to avoid the risk of infection. As well as the bone implant encouraging growth of natural material into metal, he is developing a blend of

01 Oliver Armitage of CBAS with a mannekin fitted with a prototype interface device

02 How the interface would attach to a robotic hand



elastomers and other soft materials into which skin can grow, to help create a waterproof, airtight seal between skin and the protruding part of the implant. His fellow co-founder, Emil Hewage, is a specialist in neuroscience and machine learning. While Armitage is looking at methods and materials that can connect nerves to the section of the interface inside the body, Hewage is looking at methods of interpreting the spiking electrical signals produced by nerves into forms that motor controllers can understand. This would work in two directions: signals from the motor nerves would be sent to the motors controlling the joints and fingers of the prosthetic, while the output of electronic sensors in the device would be fed into the sensory nerves.

Attaching directly to the skeleton as a variety of advantages, Armitage and Hewage said. "You have a fixed connection, so there's no slippage and no risk of sores developing on the skin of the stump," Armitage said. "The stresses of movement are passed directly into the skeleton, which has evolved to cope with them. Neural connection is already being done, and the technology we would use it is similar to that used for cochlear implants or deep brain stimulation in treatment of Parkinson's disease, but connecting to the peripheral nervous system rather than in the brain."

Another advantage, Hewage explained, is that direct attachment exploits the existing proprioception sense. "If the prosthetic moves precisely with the skeleton then it's fulfilling what the brain naturally expects be there, and we just tap into that."

Hewage agrees that the sensory input from a synthetic system can't match the richness of a natural extremity. "But we can send and receive information at the same speed the nervous system works in a non-amputee," he said. "And the brain is very good at filling in gaps. We don't perceive the world in anything like the detail that we think we do, either from our eyes or from our sense of touch. Our brains essentially use sophisticated processing tricks to fill in what our senses are not perceiving from moment to moment."

CBAS is not a large company, having about a dozen permanent research staff and around 30 regular collaborators in clinical and academic institutions in the UK and around the world. However, the company has been undertaking preclinical trials, and Armitage says that it hopes to proceed to early clinical trials in humans in 2018. The ambition is to develop a standardised interface that would cost around £10,000 per unit, and could be incorporated into upper or lower limb implants.

The *Six Million Dollar Man* is still a science fiction pipe-dream. But Luke Skywalker's hand, or at least a close approximation, might be closer than we think. ■

Sensors cut Arctic ice

SmartICE provides people in the Arctic with better information about this capricious landscape. Andrew Wade reports

At the recent United Nations climate conference in Bonn, Dr Trevor Bell was slightly taken aback that some people think polar bears are the only thing under threat in a warming Arctic.

"It was a little bit revealing how little people know about the Arctic," he told *The Engineer*. "The idea that people live in the Arctic seems to be quite a surprise to some people."

Bell was in Bonn to collect a UN Momentum for Change Climate Solutions Award for SmartICE, a project he heads up at Newfoundland's Memorial University. A physical geographer and field scientist, much of his working life has been spent studying the landscapes and settlements of the Arctic and the rapid changes affecting the region. While media glare tends to focus on the fate of the polar ice caps, coastal ice on the fringes of the continents impacts the lives of Arctic inhabitants more directly.

"Nearly all of the communities are coastal and they rely on what's called landfast ice, not the polar ocean which is mobile ice," Bell explained. "Landfast ice is ice that's frozen to the coast, if you like. It grows and disappears every year."

That ice is used by animals and humans to travel and hunt, offering flatter and more direct routes than the land. Although there have always been

"People can immediately see what the ice thickness is and how it varies"

Dr Trevor Bell

dangers associated with this dynamic landscape, recent years have become increasingly unpredictable, according to Bell.

"People have said that within the last decade or so there have been dramatic changes," he said, "such that ice might not freeze up for a month later (than usual), it may break up a month earlier, and you're finding places on the ice that are much, much thinner in places that should be thick."

The ice is being diminished as a result of both warming air and ocean temperatures in a double-pronged attack. Where the effect is primarily from below, no signs of thinning on the surface may be visible, leading to a particularly potent danger.

"It's been a dramatic change and it's catching people off guard," said Bell. "We've had accidents here in Canada. In Hudson Bay area this year three people died going through the ice on parts that they thought were safe."

Search-and-rescue operations in the Canadian Arctic have doubled in the last 10 years. About a third of those incidents tend to occur during the critical 'shoulder' seasons when the ice is forming and breaking up. Surveys in recent years indicate that one in 12 people are falling through the ice annually, with two-thirds expressing fear about travelling on the ice.

Having worked with the Inuit for many years, Bell was approached regarding how technology might be used to complement traditional indigenous knowledge about sea ice. The result is SmartICE, a system that uses sensors and satellite imagery to provide the communities with better information about the landscape they so fundamentally rely on. "That first reach-out was from the Inuit community, so that is an important part of SmartICE," explained Bell. "It's a service for communities by communities."

The system uses two types of sensor to help identify potentially dangerous spots where the ice is thin. SmartBUOYS are long tall sensors that penetrate through the ice to the sea below in locations decided upon by the Inuit. Rather than taking a measurement of the physical thickness directly, the buoys measure the difference in temperature above and below, with thickness calculated from the temperature gradient. Sea temperatures tend to remain relatively constant around -1˚C, but air temperature can reach as low as -50˚C depending on the season.

"It's that change in the temperature from the warm ocean up into the cold atmosphere that allows us to measure the sea ice thickness," said Bell. "That then is communicated by satellite back to us or back to the community, and we translate that into an evolving diagram that shows the progression of the ice thickness and snow depth over the season."

Depending on how big an area a community travels across, between five and ten of the stationary buoys might be deployed. SmartICE also uses a mobile sensor called SmartQAMUTIK (from the Inuit word for sled) that can be towed behind a snow mobile. Rather than measuring temperature, it uses a conductivity metre to detect the bottom of the sea ice. The difference in conductivity between the saline water and the sea ice – which ejects most of its salt when it freezes – allows thickness to be gauged, according to Bell.

"As the snowmobile travels around on the trails, it's providing – in real time – the ice thickness to the operator," he said. "But it's also collecting that information so that when it comes back into the community, it's automatically detected by a WiFi system that downloads it, processes it and sends it back to the community as a colour-coded travel-track... so people can immediately see what the ice thickness is and how it varies."

The edge of the landfast ice is biologically rich, and this is where much community hunting and fishing takes place. But it's a double-edged sword, as this is also some of the most treacherous territory. It being the Arctic, there's also 24-hour darkness to contend with for around three months of the year. When the spring finally comes, surface slush presents a brand-new hazard. When it's deep enough, snowmobiles can get stalled in this slush, often with disastrous consequences. If you're a long way from home, with no snowmobile and soaked to the bone, exposure can lead to amputations and even death.

"That's why the freeze-up and the break-up, those shoulder seasons, are when there's the most search-and-rescue incidents," said Bell.

The sensor data gathered directly from the ice is supplemented by radar imagery from the European Space Agency's Sentinel-1 satellite. This helps to identify 'no go' and 'slow go' areas, as well as areas showing typical conditions for that time of year. Currently, these images are accessed about once a week, but this will soon become more frequent with new satellites coming online.

Alongside a UN Momentum for Change Award, the project received the 2016 Arctic Inspiration Prize. Increased prominence has brought increased demand, and Bell receives requests to join the programme on a weekly basis. This winter, SmartICE should be operating in at least eight communities, but there's another dozen on a waiting list. How to fund it all has become a key challenge.

As well as the social and cultural benefits the programme enables, there is also a solid brass-tacks argument. Search-and-rescue operations in the Canadian Arctic are eye-wateringly expensive, as coast guard bases are located almost exclusively in the south. A CH-149 Cormorant rescue helicopter takes 12 hours to reach some of the northernmost communities. Choppers sometimes have to be accompanied by Hercules planes carrying supplementary fuel and a second search-and-rescue flight crew. If SmartICE prevented a single call-out, it would virtually pay for itself.

"We're talking about hundreds of thousands of Canadian dollars to do that, which in itself would pay for the operation of SmartICE for a year, in potentially multiple communities," said Bell. "Unfortunately, of course, climate change isn't going to get any better, it's probably going to get more intensive moving forward. We're going to have to, obviously, adapt and scale up our services as each winter continually gets tougher for sea ice travel." ■

Making a power of difference

The boss of one of the world's largest automation companies on collaboration, innovation, and why we shouldn't fear the robots. Jon Excell reports

The rapid march of automation and robotics is a divisive trend. For some, it's a destructive force that threatens jobs and even entire professions. Others trumpet its productivity-boosting powers and the trickle-down benefits this brings to the wider economy.

There are no prizes for guessing where CEO of power and automation giant ABB Ulrich Spiesshofer sits on this. On a recent visit to the UK he explained to *The Engineer* why he believes we should welcome the rise of the robot.

"If you correlate robotic density with unemployment rates you will see the lower the robot density the higher the unemployment," he said. "In the US, we have about 100 robots per 10,000 workers and an unemployment rate that is still significant. France has about 130 and an unemployment rate between 9 and 10 per cent. Germany, Japan and South Korea all have more than 300 robots per 10,000 workers and the unemployment rate is below 4 per cent. There is no correlation that would say that robots create unemployment. Quite the opposite. Robots drive employment because through new ways of competitiveness you create additional jobs."

What's more, while automation may not have delivered the life of universal leisure and indulgence once predicted by science-fiction writers, it has, Spiesshofer believes, been one of the single-most important factors in driving up global living standards. "In the last 50 years mankind has moved more people from below the extreme poverty line than the accumulated 500 years before and one of the key drivers is industrialisation of automation," he said.

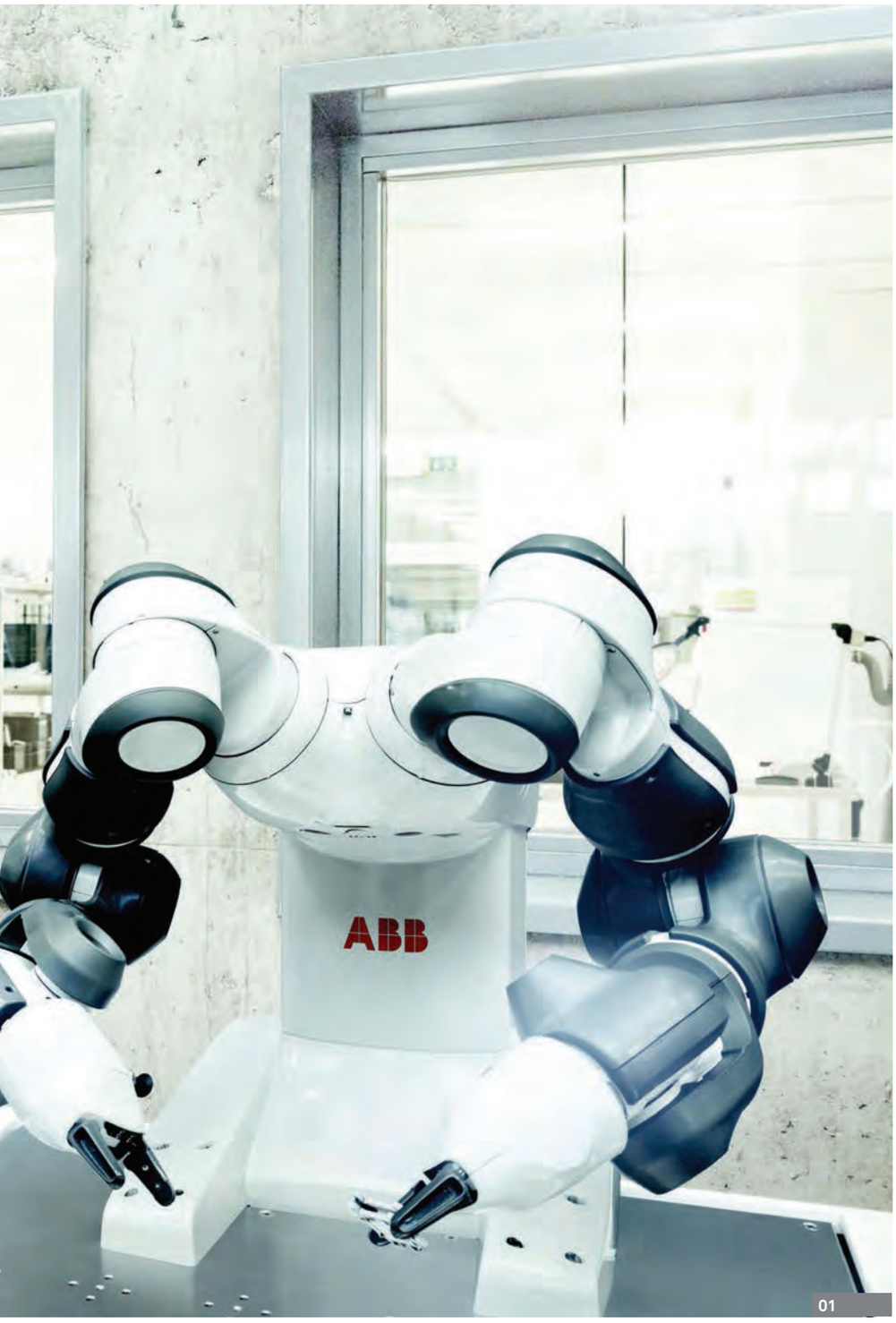
With the recent advent of Industry 4.0, collaborative robotics, and artificial intelligence – to name just a few transformative technology trends – this automation-driven revolution shows no sign of slowing. And, since taking the helm at ABB back in 2013, Spiesshofer has presided over a restructuring process designed to ensure that the firm is well placed to help drive this ongoing revolution.

One key change to the way the company operates has been a greater emphasis on collaborating with external partners, particularly in the academic research community. "We have changed the model in the last couple of years to where we rely much more than in the past on partnerships, not just on the business side but also in education and research," he explained. "We need to tap innovation where it happens."

The company's relationship with Imperial College London is an example of that in action. Indeed, during his recent visit to the UK Spiesshofer signed a memorandum of understanding with the university to collaborate on research into the digital power grids, a key emerging area for the company.

"Robots drive employment because through new ways of competitiveness you create additional jobs"

But in parallel with an increased appetite to collaborate with the outside world, the firm has also upped its investment in internal R&D, particularly in emerging areas such as artificial intelligence, which Spiesshofer believes will define the future of the automation sector. "We're coming from an industrial environment where automation helps to replace muscle,



01

02

into a new environment where we bring together actuation, control, sensing, digitalisation and AI to make sure the expertise that's captured in the brains of our people and control systems gets lifted out and aggregated so that we can really augment human potential by the use of AI."

Restructuring the organisation to achieve this change has been a key goal for Spiesshofer and, over the past few years, he's simplified the way it functions: maintaining the distinct focus of its four global business areas – power grids, electrification, industrial automation, and robotics – while maximising the opportunities for collaboration and expertise sharing across the business. "In the past, we were a vertically focused company that hung together horizontally, now we are a horizontally leveraged company that has deep vertical domain expertise," he said.

To help create the right conditions for this collaboration to take place, Spiesshofer has put in place a process he calls the "growth port": whereby all of the key division leaders meet regularly in a structured way with different parts of the business to identify opportunities. "First we bring in the sales people in and ask where are the priorities for market penetration," he explained. "Next time we focus on innovation, then we bring the R&D leaders together and ask what can we do on the innovation side. Third time, we talk about market expansion and going into new areas and again we bring the business leaders together. We have created a growth and innovation machine that's much more aligned than ever before."

The transformation engineered by Spiesshofer has taken place against a backdrop of broader global economic change and uncertainty, a climate that has hampered global infrastructure investments, and created further challenges for technology suppliers such as ABB. However, Spiesshofer prefers to view this uncertainty as an opportunity. "We need to appreciate that in the years to come the world will have a lot of volatility and uncertainty, but technology can help us to become more independent from these uncertainties by providing a base productivity improvement, and by providing competitiveness. The countries and companies that are leading in technology adoption are leading in the world of uncertainty."

It's a point that's perhaps particularly relevant to the UK, where the much-publicised productivity gap and continuing uncertainty over the shape and impact of Brexit are causing major concerns across industry. "I think that the UK with all the uncertainties on the political side at the moment should continue to deploy technology in a good way, and should become a faster adopter in more areas. Altogether, the UK has a tremendous opportunity for technology use. The robot density in the UK is far below Germany and Japan – so there's an opportunity to do something and I think it will have a positive impact on the economy when you deploy technology more." ■

01 ABB's YuMi collaborative robot

02 Increased digitalisation is helping to drive productivity

SOUTHERN 18 Manufacturing & Electronics

Incorporating The Subcontract Engineering Exhibition
AUTOAERO
FARNBOROUGH • 6-8 FEBRUARY 2018

FARNBOROUGH | Hants | GU14 6XL

6th – 8th February 2018
9.30am – 4.30pm (3.30pm close Thurs)

2018 celebrates the event's 20th Anniversary with a move to the brand new FARNBOROUGH venue

The UK's must-attend event for every industrial engineering and manufacturing professional

Meet over 800 national and international suppliers under one roof in the brand new Farnborough venue next February at Southern Manufacturing & Electronics (inc AutoAero) 2018.

See live demonstrations and new product launches of machine tools & tooling, electronics, factory & process automation, packaging & handling, labeling & marking, test & measurement, materials & adhesives, rapid prototyping, ICT, drives & controls and laboratory equipment.

Free industry seminar programme online @ **www.industrysouth.co.uk**

The exhibition is **free** to attend, **free** to park and easy to get to. Doors open at 9.30am on Tuesday 6th February.

Autosport
MARINE
Aerospace
Packaging & Logistics
Electronics
Automation & Robotics
Medical
Composites
Rail and Transportation

FREE SEMINARS
FREE PARKING

Pre-register online now for your free entry badge and show preview at **www.industrysouth.co.uk**

SOUTHERN MANUFACTURING & ELECTRONICS is an ETES event organised by European Trade & Exhibition Services Ltd

Tel 01784 880890
email philv@etes.co.uk

etes Regional Manufacturing Exhibitions

Register here with your smartphone

With an eye on the weather

Novelist Jon Wallace considers the science fiction implications of engineering stories that have caught his eye. This month, the terrifying potential of the weather

Many of our earliest stories were shaped by the weather, as the struggle for survival was decided in significant part by the success or failure of crops. It's easy to see how, helpless before nature's fickle distribution of light and rain, early minds thought weather the work of cruel gods, drought and famine manifestations of their displeasure. Humans spent centuries praying, dancing or sacrificing to appease these deities and conjure rain, or indeed keep off too much of it: fearful of incurring an Abrahamic flood or other inclement biblical punishment, such as raining frogs and killer hailstorms.

The value of better understanding the weather helped meteorology become one of the most ancient and sought-after sciences, setting humanity on a path free of superstition and ritual (although gods still raise their heads again in desperate moments – the governor of Texas ordered a day of prayer to break 2011's devastating drought).

Stories developed alongside meteorology to reflect our increasing ability to measure and explain the weather and also our continuing inability to control it. So it is that individuals with a power to bend the weather to their will have retained a supernatural quality, living often in comic book form as reimagined Gods (Thor) or superpowered mutant (Storm of the X-Men). Occasionally the genre pokes fun at the very idea: Ron McKenna, of Douglas Adams' *So Long and Thanks for All the Fish*, is a rain god cursed by the drizzle he carries with him wherever he goes.

In the last half century, however, the story has rather changed. As we have come to understand that human progress is making the weather yet more unpredictable, a new sense of helplessness before imminent catastrophe, biblical in scope, has set in: worse, the part of the gods is extinguished, making man himself the architect of terrifying storms, floods and droughts.

Apocalyptic fiction has bloomed as modern scifi writers explore the implications of this unwanted responsibility. Extreme weather has created many future stories: for example: the floods and freezing of *The Day After Tomorrow*. In turn, an entire branch of 'cli-fi' literature has emerged to guess at the manner in which gathering storm clouds will break: Kim Stanley Robinson's *Science in the Capital* trilogy, alongside work such as *The Water Knife*.

For the scifi writer exhausted with such a relentlessly bleak outlook, the pages of *The Engineer* do offer at least the glimpse of an alternative future. Reports such as that on new Global Environmental Monitoring Satellites (GEMS), offering 'a new paradigm in weather forecasting', allow us to imagine salvation through the application of science: writers might be tempted to craft tales of future systems that might grant humanity control of snow, rain and heat.

Still, optimism can only stretch so far if we are to produce a good story: contented, sunlit futures have little scope for excitement. Rather the scifi author would do better to ask: would men fail to control the climate as much as they have their carbon emissions?

Extreme weather has provided the premise for many future stories

After all, even in a future of computerised world weather control, some would be unhappy: imagine a future group of forecasters, put out of work by weather machines and driven mad by their loss of eminence. Seeking revenge, they hack the weather control programmes and plunge the world into chaos, plagued by typhoons, fogs, electrical storms and droughts. The forecasters return civilisation to a primitive state and become future gods, demanding sacrifices from the terrified populace in return for clement conditions.

Control of the weather may also not work out too well: imagine some future British government that deploys a device to bask the country in sunshine, hoping to boost tourism. The technology works perfectly, but the plan fails: visits to the UK drop off, as tourists are denied one of the defining features of a UK holiday: persistent drizzle.

Indeed, a culture such as England's, where ice is so often broken via discussion of unwelcome precipitation, could be badly affected by perfectly ordered atmospheric conditions. We could tell the story of a future government that orders sun-drenched bank holidays and rain-soaked working hours in the hope of boosting productivity. Instead, the country is racked by depression, as the population stays home – unable to function without the soothing social bond of whining about the unpredictable 'bloody weather'.

The scope for such stories is boundless; for, however much we might moan about grey skies and storms, the weather crafts our characters' worlds and holds up a mirror to their state of mind. The more unsettled are conditions, the better the outlook for adventure. ■

Jon Wallace is a science fiction writer. He is author of *Barricade*, published by Gollancz

Super group

With the HIPERCAR, Ariel plans to rewrite the supercar rulebook. To do so, it is drawing on the talents of the UK supply chain, writes Chris Pickering

Developing a new car platform from scratch is a huge undertaking. When this also happens to be a radical gas turbine-electric supercar, it would be deemed an extremely ambitious project for a global OEM, let alone a small, independent carmaker from Somerset.

Throw in the small matter of 1,180bhp, four-wheel drive and a physics-defying 0-100mph claim of 3.8 seconds and you'd be forgiven for thinking the concept had been plucked from the realms of fantasy. But the Ariel HIPERCAR is a project that deserves to be taken very seriously indeed.

For a start, Ariel has been realistic about how much it intends to take on. While the fundamentals of the design and development are indeed being handled in-house, the project is supported by an all-star cast of technical partners. Names on the roster include specialist firms such as Delta Motorsport, Equipmake and GKN Hybrid Drive, plus industry heavyweights Alexander Dennis, JCB and Johnson Matthey.

Strictly speaking the HIPERCAR tag does not refer to the vehicle itself – known internally as the P40 – but to the R&D project that spawned it. Short for High Performance Carbon Reduction, it was an Innovate UK-backed project based around a feasibility study carried out by Ariel in 2014. This investigated various hybrid architectures for a low-emissions sports car and concluded that a range-extended EV (electric vehicle) was the best option.

"You're going to severely impact the range if you start using a meaningful percentage of the capability of a high-performance battery-only EV, so a range extender was always part of the plan," explained Neil Yates, Ariel's HIPERCAR project manager.

Having carried out a lot of vehicle and systems-level simulation, the team concluded that the range extender would require "quite a significant output" to maintain state of charge during aggressive road driving. That was when they thought of using a gas turbine.

"If you look at the range extender offerings on the market already, they're typically combustion engine based; they're heavy, relatively inefficient and require significant packaging space. None of that feels very clever when you compare it with the rest of the platform," said Yates.

The project has received more than £2m of grant funding, with electric motor designer Equipmake and gas turbine

01/02 The car was spun out of an Innovate UK low-carbon vehicle project

01

02

provider Delta Motorsport joining Ariel for the development phase, followed by the other partners. Each firm gets to retain the intellectual property it puts in to the project; and, while all the major technology has been developed specifically for the HIPERCAR, it has also been designed with scalability in mind.

"Very few manufacturers would have a specification requirement like ours, but the technology is absolutely applicable to other uses," Yates pointed out. "You could see a scaled-down derivative of one of the motors finding its way into a mass-produced passenger car, or perhaps an enlarged version of the battery going onto a bus or an earth mover."

Ariel unveiled the first two prototypes at the Cenex Low Carbon Vehicle Show at Millbrook in September. Crucially, when the covers came off, the crowds were greeted by a fully functioning rolling chassis, not a series of concept sketches or a styling mock-up (as is often the case with ambitious supercar start-ups).

At the same time, it was announced that the project had won a further £6m grant through the Advanced Propulsion Centre (APC), adding credence to Ariel's claim that the car would be production ready by 2020.

As the second phase of development gets under way, the company is busy testing its two early-stage prototypes, with a further five development and validation vehicles due over the next 16 months.

The plan is to supply the P40 in two derivatives: a four-wheel-drive model with 1,180bhp (880kW) and a 590bhp model driving the rear wheels alone. Both will use one inboard-mounted 220kW motor unit on each driven wheel, complete with its own integrated epicyclic gearbox and inverter.

Developed by Equipmake in collaboration with Aim Co Japan, the design of these units is innovative, with the magnets arranged radially around the outside of the rotor like the spokes of a wheel. This is said to improve the torque density by as much as 25 per cent, while a sophisticated water-glycol cooling system enables the motors to run at high outputs for a prolonged period.

In each case, the floor-mounted lithium-ion battery pack forms a semi-stressed member of the chassis. However, the cell chemistry is different for the two variants. Delta Motorsport was responsible for the development of both designs but the two-wheel-drive battery pack fell under a separate £12m Innovate UK battery research project, headed by Warwick Manufacturing Group. It uses fewer cells than the four-wheel-drive variant and produces a lower total output, but at a higher energy density.

To overcome the challenges of thermal management in the packs, where average (RMS) power could be well in excess of 300kW, Delta has developed a unique liquid-cooling system. Refrigerated water-glycol coolant is fed directly to every cell in the pack, with a network of temperature sensors to actively control its distribution. The same modular system is used in both variants, and in four-wheel-drive form it enables the pack to operate at an impressive 1,500kW with peaks of up to 1,200A and 750V.

Ariel says an innovative charging system is also in development, which will enable the high-voltage battery pack to be charged from a conventional (i.e. sub-500V) CHAdeMO or Type 2 socket. The aim is that a full charge will give the car an electric-only range of around 120 miles for normal road driving.

Beyond that, the 35kW range extender should be enough to maintain charge during normal road use (giving a combined range of about 500 miles on a full tank/charge). For track use, however, it's anticipated that either the range extender or the plug-in capability will need to be used to charge the car in between runs. This should give about 15 minutes of flat out running at a high speed circuit like Spa or Silverstone, before the range extender is required to get the car back to the pits.

The micro-turbine system is another Delta Motorsport Innovation. It runs on regular pump petrol, spinning at a constant 120,000rpm once it's up to speed. The combustion system incorporates a recuperator, which is one of a number of features that are said to address the emissions challenges traditionally encountered with gas turbines. Overall, Ariel says the tailpipe emissions should be less than those of a typical city car (quite an achievement, considering it's expected to comfortably outpace a Bugatti Veyron from 0 to 150mph).

There were a number of concerns when the engineers first started looking at using an onboard turbine, Yates admits. One of those was the NVH implications of something spinning at 120,000rpm directly behind the occupants' heads.

"What you don't realise when driving a combustion-engined vehicle is how many other noises there are in the car," he says. "You get that in any EV, but here it exacerbates the challenge of managing the noise of the turbine. It's been a really interesting challenge; we've actually managed to make a feature of the range extender noise."

Another question mark hung over the thermal management, but the exhaust tailpipe temperatures turned out to be very similar to that of a conventional internal combustion engine. Despite its high internal temperatures the turbine doesn't require any direct cooling; the electrical half of the range extender, meanwhile, is part of the same multi-circuit water-glycol heating and cooling system as the charging inverter and the DC/DC converter.

There's still plenty of work to be done. The main task now is carrying out durability testing in order to ensure that the car is not just capable of doing 0-to-150mph in 7.8 seconds once, but time after time. Although it will be a relatively low volume model – with projected sales of less than 100 cars a year – Ariel is keen to stress that it is intended as a viable commercial proposition, not simply a concept car or a one-off.

Prices have yet to be confirmed ("more than an [Ariel] Atom and less than a Veyron", quips Yates) but the production-ready model is due to be unveiled in 2019, with deliveries beginning in 2020. By that point it will have a new name to replace the current in-house designation, plus a fully enclosed carbon-fibre body. Under the skin, however, the company promises it will remain every bit as crazy as the prototypes you see here.

If they can pull it off, it will be a massive coup for this small independent manufacturer – one made possible, at least in part, by the unique way the project has been structured. And given the company's track record, not to mention to the heavyweight engineering talent supporting it, the omens look very good indeed. ■

Return of the lost engineers

Industry bodies are working together to bring more women into engineering and entice lost talent back into the fold, reports Helen Knight

It is well known that there is a significant gender gap within engineering, and the professional bodies have invested a considerable amount of time and effort into improving diversity in the profession.

However, while most of these efforts are focused on trying to encourage young women to enter the profession at the start of their careers, much less attention is paid to trying to entice them back into the industry after having children.

According to research by the Women's Engineering Society (WES), there are approximately 20,000 skilled engineers who have left the profession, and now find that they cannot get back in again.

Tapping into this lost talent pool could help companies tackle some of their skills shortages, while improving diversity within the profession.

Now a growing number of industry bodies are investigating ways to seek out these lost engineers, and offer them a path back into the profession.

The Institute of Marine, Engineering, Science and Technology (IMarEST), for example, has launched a return- to-work programme for professionals who have taken a career break, or are looking to transfer to a different sector.

The programme, known as STEM Returners, was developed alongside WES, and involves a 13-week paid employment placement at one of a number of partner companies.

Many returners have been out of the industry for between one to 10 years, which can have a significant impact on their confidence, according to Natalie Desty, director of workforce development at IMarEST.

"Returners tend to undervalue their skills and experience, and expect to come in at a much less senior role than they would have been in when they left," said Desty.

But even those who do apply for a role can often be overlooked by recruitment agencies who will not put candidates forward for a role if they have a gap in their CV, as this is often equated with a deterioration in skills.

What's more, with so much of the recruitment process now carried out online using artificial intelligence, many CVs will be discounted by such systems before they ever reach a hiring manager, said Desty.

"If you then add to that any unconscious bias by the hiring manager against those with a CV gap of two or three years or more, believing that the person's skills aren't up to date, then more often than not they are discounted straightaway," she said.

Alongside the experience gained from a 13-week work placement, the programme is designed to offer the returners support such as confidence building, training, career coaching, networking opportunities and peer support.

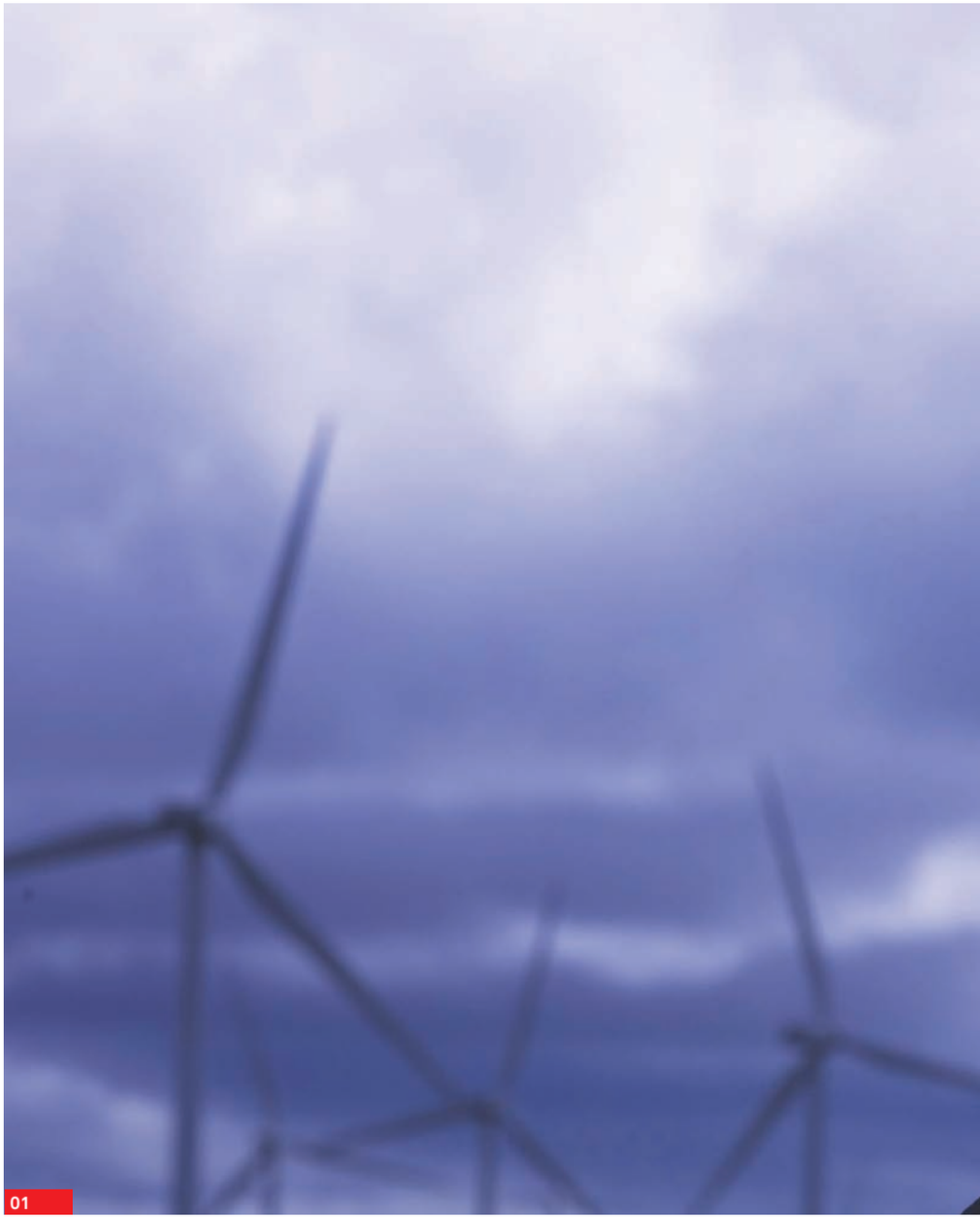
At the end of the programme, if both the employer and returners are happy, all those going through the placement are matched with an existing job vacancy within the company. In this way the placement also acts as a 13-week job interview for the employer, while allowing the engineer to really get to know the company before joining.

In January the first 10 returners will begin their placement with the programme's pilot partner, construction company Kier, where they will be working in different areas of the business.

Around seven other partner organisations are also expected to begin placements between January and April.

"I would say we are probably looking to get 60-70 people placed within the next six months, and that is obviously just with the companies that are currently signed up to run the programme," said Desty.

Similarly, Equate Scotland, which aims to redress the gender imbalance in STEM sectors in the country, has also established its own returners programme. Following a successful pilot in 2016, the



01

> "We are looking to get 60-70 people placed within the next six months"
>
> Natalie Desty, IMarEST director

organisation, in partnership with the trade union Prospect and with funding from the Scottish government, launched the programme in May 2017.

Three women began paid placements in July and August; two with Scottish Power and one with EDF Energy, with a further two Scottish Power placements beginning in October.

The programme gives women structured support to brush up their skills and rebuild their confidence. Participants receive a range of support services, including workshops, webinars, networking events, one-to-one career clinics and online support.

Similarly, the Institute of Civil Engineers (ICE) is partnering with a number of engineering firms, including Morgan Sindall, to offer paid work placements for professionals returning to work after a career break.

The placements, called returnships – an initiative first developed in the financial industry by Goldman Sachs in 2008 – offer 10-12 week contracts in which the participants work on one of the company's projects while gaining the opportunity to refresh their skills.

For those who are already planning to return to work for their company after a period of maternity leave, WISE offers a two-day returners programme in partnership with Skills 4. Companies taking part in the programme, which has been running for 10 years, include lead host Atkins, as well as HS2, BAM Nutall, BuroHappold, UCL, Cardiff University, Westfield and Mott MacDonald, said Jayne Little, managing director at Skills 4.

"There is some good work going on," she said. "However, if the UK is going to meet its aspirations of a more diverse workforce in certain industries and boardrooms, many public and private sectors must do more if talented people are to advance their careers and stay in industries, which can ill-afford a brain drain."

For Kier, which is taking part in IMarEST's returner programme, the scheme will allow it to offer an alternative route into the company, said Jan Atkinson, talent and organisational development director.

02

"We undertake a lot of targeted activity when recruiting for apprentices, graduates and early talent, and wanted to diversify our entry routes into Kier," Atkinson said.

01 Women returning to engineering can brush up their skills

02 Being out of the industry for many years can affect confidence

The programme will provide a way for skilled professionals to get back in to work more easily, or make the switch into the built environment sector, while offering a personalised plan and mentoring scheme to help make the transition a successful one, she said.

"Our sector has a well-publicised skills shortage in technical and professional skills and a diversity challenge," said Atkinson. "So we need to make the pathway into Kier accessible and attractive to talented professionals at any stage in their career journey, and provide them with the right support, particularly at times when the transition might feel a little harder to achieve." ■

Boosting inspection tools with augmented reality

Company believes Visual Inspect AR will mean significant time and cost savings. Supplier: Faro

Metrology specialist Faro is incorporating augmented reality (AR) into its suite of inspection tools, something the company believes has the potential to deliver significant time and cost savings.

Faro's Visual Inspect AR allows CAD models to be overlaid on a video image of parts and castings, typically displayed on a tablet.

This enables a direct comparison of the component with the plan data, so any discrepancies can be highlighted instantly.

Issues can be documented in the program using photo or video evidence, with the error report linked directly to the corresponding geometry.

After checks have been made, these reports can be exported as a document or transferred straight to the relevant PLM or PDM systems.

Post-processing the results of the checks, for example, by manually entering them into systems or creating PowerPoint presentations is no longer necessary. As well as geometry, the inspector has access – via the tablet – to additional information such as metadata, core data and ISO standards.

According to Faro, the platform can be used to monitor and inspect both incoming goods and components produced in-house. If features such as holes or slots have been omitted when creating the CAM program, this can be checked against the construction data within minutes. This means it is no longer necessary to re-clamp and set up the part being processed, potentially resulting in savings of a few hours.

Additionally, the technology opens up new possibilities in the fitting of sub-assemblies, saving time and avoiding errors.

Components can be identified directly at the site, their installation position identified and sub-assemblies checked. When it comes to maintenance, all documents are quickly available to the fitter on-site, and installation sites can be identified quickly using the AR overlay. ■

Navies look to diesel engine

Demanding trials first for product. Supplier: Mitutoyo

Cox Powertrain is set to launch a product that has piqued the interest of global navies, but it'll need to meet some exacting standards before it hits the water.

The company's CXO300 – the world's first 300hp marine diesel outboard engine – was inspired by the worldwide military's drive to adopt diesel and is set for launch this year.

The CXO300 delivers increased responsiveness, enhanced fuel efficiency and improved safety while outperforming conventional diesels. Reduced size and weight belies the power from a four-cylinder, eight-piston, supercharged, two-stroke diesel engine that generates 300hp.

Prior to launch, the CXO300 will have to undergo a series of demanding trials, in addition to satisfying the IMO, Tier 3 EPA and EU emissions compliance process.

High-quality standards are applied to the CXO300's manufacture and in addition to dimensional checks, particular attention is paid to components' critical surface roughness parameters.

To meet the criteria, Cox Powertrain opted for the Surftest SJ-500 surface roughness tester from Mitutoyo

Duncan Green, Cox Powertrain head of procurement, said: "[Surftest SJ-500] is able to inspect our parts in all our surface roughness parameters. It is also able to work in many other parameters that we may need in the future. The instrument is invaluable in upholding the quality of our manufactured components."

Ken Edwards, Cox Powertrain chief inspector, added: "As it's a menu-driven system it is so easy to use. I was able to use all the SJ-500 facilities immediately after its installation. The instrument's automatic calibration function also gives me confidence in the precision of the reading that I achieve. In addition to working in all the surface roughness parameters we use, the unit's detector system can also be mounted laterally for transverse measurements." ■

Measuring up for four-wheel drive

Manufacturer of car parts looks for a new method in an inline measuring process. Supplier: Hexagon

GKN Driveline's plant in Koping, Sweden develops, manufactures and assembles the most vital parts of the four-wheel drive for many of today's cars.

Production engineer Jan Engström works within the crown wheel manufacturing department and is responsible for 34 processing machines that run 24 hours a day. Together with Hexagon Manufacturing Intelligence, Engström has been involved in a project that will change the way GKN measures parts.

"In the past we have used set measuring gauges to do control measurements of our products," said Engström. "The downside was that with each new detail we produced we needed to buy the matching gauges. When we received orders for several new products we needed a more flexible solution."

The project started when Engström began discussions with Hexagon on finding the right solution for an inline measuring process. The final result was the installation of an automated solution where a Global Shop Floor coordinate measuring machine (CMM) equipped with PC-DMIS software has been integrated into the production line.

Previously, parts were taken from the production line into a measuring room for inspection, which caused production delays. The new system does the same job in 90 seconds.

Flexibility was important as GKN Driveline needed to measure different parts for different customers. New parts can be measured in the cell with Hexagon's new process.

Engström said: "Compared to the gauges, the CMM... can measure everything we put on the table. Now we can start producing all-new products directly. This also frees up time in our measuring room, as the measuring machine can handle additional controls that the gauges could not."

GKN currently has 10 Hexagon CMMs within the factory. ■

Accuracy is key for gearbox specialist

Height gauges used for variety of high-precision components. Supplier: Trimos

British gearbox specialist Xtrac is using multiple Trimos VL300 Height Gauges to accurately measure and inspect a range of components.

The Berkshire-based manufacturer produces high-performance transmission systems and driveline components for the motorsport industry. It uses the height gauges for everything that requires an accurate height or length measurement, including a variety of high-precision components ranging from washers, right up to full casting gearbox main cases.

"We particularly like the Trimos height gauges because they are very accurate and really easy to use," said Xtrac inspection manager Neil Warwick. "There's no learning curve with them; they're self-explanatory and minimal training is needed to get operatives up to speed."

Gear cutting and manufacturing is extremely specialist, requiring accuracy to within a few microns and inspection equipment to match the tight tolerances. The Trimos VL300 Height Gauges were supplied to Xtrac by Bowers Group, the metrology specialists established in Bradford in 1915.

"The service we receive from Bowers Group is brilliant," said Warwick. "They are very reliable height gauges, but when they do need a full service, the technicians really know their stuff. We always get them back within a week to 10 days when they're sent off for repairs or maintenance. The support and back-up that we receive from Bowers is exceptional.

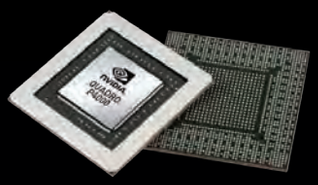
"We've had some of the older models of the Trimos height gauges for a long time now and they're still performing well. They've not worn out or failed; with some periodic maintenance they're going strong even after 20 years. We've very nearly got one per person in our inspection department now, which just shows how useful and valuable they are to us; we simply wouldn't consider an alternative." ■

PNY®
Professional Solutions
NVIDIA Quadro® / NVIDIA Tesla® / NVIDIA Grid®/ Servers

PNY PREVAIL**PRO** MOBILE WORKSTATION

Pro Performance. Anytime. Anywhere.

NVIDIA Quadro P4000 Mobile GPU | 1792 CUDA Cores | 8GB GDDR5
NVIDIA Quadro P3000 Mobile GPU | 1280 CUDA Cores | 6GB GDDR5



Certified by Independent Software Vendors:

AUTODESK®
AUTODESK® 3DS MAX® | AUTODESK® INVENTOR®
AUTODESK® AUTOCAD® | AUTODESK® MAYA®

Adobe
Ai Illustrator | Pr Premiere Pro
Ae After Effects | Ps PhotoShop

DASSAULT SYSTEMES | SIEMENS
SOLIDWORKS | SOLID EDGE

Ultra Light: 2.18 kg
Ultra Thin: 0.73" / 1.85 cm
4K ULTRAHD Available in FHD or UHD
MAX-Q DESIGN
NVIDIA VRREADY
POWERED BY NVIDIA QUADRO®
intel inside CORE i7

Learn more and visit www.pny.eu

For more information please contact quadrouk@pny.eu

Insight
Insight
uk.insight.com
Tel: 0844 846 3333

Workstation Specialists
Workstation Specialists
www.workstationspecialist.com
Tel: 01332 280380

novatech
Novatech
www.novatech.co.uk
Tel: 0239 232 2500

SCAN
Scan Computers
www.scan.co.uk
Tel: 0871 472 4747

Harvesting data from the field with intelligent connectors

Agritech companies look for sophisticated field-based sensor networks. Supplier: Bulgin

As the world's population races towards 8 billion, there is mounting pressure on farmers to produce enough food. The agricultural sector needs to use technology to harvest real-time data from fields to become more efficient, avoid crop damage and reduce costs.

However, agritech companies looking to build sophisticated field-based networks for sensors and other types of technology are faced with a fresh set of challenges. Agriculture is characterised by extremes in temperature, water, corrosive chemicals, dirt and dust – not normally conducive to sensitive electronics.

When Californian start-up AgTech Industries designed its smart infield telemetry system, AgriCapture, it needed a reliable supplier of rugged connectors that could solve this problem. AgTech worked closely with connections specialist Bulgin to incorporate integrated electronics into its 400 Series Buccaneer range of rugged connectors.

The demands placed on food production are intense, with each grower constantly under pressure to produce high quality crops at low prices. Despite the shrinking proportion of arable land, the UN predicts food production will need to increase by 70 per cent per year to feed an additional 2.3 billion people by 2050. Moreover, stresses on the world's fresh water supply and the unpredictability of climate change mean disaster could be closer than most people imagine.

To avoid famine, farming will need to become more precise and technologically advanced. 'Smart farming' is already a reality to an extent, with genetically modified seeds, soil mapping and automated machinery.

Founded in 2013 by Aaron Magenheim and Jesse Martin, AgTech brings modern, user-friendly technology to the agricultural industry. The company provides hardware and software products that allow growers to monitor and record water consumption, or remotely control irrigation sets based on soil, weather and other geographical data – all accessible, programmable and controllable from smartphones.

When Magenheim and Martin began to develop AgriCapture, they realised they needed a connector that wasn't available off the shelf. AgriCapture's mobile app was designed to enable farmers to easily connect and configure sensors from a smartphone, without IT experts. They needed a connector with a built-in integrated circuit, allowing it to pair electronically with the correct sensor, and resistant to the harsh conditions, from freezing cold to desert heat, with the ability to sit in wet mud and receive direct spray from sprinklers.

"Our main intention currently is to extract data out of the field, assist clients in their growing practices from planting to harvest, trying to improve their operations, and allow them to make decisions quickly," said Martin, now CPO of AgTech. "We also needed them to connect very easily, to be cost-effective, sit potentially disconnected for months or years straight, and to be able to reconnect without dealing with issues such as corrosion or unreliability," said Martin.

Widely recognised as a leading manufacturer of environmentally sealed connectors and components, Bulgin serves a global customer base across a variety of markets. Its Buccaneer circular connector range is well known for providing reliable, robust connections for power, signal and data in challenging environments.

"AgTech asked us if we could encapsulate an EEPROM device into a connector," said Christian Taylor, Engineering Team Leader at Bulgin. "I think they had already done some trials themselves with our self-assembly version of the 400 Series, which is why they had already decided that was the one they wanted to go with after seeing the size of the overmould."

The 400 Series is one of the most compact within the Buccaneer range, and is ideal for designs requiring a small footprint. The miniature power connectors take a selection of the best features and specifications from its larger Buccaneer family members and condense them into a compact form factor, giving engineers greater flexibility in the design phase.

With a lightweight and rugged construction, these sealed circular plastic connectors offer highly reliable power or signal connections for use within medical, industrial, infrastructure and automotive applications where space is limited.

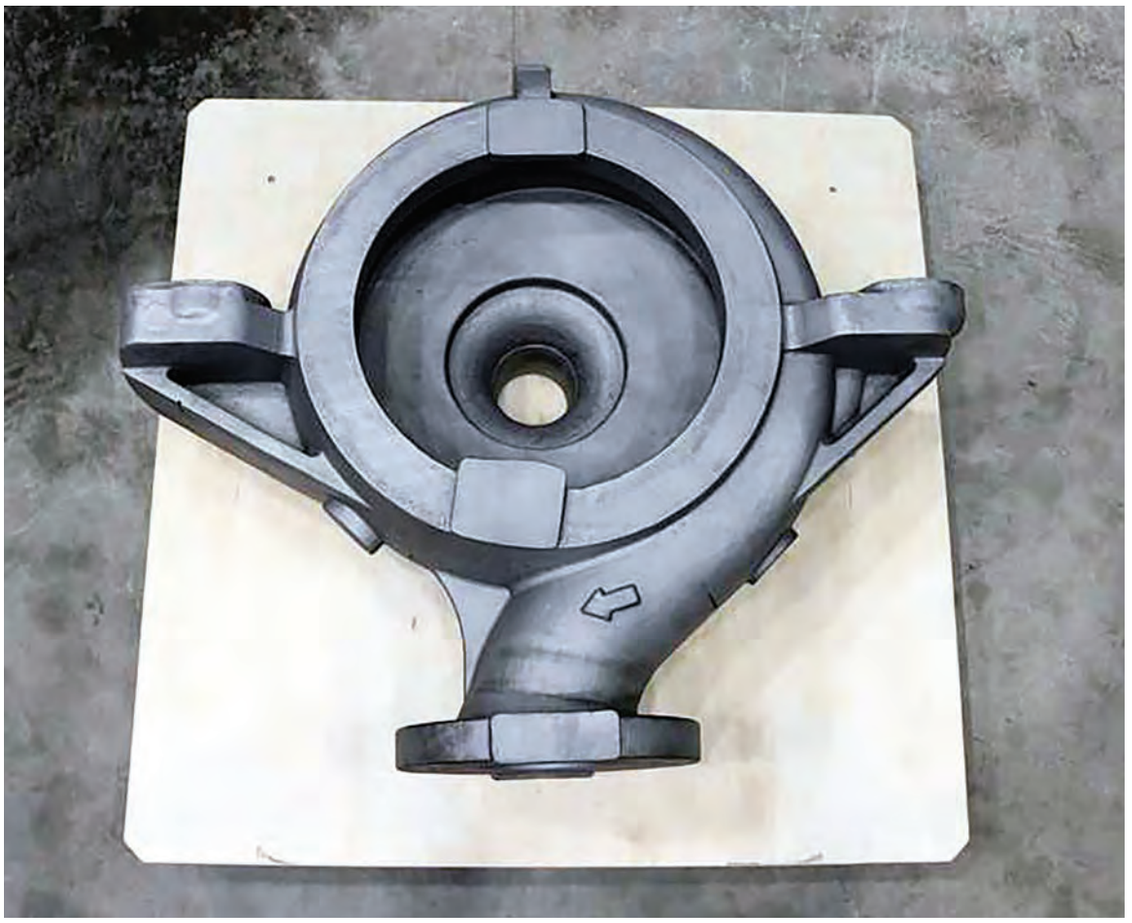
Examples of EEPROM uses in wider connector applications include medical devices, test and measurement probe calibration, sensors and devices with TEDS (transducer electronic datasheet) requirements.

When Bulgin's team was asked in January 2016 if it would be possible to mould the EEPROM device into the connector without causing any damage to the electronics, they first embarked upon a feasibility study to determine whether any issues could arise from moulding the device into the connector.

"We looked into the materials, what sort of temperatures we were hitting during the mould process and whether or not the EEPROM would actually survive the moulding process," explained Taylor. "After establishing that it would, we started looking at PCB design, trying to make sure that the PCB that the EEPROM would sit on would actually fit comfortably inside the mould tools." The entire customisation project took about 12 months.

The ultimate result is that AgriCapture users can easily pair up each sensor to the correct connector on the harness, eliminating the possibility of misuse or incorrect cables plugged into sensors on the fields. ■

Advanced Manufacturing



Pump housing weighing 200kg is Europe's largest ceramic shell titanium casting

Titanium casting breaks the mould

Europe's largest ceramic shell titanium casting has been unveiled in South Yorkshire by the Castings Group of the Advanced Manufacturing Research Centre.

The large-scale, near net shape casting is an industrial centrifugal pump housing used for highly corrosive applications in the chemical and petrochemical sectors. It was a single pour from a 680kg melt, with the finished part weighing 200kg.

AMRC Castings said it is working towards pouring over 1000kg of titanium for a 500kg part-weight centrispun casting by May. A molten mass in excess of 1000kg is required to make a 500kg titanium casting and a small number of furnaces exist globally that can cast near net shape components of this size.

Richard Cook, AMRC Castings' general manager, said: "We are the UK's only titanium-melting facility and this achievement sends a clear signal that the country is open for business for large-scale titanium casting. Global capacity for titanium castings, particularly of this size, is scarce – indeed it has actually decreased in recent years, despite growing demand. There is a clear need for this kind of capability."

The facility's Retech consumable electrode castings furnace has three interchangeable crucibles capable of melting titanium for castings weighing up to 500kg and 2000mm (2m) in diameter by 2500mm (2.5m) in length.

Principal metallurgist Matt Cawood said: "The AMRC are currently engaged in several projects looking to improve capability and technology to enable more complex, higher integrity components to be designed for manufacture with improved metallurgical quality and increased dimensional accuracy."

AMRC Castings' new furnace became operational in March 2017 and is part of an investment and R&D programme expected to give UK companies a springboard into global markets for large-scale titanium aerospace engine and structural components. **JF**

Qatar in £6bn aircraft deal with Typhoon

Qatar has become the ninth customer of Typhoon aircraft following the signing of a £6bn contract for 24 multi-role combat aircraft plus weapons systems.

BAE Systems is the prime contractor for the aircraft and in-service support and initial training. The deal includes an agreement with MBDA for Brimstone and Meteor missiles and Raytheon's Paveway IV laser guided bombs. Aircraft deliveries are expected to commence in late 2022.

The agreement, signed on December 10, 2017, includes "a clear intention to proceed with the purchase of Hawk aircraft".

UK defence secretary Gavin Williamson and his Qatari counterpart Khalid bin Mohammed al Attiyah oversaw the signing.

Williamson said: "These formidable jets will boost the Qatari military's mission to tackle the challenges we both share in the Middle East."

BAE's contract is subject to financing conditions and receipt by the company of first payment, which are expected to be fulfilled no later than mid-2018. **JF**

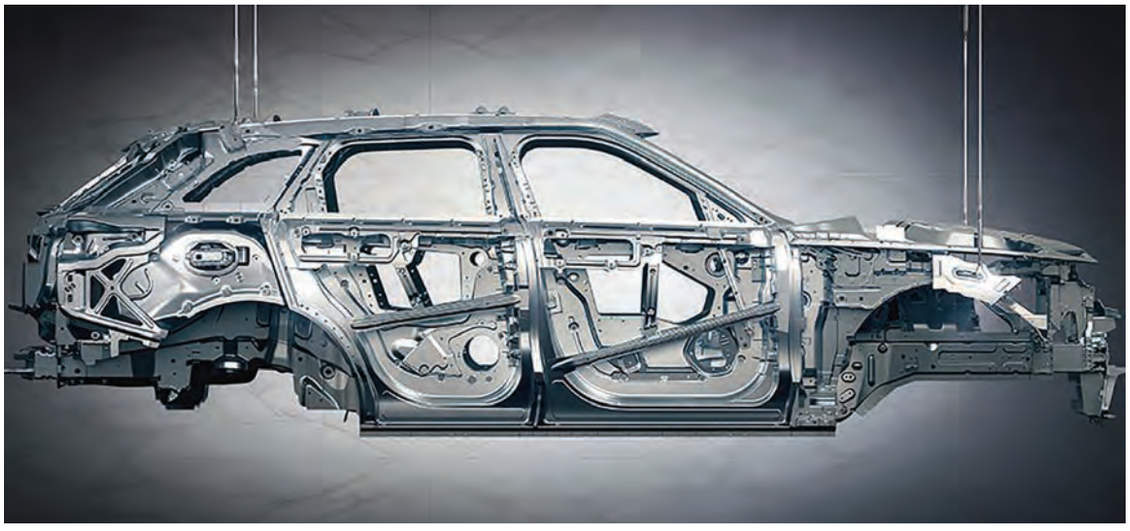
Contents

METAL FORMING

New drive to produce more car parts from aluminium

UK project to scale up production of low-cost, lightweight and recycled parts for mass production

HELEN KNIGHT REPORTS



The technique, known as Hot Form Quench, can produce high-strength aluminium sheet alloys

A manufacturing process designed to produce low-cost, lightweight and potentially recycled aluminium car parts is being scaled up for use in high-volume vehicles, as part of a UK project.

The production technique, known as the Hot Form Quench (HFQ) process, is capable of producing high-strength aluminium sheet alloys in even complex shapes. The aluminium components could reduce the weight, and therefore energy consumption, of mass-production vehicles.

The process was originally developed by Prof Jianguo Lin at Imperial College London. It has already been used to produce low- volume parts for the Aston Martin DB11, as part of a collaboration between the car maker and Imperial College spin-out Impression Technologies.

Now in a £9.6m project, including a £4.8m grant from Advanced Propulsion Centre UK, the process will be scaled up for mass production. The RACEForm (rapid aluminium cost-effective forming) project includes Impression Technologies, Imperial College and the Brunel Centre for Advanced Solidification Technology (BCAST) at Brunel University, as well as an unnamed UK-based passenger car OEM.

In the HFQ process, an aluminium sheet is heated in an oven and then transferred to a high-speed press for cold-die quenching. It is then heat- treated, according to Dr Roger Darlington, BCAST's director of technology.

"As you press the material in the dies, you're cooling it," said Darlington. "So you stamp it while its soft, quench it to trap the strengthening behaviour of the material, and then heat-treat it."

High-strength aluminium alloys are typically more difficult to form into complex parts than traditional steels, as they can split and crack.

The new technique allows even high-strength aluminium alloys to be processed and then stamped into complex shapes, said Darlington. "This offers design-enabling opportunities, such as slimmer structural pillars, for example."

Recycling aluminium alloys from scrap sources such as End-of-Life Vehicles could significantly reduce carbon dioxide emissions from component manufacture. But recycled materials can also be harder to form, using conventional techniques.

So the researchers hope that the HFQ process will also allow greater use of recycled aluminium alloys. "This should be a key enabler for the introduction of these types of materials," said Darlington. ■

TRANSPORTATION

£80m award to aid battery innovation

Developing products for vehicles and transportation

JASON FORD REPORTS

A West Midlands partnership has been awarded £80m to establish a new National Battery Manufacturing Development Facility that will develop products for vehicles and transportation.

The new national facility – to be established in the Coventry and Warwickshire area by WMG, the Coventry and Warwickshire Local Enterprise Partnership and Coventry City Council – will be open to UK companies and researchers looking to develop manufacturing technologies for batteries and their components. In doing so, it is expected to provide a new strategic link between the research, development and full-scale industrialisation for battery technologies across Britain.

A learning facility will train the future skills base in all elements of battery manufacturing, which will include the next generation of battery systems across battery chemistry, electrodes, cell design, module and pack levels.

WMG has spent 15 years working with industry to develop and prove new battery technologies. More recently it has been working through the APC Spoke, the National Battery Scale Up facility and the Energy Research Accelerator. Research projects already underway are investigating new battery technologies, how to scale up battery manufacturing, and the reuse and recycling of batteries.

Prof Lord Bhattacharyya, chairman of WMG, said: "Having a 37-year track record of working jointly with industry to innovate, and as leaders for over 10 years in battery development, WMG continues to drive forward battery innovation, and help create growth and employment."

The National Battery Manufacturing Development is part of the government's £246m Faraday Challenge and awarded through a competition led by the Advanced Propulsion Centre, supported by Innovate UK. ■

Engagement strategy

The government's new Industrial Strategy lacks neither vision nor detail. The real challenge will be in the delivery of such a grand plan, writes Kieron Salter

Stretching to more than 250 pages, the long-awaited Industrial Strategy was published by the government in November 2017 and is a coherent and fully formed vision for the future of manufacturing in the UK.

Comprising five foundations of productivity (ideas, people, infrastructure, business environment and places) and four grand challenges (AI/data, mobility, clean growth and the ageing population), the document is undoubtedly impressive. Greg Clark, secretary of state for business, energy and industrial strategy, has produced a laudable plan.

While the details concerning continental trade in the wake of Brexit are understandably vague ("we are leaving the EU, but we are not leaving Europe"), the government has not swept under the carpet the chronic weaknesses of UK industry (most notably, our poor productivity).

Hidden away on page 169 is an important section looking at the UK's inherent productivity puzzle, which has dogged policymakers for decades. While our nation's ability to create new enterprises is impressive (apparently at a rate of over 1,100 every day), and our unemployment rate is much lower than those of most other European economies, productivity is remarkably low. This productivity gap is especially evident when comparing 'frontier' businesses (top 5 per cent of performers) against the long tail of 'non-frontier' laggards.

While poor management and skills have been identified as major contributing factors to this problem, low levels of fixed-asset investment (that is, new technology and machinery) are seen as a key barrier to improved productivity. France invests around 23 per cent of its GDP into technology; in the UK this figure is closer to 17 per cent, according to the OECD.

The earlier green paper, a Scale-Up Task Force led by Margot James MP, was established to help SMEs grow into viable larger enterprises. While the Industrial Strategy highlights four issues identified by the task force – data, skills, finance and marketing – this seems to lack conviction and energy as a plan, given the vital nature of the SME engineering sector that is so ripe with potential.

I'd like to see much more detail on the delivery of this aspect of the Industrial Strategy. As mentioned earlier, while not decrying the ambition and scale of the plan, as a fast-growing SME in the high-performance engineering sector it is sometimes difficult to see how businesses like KWSP fit in to the complex kaleidoscope of the strategy.

The UK continues to struggle with a productivity gap

Although there is a lot of very good thinking within the 250-plus pages, the well-known song title, 'It's not what you do, it's the way that you do it', comes to mind. With so much vision and admirable aspiration for UK manufacturing, my greatest fear is that innovative, fast-growing enterprises with great ideas, great people and huge potential could get lost along the way.

With so many high-level minister-backed groups, focusing on the five foundations of productivity or the four great challenges, I'm worried that those who could benefit most and contribute much will be side-lined.

SMEs are used to getting on with business, often without any centralised support. Typically, access to grants has been filed under 'too much trouble' for fast-growing enterprises more concerned with their next project than with filling in pages of forms.

A good potential model for success lies in the foundation of like-minded cluster groups, such as the recently established Silverstone Technology Cluster based in Motorsport Valley, Northamptonshire. Comprising mostly SMEs, this cluster demonstrates how the sharing of ideas and technologies across sectors, known as horizontal innovation, is already working well in the UK.

While top-led initiatives such as the Scale-Up Task Force should be welcomed, it would be an opportunity lost if these two groups were not linked in some way.

> "My greatest fear is that innovative, fast-growing enterprises could get lost along the way"

Whatever part of the manufacturing sector you're from, it is vital that we all read the brave new Industrial Strategy and understand how we can play our part.

Plans are only as good as the people carrying them out; it would be a crime if industry failed to engage with this crucial vision for success. ■

Kieron Salter is MD of high-performance engineering firm KWSP

A cut above

Latest-generation machining centres tackle the need for adaptable and versatile manufacturing; while cutting tool developers attend to the detail at the sharp end. Mike Excell reports

The 21st century watchword for production equipment has been multitasking and machine tool builders such as DMG Mori have continued to push the capability envelope. The company's latest offerings include the possibility of milling, turning and grinding in a single set-up on its Duoblock FD series of 5-axis mill-turn centres. The addition of grinding on the same platform should attract manufacturers wishing to exploit single set-up potential for preserving dimensional accuracy, while enjoying the levels of surface finish achievable with grinding.

Sizes 80, 125 and 160 in the Duoblock FD series can be equipped in this way. Technology cycles in the machine control for internal, external and face grinding support the processes and there is a specific cycle for calibration of the grinding wheel truing station. A similar philosophy, incidentally, is evident in the company's Lasertec 65 3D hybrid machine, currently employed on a collaborative project with roller bearing specialist Schaeffler (brands include INA and FAG). The machine is being used to produce one-offs and small batches. The one-hit process combines the flexibility of additive manufacturing, with 5-axis milling.

Schaeffler is of course a leading high technology company – it was, for example, already using 3D printing for prototypes, fixtures and small series production. But familiarity with new technologies is an important consideration for manufacturing companies of all sizes, especially at the operator level. With this in mind Heller has introduced an advanced training machine designed to raise the skill level of horizontal machining centre operators away from the shop floor. The CNC ProfiTrainer builds on the capabilities of an existing 4-axis version with rotary table by offering the option of an additional A-axis. Designed to tolerate operating errors, it provides skills training without tying up a machine on the shop floor, or risking a crash on a 'real' machine.

Meeting the needs of customers starting out in 5-axis work – alongside those already well versed in the technology – drove XYZ's introduction of a full simultaneous 5-axis, gantry-style machining centre with a trunnion table machining centre to its range. A key design feature is that when the table is tilted 90° towards the rear (component facing forward), there remains 500mm of Y-axis travel forward of the table surface. This, says the company, is much greater than many competitor machines, including those that quote the same axis travels, allowing larger workpieces to be machined.

Established builders and suppliers continue to launch new or enhanced 5-axis machining centres. Makino's new a500Z horizontal, with a working volume of 730 x 750 x 700mm, features a highly rigid structure and low inertia, providing production efficiency similar to a 4-axis machine. One-piece bed casting, slant-bed and three-point support constitute a design which focuses on stiffness and stability, while the innovative swivelling table has minimal overhang to enhance rigidity.

Regarding temperature control, the a500Z combines a thermally symmetrical structure with effective heat removal from the spindle, core-cooled ballscrews and motors to ensure machining accuracy during long hours of operation. Direct-drive motors on the rotary axes are fitted with cooling jackets to suppress heat generation. High productivity means that coolant and chip management are significant issues. To deal with this, unlike the conventional 5-axis trunnion table set-up, the a500Z has a wide trough located beneath the table. Coolant flow from a comprehensive washing system that encompasses the pallet loading area prevents chips accumulating by ensuring that they fall directly into the trough.


01

Chip disposal was also a serious consideration in the design of the new VC1650 5-axis machine from Spinner. Four spiral augers deliver chips to a conveyor at the front of the machine for convenient removal. This also ensures negligible heat transmission and allows space on the shop floor to be saved when installing the 16-tonne machine. In addition a single wiper system, eliminating the need for a telescopic cover, protects the Y-axis guideway from swarf and coolant ingress (the depth of the machine is thus shorter, bringing a 30 per cent reduction in overall footprint).

Meanwhile Burkhardt + Weber's new MCC 630 is claimed to be one of the most rigid and powerful metal-cutting centres in its class for producing prismatic components weighing up to 1.5 tonnes. A 4-axis machine, there's an option of a +45°/-110° tilting spindle to add a fifth CNC axis. The single-piece bed casting allows rapid installation and commissioning, either as a stand-alone machine or as part of a line.

The practical matter of how to fit new machines into existing production facilities with space or access limitation can't be overlooked. For Coventry-based small-batch sub-contractor Overstone Engineering, the factory entrance was actually the main issue when choosing a 3-axis VMC, as the door lintel is only 2.2 metres from the ground. This prompted selection of a Hurco VM5i which is under 2m tall with the ram lowered, and has a compact footprint of slightly over 1.6 x 2.2m.

Selecting the right cutting tools to match a wide range range of workpiece materials and component specification is a critical part of process design, and it's an issue that faces specialist SMEs such as Yeovil-based Talon Engineering. The company mainly serves the off-road motorcycle industry, and has worked

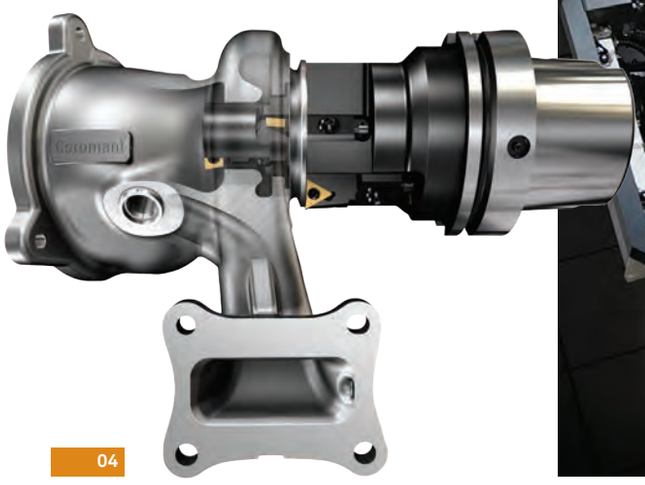
02

1 Burkhardt + Weber machining centre

2 DMG Mori and Schaeffler developing additive/subtractive processes

3 Ariel Hipercar features parts from Talon Engineering using WNT tools

4 Sandvik Coromant's M612 face mill provides smoother cutting action



04

03

on a number of high-profile projects, such as the Ariel Ace motorcycle. It is now undertaking a new range of parts as Ariel develops its Hipercar (described as an ultra-high performance, range extended, electric sports car). All mechanical components must be machined to high standards, incorporating Ariel's own idiosyncrasies.

The pace of such projects requires cutting tools to be on the machine at short notice. Working with WNT (UK) Talon has developed a standard list of tooling, including HPC cutters, Type W Alu line cutters, as well as making major use of WNT's Centro P toolholding system. Most of the cutting tools are held in WNT Vending machines, which can hold up to three months of stock, ensuring availability around the clock.

In some respects the complex work that Talon is producing for Ariel appears to be suited to 5-axis machining, but Talon has taken the decision to maximise its 3-axis vertical machining centres. The components being machined include wishbones, accelerator and brake pedals and assemblies, handbrake and chassis brackets, most requiring significant 3D milling. Unusually, Ariel requires feed marks to be visible and, in some cases, corner radii machined to resemble welds, leading to some complex programming. As part of this project, Talon has adopted new machining techniques with the support of WNT, with trochoidal milling being the way forward for much of the machining undertaken. "As this project moves forward into production trochoidal milling will bring further advantages as it reduces the stress and pressure on machine spindles," says process engineer Sam Chinn.

In the wider, high volume, automotive sector, any advantage on machining of components will return significant dividends. Around 50 million turbo chargers are produced worldwide annually. These parts must withstand temperatures of 1300°C in service, and productive face milling can be a challenge due to abrasive stainless steel or cast-iron workpiece materials. In addition, the complex shape of these thin-walled components makes for intricate clamping and a process that is highly susceptible to vibration. Sandvik's new M612 indexable insert face milling cutter is designed especially for this purpose.

1 XYZ's UMC-5X aims to meet the needs of a wide variety of customers

2 Horn's DCG milling cutters are suitable for a range of thread pitches

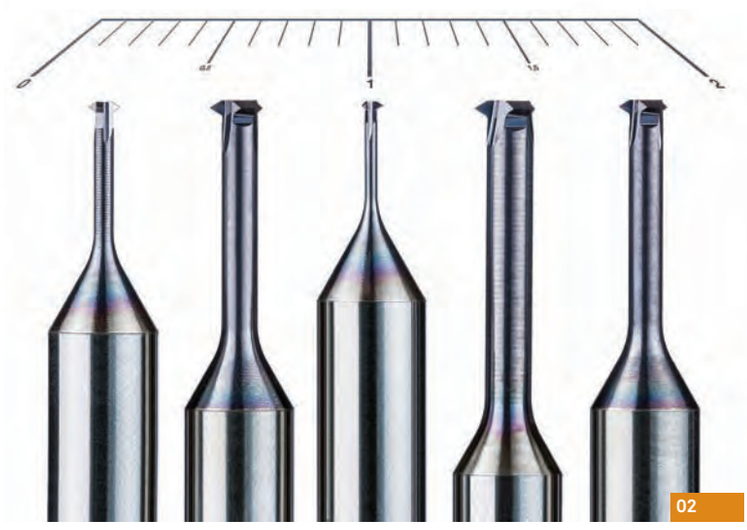
3 Heller's new Profitrainer training machine can simulate 3, 4 or 5-axis operation

The development goal was to develop a strong and robust cutter that would be able to reduce cost per component. "The biggest advantage of the new M612 milling cutter is its use of inserts with 12 cutting edges – six per side," says Jacques Gasthuys, automotive application engineer at Sandvik Coromant. "The specific geometry combined with the position of the insert inside the tool provides a very sharp cutting effect that allows production engineers to increase cutting data."

The positive geometry and edge line quality of the M612 provides a smooth cutting action that helps to reduce power consumption and eliminate vibration. This permits higher metal removal rates and quicker cycle times, which, in combination with 12 cutting edges, contributes to lower cost per part. The choice of round inserts also adds flexibility for machine shops in terms of the material types that can be processed and the milling operations performed, while the highly secure insert indexation interface delivers both accuracy and repeatability.

Finally, on a more specialised note – but one which nevertheless acknowledges the need to tackle an ever-widening range of workpiece materials – the new DCG thread milling system has been developed by Horn for producing M1 to M2.5 metric ISO threads DIN 13-20. The solid carbide, single-row, coated milling cutters, which have extremely sharp edges and are suitable for universal use, are available as standard for producing a thread length up to 2 x D. They demonstrate their special capabilities and efficiency when machining steels, stainless steels, cast iron, non-ferrous metals and in particular hard-to-cut materials. ■

01


02


03

INDUSTRY 4.0 SUMMIT

UK'S PREMIER EVENT FOR INDUSTRY 4.0

www.industry40summit.com

2 EVENTS 1 PLACE

COVERING THE DIGITIZATION OF MANUFACTURING

MANCHESTER, UK

28 FEB - 1 MAR 2018

REGISTER TODAY

£650 + VAT per delegate
(Discounts for member supporters)

Hear industry leaders debate and discuss the issues and challenges facing the manufacturing industry in 2018 and beyond. Speakers include:

*** GE DIGITAL EUROPE * BOSCH REXROTH * ACCENTURE * INTEL * ELISA * GKN * MEGGIT ***
*** IBM * FORD *BABCOCK * TRUMPF * PANALPINA * ADS GROUP * SCHNEIDER ELECTRIC ***

FACTORIES OF THE FUTURE EXPO

CO-LOCATED

FACTORIES OF THE FUTURE

If you provide digital solutions to manufacturers then this is a must attend event for you. Robotics, Automation, VR/AR, IIoT, Sensors, Cybersecurity, Advanced Manufacturing and much more.

FREE TO ATTEND

Contact Andy Pearce
07979 500937
EMAIL: info@gbmediaevents.com

LAST EVENT ATTRACTED:

Nestlé, PepsiCo, Airbus, Heineken, BAE Systems, Jaguar, Nissan, Rolls-Royce, Tata Steel, Toyota

HEADLINE SPONSOR

Rexroth Bosch Group
The Drive & Control Company

ASSOCIATE SPONSORS

intel, elisa, Accenture Industry X.0, proto labs

SUPPORTERS

eef The manufacturers' organisation, Innovate UK Knowledge Transfer Network, GAMBICA, ADS

SPONSORS

OMRON, CRATE.IO, ifm electronic, ABB

info@industry40summit.com

www.industry40summit.com

Pioneering production

AMRC's factory 2050 facility is helping to put the UK at the forefront of manufacturing technology research and development.
Mike Farish reports

On the eastern edge of Sheffield, where the city merges into its neighbour Rotherham, a spectacular looking circular building with an almost entirely glazed exterior is the latest addition to one of the UK's leading sites for research and development of manufacturing technologies. The structure is the Factory 2050 facility started up late in 2015 as part of the Advanced Manufacturing Research Centre (AMRC) – a joint initiative of the University of Sheffield and US aerospace giant Boeing – that has operated over the wider immediate area since just after the turn of the millennium.

According to Stuart Dawson, chief technology officer for the AMRC, some 500 people are now employed across the site, generating an annual turnover of around £32m. Activities range across several different application areas, including nuclear, castings and composites, but in all cases the basic methodology is that of cooperative technology development projects between the AMRC's own personnel and industrial partners. In the case of the new Factory 2050 building, the emphasis, as the name indicates, is to explore the technologies that could form the basis of manufacturing over the coming decades. Four in particular, says Dawson, form the current focus of work there:

- Robotics and automation
- Integrated large-volume metrology
- Digitally assisted assembly
- Manufacturing informatics.

The evidence is to be found most tangibly in a series of cells occupied by robotic and other hardware, where much of the work takes place. Dawson makes the point only half jestingly that though project details are often confidential, the fact that the physical activities involved are literally open to view is quite deliberate – apart from its practical contribution to real manufacturing now the whole facility is also intended to act as a showcase to stimulate interest in manufacturing technology, particularly among younger people. They would, he says, be welcome to "press their noses against the windows".

Nevertheless, the work that takes place in the Factory 2050 building is a continuation of previous operations carried out by the AMRC's Integrated Manufacturing Group (IMG), which now comprises over 60 engineers boasting a noticeably wide range of individual skillsets, including mechanical, control, electronics and even some derived from the world of video gaming. That team is headed by Ben Morgan, who joined the AMRC as a graduate nine years ago and who says the breadth of skills it embodies is a key reason why it can work just as easily with small SMEs or massive multi-national companies. Indeed, he adds, factor in the way that the IMG can tap into a wider range of resources such as those at its parent university, and the whole operation boasts a depth of expertise "that even big multi-nationals

02

01 Over 60 engineers work on a range of projects

02 Boeing and McLaren are to set up manufacturing facilities at the site this year

01

sometimes cannot match".

But, Morgan continues, projects do not necessarily need to include intensive research and development work. Instead they may sometimes comprise just a few weeks of consultation. He says around 60 separate initiatives involving the IMG and client companies are currently underway.

One project that definitely stands at the high end of the spectrum – whether the benchmark is that of the technical challenge involved or simply money saved for the client company – is represented by a robotic manufacturing cell that stands in an annexe to the main Factory 2050 building. Morgan confirms the cell in Sheffield is an exact replica of one that is now in operation at the BAE Systems plant in Salmesbury, across the Pennines in Lancashire, where it is used to drill to highly exacting tolerances the countersinks in carbon fibre composite wing skins of F35 aircraft through which fasteners are inserted to join the skins to the aircraft frames. Getting the process right is crucial to the performance of the plane – drill the holes too wide so that the head of a fastener goes below the wing surface and aerodynamic performance is impaired, drill them too narrow so that the fastener stands fractionally proud and anti-radar stealth capability is reduced.

The project that enabled that aspiration to become reality took three years before the cell went into

> "People are welcome to press their noses against the windows"
>
> AMRC's Stuart Dawson

operation in 2015. But, as Morgan is keen to stress, the replica at Factory 2050 remains a working installation used for continuing development work. That way, he explains, BAE can avoid the downtime that might result from debugging enhancements to the system on its own shopfloor and can instead implement them in a seamlessly and reliably rapid manner.

This highly automated approach is in stark contrast to the previous methodology employed for the task by BAE which was, Morgan confirms, entirely manual. Moreover, that way of doing things was "extremely strenuous" for the workers, with a high rate of repetitive strain injuries. Furthermore, with BAE looking to ramp up to a production rate of an aircraft every couple of days, that way of proceeding was also unacceptably slow.

But, Morgan further explains, though existing automated manufacturing technologies were capable of satisfying both the required accuracy and speed requirements, the necessary capital outlay would have been daunting. BAE would have required probably half-a-dozen specialised CNC milling machines so that the total investment would have been "tens of millions of pounds".

Work at Sheffield did not, however, start from scratch. Morgan says when the team there took on the project, BAE had already worked with robot supplier Kuka to develop a concept that he describes as at "level four – proven in principle" of the one to nine hierarchy in which seven would indicate ready for implementation and nine proven in practice.

As such the work required to progress the cell from the first to the second of those levels involved aspects of both programming and mechanical design intended to make robots – a type of device that he observes is typically associated with the comparatively less demanding world of automotive manufacturing – compatible with the extreme demands of military aerospace. Morgan says the crucial parameters were those of accuracy and stiffness and that a key aspect of the final cell configuration that achieved the necessary performance goals was the use of two robots – one behind the work piece to hold it in place and one in front to carry out the hole drilling.

But literal stiffness has also been combined with metaphorical flexibility. As Morgan further explains, BAE manufactures 60 different wing-skin variants in total and so another key attribute of the system developed by the AMRC is that it has avoided any requirement for hard, bespoke fixturing for each variant. Instead, the technique of augmented reality has been utilised to provide computer-generated visual guidance for operators to support them in configuring the cell accurately and reliably for the manufacture of particular variants.

"We used optical projection a bit like you get in a boardroom," he notes. "The key thing with automation is that to get a consistent output you need a consistent input so we needed a robust process to ensure that the position of the part is the same each time."

Moreover, Morgan adds, the sheer speed of the drilling operation itself has been reduced "from 55 seconds per hole to under 20 seconds". Given that several thousand such operations are required for each aircraft, the time savings the new cell achieves are self-evident. Continuing work on the cell, he says, is focusing on using the Industry 4.0 concept to enable closed-loop feedback of sensor data to optimise the procedures while they are underway.

2018 will also see two further notable additions to the AMRC site. One will be a manufacturing facility for UK super-car manufacturer McLaren, where it will make the composite safety tubs that provide impact protection for drivers. The other, due to open, according Stuart Dawson, in "Q3-Q4", will arguably be even more significant – the first-ever directly-owned manufacturing facility outside the US for Boeing, where it will produce parts for landing gear actuators. ■

Making it ship shape

Dutch ship-builders unveil the world's first 3D-printed marine propeller. Stuart Nathan reports

Over the past few years, firsts in additive manufacture have been coming thick and fast. But with the technique well suited to making small structures with complex geometries, these first tend to be components which play to its strengths. They are small, often optimised to cope with specific mechanical stresses and pared down so they only have material where they need it most, so they are often skeletal in appearance. Waampeller is very different.

The first fully certified marine propeller to be made by additive manufacturing, Waampeller was recently unveiled in Rotterdam, installed on the type of tug that works the city's docks. It measures 1.3m across, weighs 180kg, and does not have the pared-down structure common to many additive parts; indeed, an observer would find it difficult to distinguish it from any other propeller.

The propeller was made at RAMLAB (Rotterdam Additive Manufacturing Laboratory) as part of a collaboration involving marine constructor Damen Shipyards Group, manufacturing software firm Autodesk, Dutch propeller and marine technology specialist Promarin, Port of Rotterdam (one of RAMLAB's owners) and the Dutch marine testing, inspection and certification house Bureau Veritas. Its name comes from the specific additive process that was used to build it – wire-arc additive manufacturing. This is essentially a form of welding, where an electric arc is used to melt and then deposit a metal welding wire in a continuous fashion; it is often used to build cylindrical or conical structures, with the printing head depositing a continuous helix of metal that builds up.

Waam is one of the fastest additive methods currently in use, depositing tens of grammes of material per minute rather than the milligramme or microgramme per minute rates of powder-bed additive. Moreover, it is not confined to the small volumes of conventional 3D printing machinery as it can be integrated with robotics. The printing head is installed as an end-effector on the type of robot arm whose use has become well established in many fields of manufacturing.

The Waampeller was unveiled after it had successfully completed sea trials on the Damen sea tug, involving tests such as speed trials, a bollard pull and a crash stop going from full forward to full reverse thrust. This resulted in the component being awarded full type approval by Bureau Veritas. "One of the most exciting things about this project is that we have not just produced a one-off demonstrator. It's relatively easy to do something once, but to produce a certified part and establish a process takes more time and consideration. Working with a great team of partners, we've harnessed the best of additive and subtractive manufacturing to create a process that is repeatable. This repeatability provides the potential to radically transform the whole industry," said Kelvin Hamilton, senior technical consultant at Autodesk, who was involved in the project from beginning to end.

01


02

> "This could radically transform the whole industry"
>
> Kevin Hamilton, Autodesk consultant

01 Waam is one of the fastest additive methods currently in use
02 It took three days to grind the final article by hand

It was Hamilton's inspiration that kicked off the whole project. "I thought a propeller would be an intriguing geometry to tackle with additive manufacturing; it has complex curves and has to endure severe stresses in service, " he told The Engineer. "I built one as an exercise at Autodesk in Birmingham, and Damen happened to see it and decided to take the project further."

The design of the Waampeller is one of Promarin's standard propellers, and Port of Rotterdam then got RAMLAB involved.

Based in a small, screened-off area of a cavernous former submarine factory in Rotterdam's docks, RAMLAB shares space with a large number of other small technology operations. Pride of place in its cramped premises go to two Waam-equipped robots. The acquisition of these was guided by a collaboration with the Waamlab at Cranfield University, explained RAMLAB co-founder and managing director Vincent Wegener. "Cranfield is focused much more on aerospace applications, but they were very helpful when it came to us making our investment decision, " he said.

Four versions of the Waampeller were made; the first in mild steel to help design the construction strategy – the path that the welding head took to build up the structure onto the cylindrical propeller shaft; the second in stainless steel, and a prototype in the final construction material of nickel aluminium bronze alloy. This is a standard material for propellers, Hamilton said. "We would normally cast them, but it isn't normally available as a welding wire so that had to be custom-made."

The Waam process creates a deeply ridged surface, so the propeller has to be ground down to create the smooth surface needed for its operation. The prototype was finished by CNC Milling, but the actual final article was ground by hand in a process that took three days. "The castings are generally hand-ground, so for the purposes of certification we wanted to keep one part of the manufacturing process the same; everything else is different," Hamilton added.

The propeller is built from 298 layers of bronze, deposited over 256 hours. "Production of the second Waampeller was greatly improved because we had learned a lot from producing the prototype," says Wegener "This mainly concerned the hardware/software interaction because, when laying down 298 layers of nickel aluminium bronze alloy, it is important to have a tight control on all process parameters."

The shape of the molten metal bead deposited by the welding head is particularly important, and testing had to take intro account the effects of anisotropy. Characteristic of materials built up in layers, this is a variation in physical properties depending on the direction through the material; cast metals are isotropic, with the same properties in all directions.

"We know welds are strong, and Waam essentially makes a single continuous weld, so we thought it would be OK, but we still had to prove it," Hamilton said. "We did the entire manufacture for this item, but I think its real strength will come in maintenance; if a propeller is damaged, for example, a piece gets knocked out of a blade or a blade gets deformed, we will be able to grind away the damaged part and print directly on top to reform it. That will be much faster and cheaper, and potentially stronger too."

Another potential advantage, Wegener said, is that Waam produces hollow parts. "If you print a hollow propeller blade, it will be lighter, so the boat will burn less fuel to turn it,' he said. "Also, you have the opportunity to incorporate strain sensors directly into the structure as you are printing, which could give you advance warning of failure. ■

Taking measures

Additive manufacturing can throw conventional metrology off-course, so new techniques need to be devised to improve sampling and measuring. Will Stirling reports

Accurate measurement relies on super-accurate equipment and comparing distances between points on the surface of the part being measured. Measurement in precision engineering has been developed around the – highly reasonable – assumption that these points or datum are fixed and clearly defined. The flatter the surface to fix a point, the better.

Then came additive manufacturing. Additively manufactured (AM) parts have several features that throw conventional metrology techniques off-course. By its nature, a 3D printed part has an extremely rough surface, as it is created by building layers of material and therefore creates a rough or 'bobbled' surface.

Then, certainly with metal AM, the particle size adds to the problem – frequently 100 microns in diameter and the smallest is only 10 microns, bigger than the tolerances that components in some industries demand. "If a big particle is just outside the path of the laser [or electron] beam, it might stick to the side of the layer," said Dr Phil Reeves, vice-president at 3D printing solutions company Stratasys.

"If you measure at the point where you accidentally stuck that particle, the part will seem inaccurate. That is why we have to devise new measurement techniques and think differently about sampling and measuring between several points."

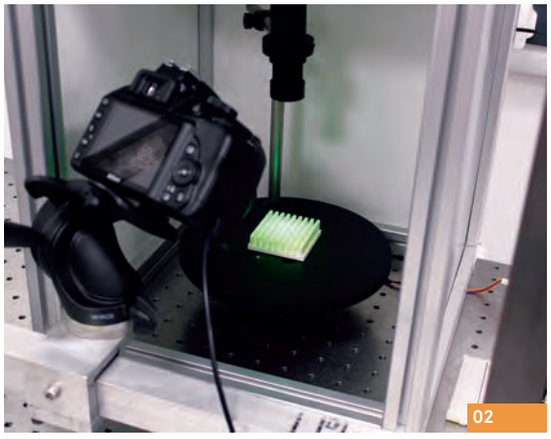
Then there is the issue with shape complexity. A big advantage with AM is its design flexibility. "With AM you have almost infinite design freedom, you can make what you want," said Prof Richard Leach, head of the manufacturing metrology team at the University of Nottingham, which houses the biggest AM research group in the world. "You are not held back by knowing you have finite tool size, so can design very complex geometries. But in making such complex objects you have to be able to measure them, which brings an extra level of complexity."

Measuring the inside surfaces of complex parts such as cooler manifolds and lattice structures is impossible for conventional contact methods such as a touch probe, and most non-contact scanning methods such as laser.

Because AM has such massive, disruptive potential for manufacturing, industry and universities are pumping money into perfecting these techniques, as the entire validation of AM as a practical industrial technique is at stake.

AM metrology is looking to improve in two areas: final part and in-process inspection.

The EPSRC Future Manufacturing Hub in Advanced Metrology, aka the Metrology Hub, is developing a process to accurately measure finished complex AM structures using X-ray tomography. At the moment, large companies, including GE are using X-ray computerised



01/02 Industry and universities are pumping money into perfecting AM techniques

01

tomography in the field for measuring some complex structures.

"We rotate an X-ray source in front of an X-ray gun," said Professor Liam Blunt, platform director at the Metrology Hub at the University of Huddersfield. "You rotate the part half a degree, take an image, collect the data, rotate it again, take an image, and repeat this up to 700-800 times in a rotation. This creates a 2D series of X-ray images into a 3D X-ray model."

The process is currently time-consuming and costly, taking 1.5 hours on the X-ray scanner and the same time again to do the computational analysis. But many safety-critical parts made using AM are expensive so there is a cost-benefit equation. The Metrology Hub's job is to push the limits of the hardware's range resolution and capability to optimise a process that is as reliable and quick as possible.

The X-ray technique is also suitable for detecting porosity, a feature of AM parts. Fusing millions of powder particles often produces pores in the structure, and knowing how many and where these pores are can be vital for inspecting safety critical applications. Prof. Blunt said the X-ray technique has clear advantages over other methods. "Laser scanning won't show pores because it does not penetrate into the part. Another older technique, ultrasound scanning, is notoriously difficult to interpret for non-experts. But with CT it's a visual image, showing the porosity and its orientation clearly so the untrained eye can interpret it," he said. This makes it a better solution for companies with limited inspection skill sets.

> "With AM, you have an almost infinite design freedom"
>
> Prof Richard Leach, University of Nottingham

Research into additive manufacture metrology by the University of Nottingham's manufacturing metrology team is divided broadly into 1) how companies can use existing inspection equipment to measure the types of surfaces AM produces, and how can this kit be optimised, therefore developing good practice, and 2) by using mathematical approaches, finding a link between what is observed on the surface with the method that produced the surface finish. "Then you can say which parts are good and which have gone wrong," said Leach. "To do this you have be able to identify structures of interest from the data."

His team's work spans several fields of AM measurement, including texture metrology and form metrology. The former uses techniques such as coherence scanning interferometry and X-ray computed tomography to make topographic comparisons on the part's surface to check it meets a tolerance requirement. Feature-based characterisation can reveal the character of weld tracks and random features, which can throw off many existing metrology methods.

For form metrology, that is, inspecting the finished shape, the Nottingham team set the challenge to build a complex form measurement system, based on fringe projection, that operates on a "place-and-shoot" basis, capturing a complex form in one shot, that is, it requires no expert operator skill. The solution combines principles of AI and machine learning with conventional metrology and has resulted in very fast methods for measuring very complex structures.

The team has developed fringe projection using projectors and cameras. "This shines a pattern on to the object and looks at how the pattern warps because of the objects finish, from which you can calculate the shape," said Leach. His team is spinning out a company to sell one aspect of this optical shape measurement equipment.

Measuring an AM build layer by layer for in-process measurement requires good software to connect the AM machine to process monitoring hardware, and then display the results in real-time, potentially from multiple systems.

Renishaw's InfiniAM Spectral software operates with its LaserVIEW and MeltVIEW hardware, embedded in the RenAM metal additive machines. The software helps Meltview to monitor emissions from the AM process across a wide spectral range. Sensors and photo detectors capture emissions and the balance between visible and infrared emissions from the build process can be used to spot build anomalies. Laserview measures the input intensity of the laser using an infrared photo diode. Tracking the temporal behaviour of each laser pulse provides insight into the evolution of the melt process. The Spectral software allows this data to be visualised on PCs, and for up to 8- AM systems for large-scale manufacturing.

How complete is this system for accurate in-process AM inspection? "As far as the capability to 'solve' problems such as surface finish and porosity, it is early days but the resolution and speed of the sensor signals has the potential to detect these issues as the build runs," said Renishaw's Robin Weston. "Any corrections required are presently dependent on the judgement of the engineers preparing the machine data. However, we do anticipate enabling some autonomous feedback in the future." ■

Engineering events and exhibitions

JANUARY		
Autosport International	11-14 January	NEC, Birmingham
SteelFab	15-18 January	Expo Centre Sharjah, UAE

FEBRUARY		
Southern Manufacturing & Electronics	6-8 February	FIVE, Farnborough
DECOM Hub Supply Chain Networking Event	8 February	Hilton Hotel, Rosyth
Embedded World	27 February-1 March	Nuremberg, Germany
Industry 4.0 Summit	28 February -1 March	Manchester

MARCH		
Ecobuild	6-8 March	Excel, London
JEC World	6-8 March	Paris, France
StocExpo Europe	20-22 March	Rotterdam, Netherlands

APRIL		
MACH	9-13 April	NEC, Birmingham
Vacuum Expo	10-11 April	Ricoh Arena, Coventry
Drives & Controls	10-12 April	NEC, Birmingham
StocExpo Middle East Africa	17-18 April	Dubai World Trade Centre, Dubai
Medtec Europe	17-19 April	Messe Stuttgart, Germany
TotalDECOM	23-25 April	Manchester City Central, Manchester
Hannover Messe	23-27 April	Hannover, Germany
Plastics Recycling Show Europe	24-25 April	RAI, Amsterdam, Netherlands
Commercial Vehicle Show	24-26 April	NEC, Birmingham
Med-Tech Innovation	25-26 April	Ricoh Arena, Coventry

MAY		
Infrarail	1-3 May	Excel, London
All Energy	2-3 May	SEC, Glasgow

JUNE		
Automechanika	5-7 June	NEC, Birmingham
Subcon	**5-7 June**	**NEC, Birmingham**
The Engineer Expo	**5-7 June**	**NEC, Birmingham**
PDM Event	19-20 June	Telford International Centre, Telford
Additive Manufacturing Europe	26-28 June	RAI, Amsterdam, Netherlands
JULY		
Farnborough Air Show	16-22 July	Farnborough
SEPTEMBER		
The Energy Event	11-13 September	NEC, Birmingham
What's New In Electronics Live	25-26 September	NEC, Birmingham
PPMA Show	25-27 September	NEC, Birmingham
TCT Show	25-27 September	NEC, Birmingham
Tank Storage Asia	26-27 September	Marina Bay Sands, Singapore
NOVEMBER		
Advanced Engineering Show	31 October-1 November	NEC, Birmingham
Maintec	6-7 November	NEC, Birmingham
Electronica	13-16 November	Munich, Germany
DECEMBER		
Tank Storage Germany	5-6 December	Hamburg, Germany

Show home

The UK's longest-running annual industrial technology show is celebrating its 20th anniversary at a new venue

New venue is largest exhibition space to be built in the UK for two decades

The Southern Manufacturing & Electronics show will mark its 20th anniversary in 2018 with a move to a new, permanent venue at FIVE, Farnborough, in February.

The UK's longest-running annual industrial technology show will be the first major event to be held at the brand-new £30m conference and exhibition centre at Farnborough International in Hampshire, home of the iconic airshow. The Southern Manufacturing show moved to the Farnborough site in 2008 and, over the past decade, has grown to become one of the largest annual engineering exhibitions in the UK and an important international showcase for British manufacturing expertise.

The 2017 show attracted around 800 exhibitors and nearly 9,000 visitors from all over the world. With approximately 22 per cent of the UK's 3,400 aerospace businesses and significant numbers of automotive, medical technology, marine and high-tech engineering firms located within a 50-mile radius of Farnborough, the show is situated at the centre of one of the country's most important manufacturing regions.

Alongside exhibitors drawn from across industry, this year's event will feature a free seminar programme running over all three days and covering a range of technical and business-related issues, from understanding lithium-ion batteries and Industry 4.0 to the forthcoming GDPR regulation and the industrial implications of Brexit.

Among the many speakers, Tim Scurlock, director of ALC, will guide delegates through the benefits of Lean – such as eliminating waste from existing processes – together with the problems and pitfalls in bringing Lean into their organisations, while Dr John Loftus of HMK Automation & Drives will look at the future role of Cobots.

Commenting on the event's new venue – the largest exhibition space to be built in the UK for two decades – show director Phil Valentine said: "Southern Manufacturing & Electronics' new home in Hall 1 will completely transform the exhibition experience for visitors and exhibitors alike. The new building is a superb modern facility offering high-speed WiFi throughout, drive-in access for exhibitors and 3,500 free on-site car-parking spaces.

"We are delighted to be the first tenants of this landmark development, and excited at the possibilities it offers us for further development as we enter our third decade."

Southern Manufacturing & Electronics 2018 runs from 6–8 February. Admission to the show is free. More information and tickets are available from *www.industrysouth.co.uk*. Farnborough Exhibition and Conference Centre is easily reached by road, air or public transport.

More information can be found at *www.farnborough.com* ■

SMEC PL1600C on show at Southern Manufacturing

SOUTHERN 18 Manufacturing & Electronics
FIVE | Farnborough | Hants | GU14 6XL
6th to 8th February 2018

SMEC PL1600C

Machine in Stock

SMEC MACHINE TOOLS

Features

- Made in Korea
- Fanuc 0iTF control with 8.4" screen
- Mill/drill
- Full C axis
- 530mm max swing diameter
- 290mm max turned diameter
- 8" chuck
- 12 station servo bi-directional turret
- 68mm bar
- Through spindle coolant

See us at stand J230

DUGARD Machine Tools

www.dugard.com | sales@dugard.com | +44 (0)1273 732286

Rencol
COMPONENTS

INDUSTRIAL MANUFACTURING SINCE 1923

Rencol Components continues a tradition of quality manufacturing dating back to 1923. Our brand is synonymous with high quality plastic and metal components, and our team is unmatched in industry experience & product knowledge.

Take advantage of our near century of industry experience, diverse manufacturing capability and unbeatable value – **contact us to find out more & receive our updated catalogue**.

Tel: +44 (0) 117 916 0090
Email: sales@rencol.com
Website: www.rencol.com

Visit our stand D220 at Southern Mfg. 2018

Pools of engagement

SMEs, often hardest hit by the skills gap, can learn valuable lessons on recruiting talent from larger engineering firms. David Fowler reports

01 KW Motorsports has forged links with local schools and the UTC at Silverstone

02 Leicestershire SME JJ Churchill prefers to focus on apprentices

Difficulty in recruiting sufficient high-calibre engineering graduates is a long-standing concern throughout industry. Engineering UK's estimate that the UK faces a shortfall of 20,000 skilled engineers annually is widely quoted.

But is the situation worse for small and medium-sized firms, lacking the scale, resources and brand recognition enjoyed by larger companies? Do the large organisations cream off the most talented graduates? And is there anything smaller companies can do to make their recruitment more effective?

Asked if graduate recruitment is more difficult for smaller firms, EEF head of education and skills Verity Davidge has no doubt: "The short answer is yes."

Larger companies have well-organised operations geared up to recruit graduates in bigger volumes in a range of disciplines, compared with smaller firms, she said. "It's particularly acute for smaller companies. They don't have the human resources function, and struggle to undertake the activities larger companies do, such as attending careers fairs or recruitment days, or offering industrial placements."

When EEF survey results are broken down by company size, there is a clear mismatch in all these activities between large and small firms (see box opposite).

"When you look at things that cost money, such as placements, sponsorship and sandwich courses, there are big differences," said Davidge.

Asked about barriers to such recruitment activity, smaller firms cite a lack of management time, followed by monetary cost, lower awareness of smaller companies among graduates, and a lack of understanding and communication between universities and business.

Davidge suggests small companies try a "light touch" approach to careers and recruitment fairs.

"If companies plan their time to release one person to attend a careers fair, that can help to sell the firm."

Alternatively, companies in the supply chain of larger firms could seek to be involved when the client company attends a careers fair.

Ultimately, difficulties in recruitment reflect on a firm's overall performance.

"Having the right skills is the foundation for growth, increasing exports and developing new products," said Davidge. "You can't grow without the right people."

Gloucestershire-based Renishaw is a significant recruiter of engineering graduates. It has increased in size from 1,850 to 4,500 employees (with 3,000 in the UK) since 2009. It needed to expand graduate recruitment to match overall growth, and has recruited between 45 and 65 graduates in each of the past three years.

Chris Pockett is head of communications and also has responsibility for education outreach. He says the company no longer has a problem in attracting good-quality applications from graduates.

"We've done a lot of work over the past six or seven years," he said. "We started an education outreach programme, recruited an education outreach officer and built from there."

Over four to five years, applications from graduates have quadrupled, by engaging with schools and educational establishments, more active participation in careers fairs, and being more active regionally and nationally in building the company's reputation.

But some SMEs in the region report difficulties. The West Country is competitive, with numerous large engineering companies in the vicinity, including the north Bristol aerospace cluster, and Dyson.

"A lot of smaller companies can get squeezed and struggle to get applications in," he said.

"My feeling is that it's incumbent on bigger companies like Renishaw to do the heavy lifting to widen the pool of talent through outreach and early intervention, including primary schools."

The company has even engaged with Rainbows (a younger version of Brownies for girls aged five to seven), and has developed an engineering badge for Brownies and Cubs as part

01

02

of efforts to inspire young children to study sciences and maths.

Renishaw collaborates with Airbus, Delphi and other supporters to hold Festomane, the annual Stroud Festival of Manufacturing and Engineering, in which local engineering companies large and small participate. The festival includes activities for all ages, as well as showcasing companies and careers in engineering.

Over two weeks last summer, more than 100 students aged 15 to 17 from local schools took part in Renishaw's work experience programmes, and another 100 students each year undertake placements over the summer or as the industrial year of a sandwich degree course.

Pockett added: "I see a lot of smaller companies engaging with local schools and like to think we help to create the right environment to make it easier for all engineering companies. Ultimately, we don't want people to say 'We can't get the talent because they all go to Renishaw, or Rolls-Royce.'"

Leicestershire-based precision engineer JJ Churchill specialises in complex aerospace, gas turbine and diesel engine components and is a tier 1 supplier to companies such as Rolls-Royce and Siemens. It has a growing workforce, currently 130 strong. But executive chairman Andrew Churchill says that, although most of its directors, senior management team and engineers have degrees, all but two started as apprentices.

"We haven't recruited a graduate for a couple of decades," he said. "We need doers, who have been moulded in the world of work. There is a disconnect between fresh graduates' expectations of salary and their ability to deliver. We typically find an apprentice operates at a higher level, age for age."

However, information about available apprenticeships is "more fragmented and not clear to young people", compared with the UCAS system. Churchill would like to see the establishment of "a formal clearing house" where prospective apprentices can log in and see what's available in their area. He favours support for apprentices' travel, given that many are aged only 16, and says better communication is needed between smaller companies and schools. He would also like to see more generous fiscal encouragement for SMEs to take on apprentices.

He said: "If you look at companies such as Rolls-Royce, there are always great opportunities for the best graduates. That's where graduates belong. The next level, tier 1, is in competition for apprentices."

KW Motorsport was established five years ago and has 26 employees and an annual turnover of more than £3m. With sister company KW Special Projects, the business aims to identify and transfer the technology of high-performance engineering in motorsport to other sectors.

Kieron Salter, managing director of both KW Motorsport and KW Special Projects, said: "We're constantly on the hunt for good people."

The company expects to recruit another five or six employees next year.

Of the current workforce, all but four are engineers or technical staff. There are two technician apprentices, three relatively new graduate engineers, and two on the industrial placement year of a sandwich course.

Salter said: "We have a definite requirement for more mature people with experience to guide and lead. In our recruitment of people fresh out of university, we don't look just for grades but for a mix of skills and a demonstration of their interest in engineering outside their schooling."

Generally the company focuses on the purer engineering disciplines of electrical, mechanical and aerospace.

"We don't tend to find that we have much success with people who have concentrated on things like motorsport engineering," said Salter.

The company is located in the Silverstone technology cluster, so there is competition for quality engineers from Formula One and other motorsport businesses. Jaguar Land Rover is also nearby. "We find that the people who want to work for us want a job with a bit more diversity, so our biggest competition is Formula One teams. We don't have many competitors in our market that can offer the same kind of job satisfaction and early growth."

The company has met most of its graduate needs so far through links with targeted universities – Cranfield, Loughborough and Oxford Brookes – and a number of graduates are "friends of friends of friends". It has attended job fairs with the Motorsport Industry Association and Silverstone Park. It has also forged links with local schools and the UTC at Silverstone, and this summer took on six school students on one-week placements.

"It's all very well complaining that there's not enough engineers about but you have to do something about it. It is quite a burden to ask people to take time out of their day to look after these young people, but I think it pays dividends later on," said Salter.

He echoed the point about the cost of employing new, inexperienced graduates in a market where job opportunities are plentiful. Graduates tend not to realise "that their demands for quite high salaries aren't going to pay back for the business. To encourage young people to accept a little bit less and get some training that would be better for them in 10 years' time, because they'll have more responsibility and relevant experience, is difficult." ■

Company size and recruitment

71% of companies have recruited a UK graduate in the past three years. This increases to 86% for companies with over 250 employees but falls to 56% for those with fewer than 100 employees

26% of manufacturers currently engage with careers fairs and recruitment days at universities — 49% for larger firms, 14% for small firms

39% of companies currently offer industrial placements to undergraduates: 69% for large firms, 25% for small firms

40% of companies offer internships to undergraduates and graduates: 78% for large firms, 20% for small firms

23% of companies currently sponsor students through university: 43% for large firms, 15% for small firms.

Santasalo
David Brown Santasalo

Engineering Vacancies

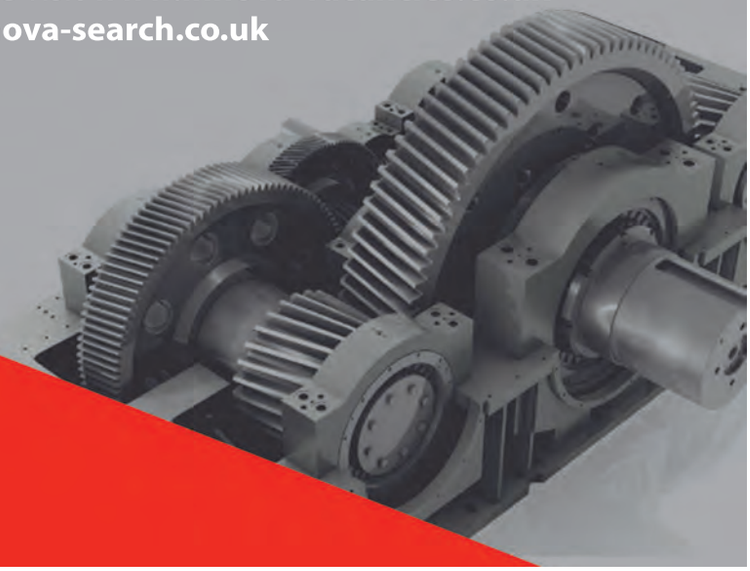
With exciting international growth ahead, we are recruiting a wide range of engineering roles across the UK & Europe.

Geared for growth...

We provide our customers with bespoke gearbox solutions on a global scale, into sectors including: fibre, pulp & paper, rubber, mining & minerals, defence, oil & gas and power generation.

Your new role at David Brown Santasalo will offer a range of opportunities for European travel along with a competitive salary and benefits package.

For a full breakdown of our live vacancies, please visit **www.innova-vacancies.co.uk**
Alternatively send your CV to **recruitment@innova-search.co.uk**



INNOVA SEARCH
MANUFACTURING AND ENGINEERING

CALL TODAY ON **0844 893 7475**

January
1946

No flight of fancy

Heathrow was intended as a three-runway airport 72 years ago, and now those plans may finally reach fruition

Heathrow Airport had a record-breaking year in 2016 when it registered 257,922 passengers on July 31 and a total of 75.7 million airborne visitors by the end of the year.

The current site is home to two runways that handle an average 1,293 flights per day, although this will change if plans progress to build a third runway at Heathrow.

What might come as a surprise is that 72 years ago the west London airport was originally intended as a three-runway facility and in January 1946 a correspondent from *The Engineer* was on hand to report on how the unfinished aerodrome was passed back into civilian hands following the end of the Second World War.

"The origin of Heathrow was the need of the Royal Air Force for an airfield near London capable of handling the heaviest types of aircraft, especially in the closing stages of the war in the Far East as it was expected to develop," our reporter said. "In planning, it was taken into account that such an airfield could be subsequently developed for civil aviation."

Placed 14 miles from central London, Heathrow was identified by *The Engineer* as being easily accessible by road and rail. "The question of a direct service of trains is being considered" the correspondent wrote, little knowing that three rail services – London Underground, Heathrow Connect and Heathrow Express – would go on to serve the airport in its current format.

Post-war Britain was, of course, still living with the economic after-effects of conflict. Air travel was the preserve of the wealthy, a situation that has gradually eroded to the point of exposing Heathrow's ability to keep pace with capacity issues.

The Airports Commission concluded in July 2015 that an expanded Heathrow would help alleviate London's airport capacity problem, a controversial decision that will displace a number of people living near the facility. Similar discussions were taking place in 1946, although the consequences did not seem so severe.

The airport was orginally set up to cater for heavy aircraft during the Second World War

"The three-runway airport... will in itself give London a first-class airport, which will be capable of accommodating the largest aircraft now contemplated, but in due course it is planned to extend the area and increase the number of runways.

"A thorough study of the neighbourhood has been made in order to safeguard the land and avoid unnecessary interference with dwelling-houses and ancient buildings.

"It is not anticipated that the number of persons who will be displaced from their homes will be large, and there will be no displacement within the next five or six years, by which time it is expected that the housing position will be easier."

Work on transforming Heathrow had begun in May 1944, with the main work focused initially on emptying ponds and disposing of a million gallons of water.

"Then followed the filling of the ponds and the making up of levels for the laying of the runway and track," *The Engineer* said. 'Concurrently, 13 miles of large concrete pipes were laid for disposing of collected rainwater. Four 54in diameter pipes run side by side to a gravel pit about a mile from the site, which serves as a balancing reservoir; two million tons of earth and gravel were excavated during the first summer and winter; some 12,000 yards of multiple ducting for electric cables were laid, and 60 miles of wire were drawn through the ducts. On the main runway the concrete is 12in thick. The laying of this mass concrete paving was started in 1945, and was completed in 3.5 months.

"Daily tests of quality and strength of the concrete showed, we are informed, an average strength of 30 per cent above the very high strength demanded by the specification."

It is estimated that the next runway at the current Heathrow would deliver significant growth in local employment through additional direct, indirect and induced jobs totalling around 64,000-66,000 (for the Extended Northern Runway scheme) or 75,000-78,000 (North-west Runway scheme) in 2050.

By contrast, *The Engineer* observed there were no more than 700 "heavy labourers" employed at Heathrow in 1944, with the site averaging 400 such workers. **JF**

Word of the issue

Anthony Poulton-Smith explores the origins of the word 'corrosion'

Not something an engineer wants to see, but corrosion is a problem to be dealt with. While rust – or iron oxide – is usually our first thought, as the name suggests this affects only iron. Alternative types of corrosion affect other metals.

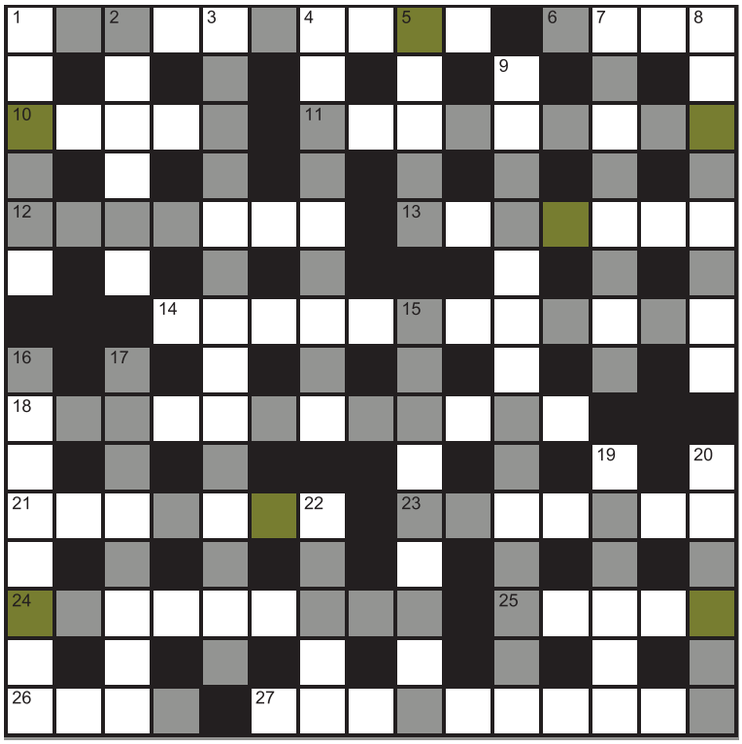
'Corrode' came to English from the Old French 'corroder' with the same meaning. However, French derived the word from the Latin 'corrodere', meaning 'to gnaw to pieces' or 'to erode away'. This is an excellent description of the effect of corrosion on metals.

We can trace the word also to 'rodere', meaning 'to gnaw' – from which derives 'rodent', a creature known for its teeth that are designed for gnawing.

Earlier still, the proto-Indo-European 'red' meant 'scratch' and 'scrape' as well as 'gnaw'. This root has given us related modern words such as 'abrade, erase, erode, rash, razor, rat' in English; the Sanskrit 'radanah', for 'tooth'; and the Welsh 'rhathu', meaning 'scrape, polish'.

Bigpicture

Bell Helicopter's V-280 Valor tiltrotor aircraft has made its maiden flight. The next-generation aircraft will be developed by a team that includes GE, Lockheed Martin and Moog. It will have a speed of 280kt and a combat range of 500–800nm.



Prizecrossword

When completed rearrange the highlighted squares to spell out an ore of aluminium. The first correct answer received will win a £20 Amazon voucher. Email your answer to **jon.excell@centaur.co.uk**

Across

1 Consisting of semiconductor materials and components (5,5)
6 Strip of land that juts out into the sea (4)
10 Medical beams (1-4)
11 A part that is joined to something larger (9)
12 Excursions taken for pleasure (7)
13 Sceptic (7)
14 Branch of mechanics that deals with the motion of gases (12)
18 Represented with technical drawings (12)
21 Driving force (7)
23 To make more taut (7)
24 Something that is put in an envelope with a covering letter (9)
25 Playing field where sports events take place (5)
26 Mercantile establishment for the retail sale of goods (4)
27 Served in a restaurant (10)

Down

1 Church officer in charge of sacred objects (6)
2 Built-on shed (4-2)
3 Total destruction (14)
4 Change completely (9)
5 Lukewarm (5)
7 Banana-like fruit (8)
8 To believe especially on uncertain grounds (8)
9 Water-resistant wrap used on exposed electrics (10,4)
15 Containing the most living leavening agent (9)
16 Eccentricities that are not easily explained (8)
17 Cold vegetable soup (8)
19 Mental tension (6)
20 Adorned with inserted pieces (6)
22 Steam bath (5)

November's highlighted solution was funicular. Winner: **Ben Elphinstone**

the ENGINEER EXPO

5–7 JUNE 2018
NEC BIRMINGHAM

ENGINEERING SOLUTIONS FOR UK MANUFACTURING

THE ENGINEER EXPO IS A BRAND NEW EVENT DEDICATED TO PROVIDING UK ENGINEERING PROFESSIONALS WITH THE LATEST IN-HOUSE MANUFACTURING AND DESIGN SOLUTIONS, ALONGSIDE CUTTING EDGE DEVELOPMENTS IN ADVANCED ENGINEERING TECHNOLOGIES.

NETWORK

with like-minded engineers and manufacturers to build new business partnerships

SOURCE

the latest advanced engineering technology, products and services to optimise your manufacturing strategy

MEET

world class suppliers of technology and equipment who can help you fulfil your latest projects

2 SHOWS, 300+ EXHIBITORS, OVER 30 FREE CONFERENCE SESSIONS

CO-LOCATED WITH

SUBCON

REGISTER FREE TO ATTEND BOTH SHOWS: WWW.THEENGINEER-EXPO.CO.UK

DCA

Helping our clients achieve success through great product design

www.dca-design.com