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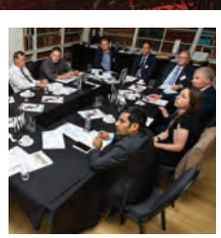

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Features

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Behind the hype

Earlier this summer, in one of our regular online polls, we asked for your thoughts on Industry 4.0: the much-hyped grand industrial vision that many claim will reshape the factory of the future.

The response doesn't exactly constitute a huge vote of confidence, with just 13 per cent of voters admitting to knowing anything about it, and almost half (47 per cent) claiming they haven't even heard of it.

Given the conversations we've had with people over the past year or so, this response is hardly surprising and doesn't really tell us anything we didn't know already. However, it does provide a neat illustration of the fact that, despite the hype, no one has done a particularly good job of explaining what exactly Industry 4.0 is.

Which is why *The Engineer*, in association with machine tool firm Mazak, pulled together a panel of leading industrialists in an effort to shed some light on the phenomenon and explore what it might mean for UK manufacturers. I'm afraid we can't claim to have arrived at a pithy definition, instantly understandable, that clears the muddy waters. But, as we report in our coverage of the event (page 30), some interesting and helpful points did emerge from the discussion, not least that rather than getting bogged down with a buzzword, it might be more helpful to simply think of Industry 4.0 as a collection of technologies that help us make best possible use of data in order to run our factories more efficiently: 'progress' in other words.

"I'm afraid we can't claim to have a pithy definition of Industry 4.0

On a related topic, we also take a look in this issue, at a technology that is frequently held up as an example of Industry 4.0 in action: Ubisense's smart factory system (page 44). Developed in the UK and now deployed by some of the world's biggest manufacturers the system is widely acknowledged as something of a game-changer, and also provides a solid example of how you don't have to rebuild your factory to make it smart.

Elsewhere in this issue we take a look a detailed look at the Royal Navy's next-generation frigate, we examine some of the fascinating technical developments in the world of armour design, and we put your questions on supersonic passenger flight to a panel of industry experts.

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NUCLEAR

Superconductors look set to provoke reaction

Operational nuclear fusion reactor could be built in 10 years

BY STUART NATHAN

Engineers at the Massachusetts Institute of Technology (MIT) have claimed that new commercially available superconductors could enable them to build an operational nuclear fusion reactor in as little as 10 years.

Known as an ARC reactor, this would be a small version of the toroidal tokomak reactor type, similar to the large reactor currently being built by international fusion project Iter in southern France.

The ARC reactor — the acronym stands for affordable, robust, compact; although it probably owes something to the fictional power reactor in the *Iron Man* superhero films and comics — uses rare-earth barium copper oxide (REBCO) tapes to form its magnets. These are claimed to produce a stronger magnetic field than the superconductors used in other tokomak designs (Iter, designed before REBCO became available, uses two superconductors, niobium-tin and niobium-titanium), which, in turn, means that the fusion reactor can be smaller, about half the size of Iter's 6m diameter: this means it would also be cheaper and quicker to build. REBCO becomes superconducting at temperatures of around 90–100K, rather than the 4K critical temperature of Iter's magnets; this means that cooling can be achieved with liquid neon, hydrogen or even nitrogen rather than liquid helium, making cryogenics simpler and cheaper.

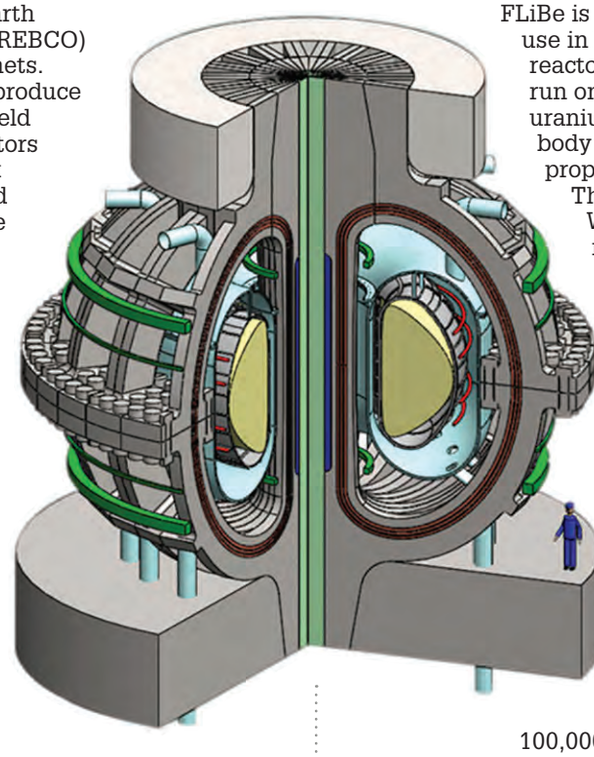
The design, which was the result of a student design project following on from a reactor design course led by Dennis Whyte, director of MIT's plasma science and fusion centre, features a few refinements to the Iter-type design. These are described in a paper co-written by Whyte, PhD student Brandon Sorbom and colleagues in the journal *Fusion Engineering and Design*.

Specially designed joints in the magnets allow the core of the tokamak, the toroidal vacuum vessel, to be removable without the need for dismantling the entire device, making it very suitable for research and systems optimisation. The 'blanket' of the device, the component that faces the hot fusion plasma while also capturing the fast neutrons generated by the fusion process (which both allows the heat to be recovered from the reaction and also generates the radioactive isotope of hydrogen, tritium, which is one of the raw materials for fusion), is not a series of solid blocks as it is in Iter.

Instead, it's composed of a molten salt known as FLiBe (a mixture of lithium and beryllium fluoride), which is circulated slowly and continuously around the inner walls of the torus at a temperature of about 900K.

FLiBe is a proposed solvent for use in liquid fluoride thorium reactors — fission reactors that run on thorium fuel rather than uranium — and there is a large body of research on its properties and industrial use. This is also easy to replace, Whyte said, making maintenance easier.

Whyte and Sorbom believe that the ARC reactor should be able to produce three times as much energy as it takes to sustain the fusion reactor, and with further design refinements this ratio could be doubled; this would produce enough electricity for around 100,000 people. Devices of similar complexity have taken around five years to build, they add, meaning that a decade might be a realistic time-frame to build and test an ARC reactor.



The ARC reactor would be like a smaller version of Iter

David Kingham, of Culham-based company Tokomak Solutions, which is aiming to build smaller spherical fusion machines to produce high-energy neutrons for research and medicine said: "The next step would be to refine the design and work out more of the engineering details, but already the work should be catching the attention of policy makers, philanthropists and private investors."

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inbrief

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Decisions, decisions
Local authorities will have 16 weeks to make a decision on shale gas exploration applications before the Communities Secretary steps in to take the decision on their behalf. The new rules reflect concerns that slow and confused decision-making by councils holds up shale applications for too long, creating uncertainty locally and preventing the establishment of a UK shale gas industry.

Secure undertaking
A newly announced £100m investment in Nissan's Sunderland plant will secure thousands of jobs and cement the UK's reputation as one of the world's leading automotive centres, the carmaker has claimed. The investment will be used to produce the second generation of the firm's Juke crossover vehicle and is expected to secure 34,000 jobs within the company and its supply chains.

Bionic hand on the prize
A low cost 3D-printed bionic hand for amputees has won the UK section of the James Dyson Award, an annual prize established by the prominent industrialist's charitable trust, The James Dyson Foundation. Developed by UK design engineer Joel Gibbard, the Open Bionics hand can be 3D printed and assembled in just 40 hours, and costs under £1,000, a fraction of the cost of other advanced prosthetics.

Inspirational hires
EngineeringUK has hired two student vloggers in an effort to inspire the next generation of engineers. It is part of its campaign to support Tomorrow's Engineers Week 2015 in November. Lily Kate France, an A-level student from Lancashire, and Nayeeb Chowdhury, a chemical engineering undergraduate from University College London, will create YouTube content that showcases science and technology.

AUTOMOTIVE

All power to the SUV

First large-scale production electric vehicle from Audi

BY CHRIS PICKERING

Audi is set to launch an all-electric SUV in 2018 that has a potential range of more than 500km (310 miles).

Based on the Audi e-tron quattro concept, due to debut at this month's Frankfurt motor show, it will be the first large-scale production electric vehicle (EV) to come from the German brand.

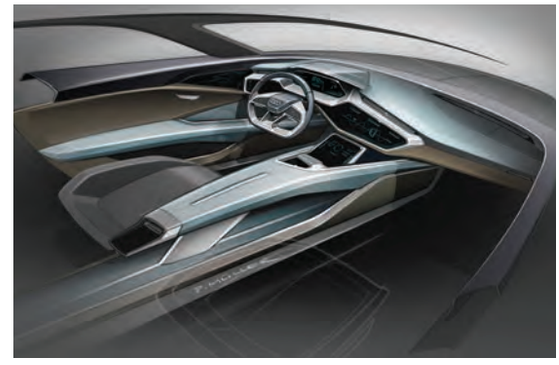
Three electric motors – one on the front axle and two on the rear – will be used to provide four-wheel drive, while a large lithium-ion battery back will be positioned low between the axles to aid weight distribution.

Audi said the car has been designed from the ground up as an EV. The concept features movable aerodynamic elements on the front, the sides and the rear to control the airflow – presumably to balance cooling requirements with drag. It also uses a completely flat underfloor, helping to reduce the coefficient of drag to just 0.25, setting a new record for the SUV segment.

The e-tron SUV's battery will use cells from South Korean manufacturers LG Chem and Samsung SDI. Both firms are investing heavily in new cell technology and are expected to supply Audi from their European plants.

Structurally, the car will be based on the Volkswagen Audi Group's second-generation MLB platform. Using a selection of modular components built from aluminium and ultra-high-strength steel, it can be stretched and shaped to accommodate longitudinally front-engined designs.

Size-wise, the new car will fit between the Q5 and the Q7. This, allied to the current trend for using even numbers for the more sporting models, suggests the coupe-like SUV will be badged the Q6 e-tron. Audi board member Ulrich Hackenberg said that the aim was to provide "an attractive overall blend of sportiness and range", and the straight line performance is expected to compare well with internal combustion models.



The all-electric e-tron quattro will follow on from Audi's existing plug-in hybrid models, including the C-segment A3 Sportback e-tron and the forthcoming Q7 e-tron SUV. Although it will be the first mainstream model from the brand to rely solely on electric power, it won't be alone. The long-awaited R8 e-tron sports car is due to go into production at the end of this year.

The Q6's technology is likely to take its lead from the R8 e-tron, which uses no less than 7,488 individual cells packed into a T-shaped battery weighing around 595kg. It boasts 90.2kWh and a power density of 152Wh/kg. The R8 e-tron's charging system has been engineered to accept fast charging at up to 150kW – theoretically enough to provide a 90-mile range in 15 minutes.

DEFENCE AND SECURITY

Looking for a clean sweep

Funding for development of new method for landmine detection

BY ANDREW WARD

Bath University has been awarded funding to further develop a new method for detecting landmines, which uses a combination of 3D cameras and metal-detecting technology.

The £100,000 of funding, provided by Sir Bobby Charlton's charity Find A Better Way, was awarded via an EPSRC competition.

Modern landmines are usually made from plastic, rendering traditional techniques for identifying them useless. The university team is looking to combine metal detection with new imaging technology that relies on 3D cameras, allowing for all types of landmines to be identified.

"Currently, manual metal detectors sweep minefields in a slow and time-consuming process that cannot detect non-metallic landmines," said Dr Manuchehr Soleimani, associate professor in the Department of Electronic & Electrical Engineering and leader of the Engineering Tomography Lab (ETL) at Bath University.

"We aim to develop an integrated technology to detect both metallic and non-metallic landmines, and to improve the speed and reliability of this process."

That integrated technology includes two different types of array, so that older, metal landmines can be detected, as well as the newer plastic landmines.

"The innovative idea in this project is a combination of capacitive array and inductive array, so that both classification of electrical properties and detection of non-metallic (and metallic) landmines can be done," said Dr Soleimani.

"The capacitive array works a bit like a touch screen, and the inductive array is like a metal detector. We were able to develop 3D subsurface imaging in our lab and also able to do some initial feasibility tests representing simple scenarios of landmines in the lab."

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Adam Meekings hopes to end after-treatment on diesel engines

AUTOMOTIVE

Clear the air

System pre-treats air going into engine cylinders to reduce emissions

BY CHRIS PICKERING

A new technology company from the UK is developing a system that could eliminate the need for after-treatment systems on diesel engines.

The new concept from Penumbra Power pre-treats air going into cylinders to reduce the emission of nitrous oxides (NOx) and other greenhouse gases.

Developed by former JCB engineer Adam Meekings, technical details are relatively scarce. What we do know is that the technology uses heat and carbon dioxide (CO_2) from the exhaust to alter the chemical composition of the air and fuel entering the engine.

Meekings said that the system has the potential to completely replace conventional after-treatment, including catalytic converters and particulate filters.

"The original aim was to eliminate the use of liquid additives like Adblue, while achieving similar levels of emissions reduction," he said. "Removing the after-treatment system also means you no longer need precious metal catalysts and it could allow the engines to run leaner without a NOx penalty, increasing fuel efficiency.

"We're aiming for a solution that's cost-neutral [to produce] compared to existing after-treatment. Typical HGV applications require around four to eight litres of Adblue for every 100 litres of fuel, which obviously has cost implications for purchase and storage. The same idea could potentially be applied to passenger cars, as well as larger diesel applications such as ships and power generation."

The concept draws on techniques used in the gas processing and medical industries. It leaves the base engine unchanged, but the turbocharger may need to be modified; intriguingly, according to Meekings, it may even allow the turbo to be removed completely.

Penumbra Power's concept is described as a closed-loop system and it uses CO_2 from the exhaust to enhance its operation.

"The product has the potential for CO_2 capture – similar to the systems used in power stations," said Meekings. "We think this could be applied to heavy truck applications, even getting to the point where no CO_2 is emitted at all. Instead it could be contained on board in a tank and then used for enhanced oil recovery or stored in a depleted gas well."

Penumbra Power was awarded funding this year from Shell's LiveWIRE scheme, which will be put towards the cost of a working prototype.

LOW-CARBON VEHICLES

Roads to research

Ricardo hopes new centre will facilitate the next wave of low-carbon vehicles

BY HELEN KNIGHT

Ricardo has launched a £10m research centre aimed at developing the next generation of low-carbon vehicles.

The Ricardo Vehicle Emissions Research Centre (VERC) is capable of testing anything from small passenger cars to light trucks of up to three tonnes, including advanced hybrid electric vehicles and technologies such as energy regeneration and start/stop systems.

Importantly for hybrid and plug-in hybrid vehicle testing, it can measure the battery's state of charge, as well as emission levels.

The facility is designed to do much more than simply testing that vehicles are meeting emissions regulations, according to Richard Murphy, head of UK test operations at Ricardo.

"The design behind the facility was to deliver more than the level of accuracy that the current and future legislation requires," he said. "Our bread and butter is in developing the technology that gives you the capability for those emissions targets, and for that engineers can require accuracies of 0.1 or 0.5 per cent," he said.

The facility is designed to test four-wheel drive powertrains of up to 300kW, and can simulate road speeds of up to 250km/h. It is also capable of carrying out climate-controlled tests with a temperature range of -30 to +55°C, and with humidity regulation.

VERC's measurement systems can support vehicle development projects to the highest worldwide emissions regulations, including Euro 6 and 7, and the US super-ultra-low emission vehicle (SULEV).

VERC is equipped with three Constant Volume Sampler tunnels in which exhaust gas is diluted to allow emission levels to be measured.

Gas analysers at VERC measure carbon monoxide, oxygen and nitrogen oxide and nitrogen dioxide (NOx), carbon dioxide and after-treatment technologies, including exhaust gas recirculation.

IMAGING

Back of the net

Picturing of insects can be used to develop better netting against mosquitoes

Engineers at Warwick University are using imaging technology to observe thousands of mosquitoes in a bid to develop better netting against the malaria-spreading insect.

When observing mosquitoes and their interaction with insecticide-treated barriers such as netting, researchers have previously relied on recording the insect's final landing location, which does not accurately reflect their approach and handling of protective barriers.

Engineers at Warwick believe they've overcome this limitation. Using a modified back-lighting technique, the insects have been imaged throughout a 2x2.4x1m volume using illumination in the near infrared, a wavelength not perceived by mosquitoes. Two cameras capture 50 images per second. Around 360,000 images are captured each hour, each taken at four million pixels, or 1.4 TerraBytes (TB) in total size.

Until now there was no software capable of analysing such a large number of high-resolution images, so it had to be specially written by the Warwick engineers. It has now been used to process more than 50TB of data. ***JF***

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RENEWABLES

Down on the farm

Sensor uses ultrasonic waves to assess when wind turbine bearings will fail

BY JASON FORD

Engineers have developed a piezoelectric sensor that lets wind farm operators know when bearings are about to fail.

The sensor, developed by Wenqu Chen, a mechanical engineering research student at Sheffield University, uses ultrasonic waves to measure the load transmitted through a bearing in a wind turbine. A paper describing the advance is published in *Proceedings of the Royal Society A*.

Prof Rob Dwyer-Joyce, co-author of the paper and director of the Leonardo Centre for Tribology at the university, said that a limiting factor with wind turbines is gearbox reliability, particularly in relation to bearings where manufacturers and operators have faced issues in relation to reliability.

He said: "[Failures] come from the fact that these are big bearings subject to quite unusual loading.

"They're subject to high dynamic loading and they're failing in ways that aren't usually seen on more conventional bearings."

The 2mm^2 sensor has been validated in the lab and is currently being tested at the Barnesmore wind farm in Donegal, Ireland by Ricardo.

Prof Dwyer-Joyce said the patented sensor has been installed in the raceway of a transmission bearing, adding that the raceway compresses slightly as the ball and roller pass over it.

He added: "We pick up that compression and that compression depends on the load applied to the ball in the first place," he said. "It's that stress… which is going to control the life of the bearing."

The time of flight of the ultrasonic pulse from the sensor is affected by stress levels in the material, making the new method the first to directly measure the transmitted load through the rolling bearing components.

Current sector-related condition monitoring methods come in the form of acoustic emission signal, vibration sensing, or oil-debris analysis that alert operators to damage after it has occurred, which puts the new sensor – and its size – at an advantage.

"Imagine the rolling elements," said Prof Dwyer-Joyce. "The balls and the rollers passing underneath the raceway – if you've got a very small sensor… the contact between the roller and the ball and the raceway is really very small so you get a very localised stress region… the smaller your sensor then the more its sensing path is within that stress region. That's how it works."

MANUFACTURING

Drilling season

Advanced techniques for aerospace parts

BY BEN HARGREAVES

The speed and quality of aerospace component manufacture is to be improved with the introduction of advanced fibre-laser drilling at the Manufacturing Technology Centre in Coventry.

MTC said it was working with Rolls-Royce to investigate the potential of fibre lasers for drilling of aerospace materials, especially the holes in aero engine turbine blades that allow them to function without beginning to melt.

MTC is using technology from US firm IPG Photonics, a laser manufacturer.

Sundar Marimuthu, a research engineer at the Coventry unit specialising in laser processing of materials, told *The Engineer* that he did not believe it was available elsewhere in the UK.

The technology had only been on the market for two years and the MTC had been working with it for more than a year, Marimuthu said.

"However, it is likely that aerospace manufacturers in the US and Europe are also exploring fibre lasers for drilling," he added.

Turbine blades in aero engines are drilled with holes to keep them cool as very hot gases circulate around them.

Marimuthu explained that Nd:YAG lasers had been used for 20 years to drill holes in blades, but fibre lasers were more controllable and had benefits in terms of quality and speed of manufacture.

Advances in technology meant fibre lasers could pulse for very short spaces of time – between 0.1-10 milliseconds – allowing them to be used for this application for the first time.

The IPG laser equipment at MTC has a high operating efficiency and is also more compact than traditional lasers, allowing better use of factory space, and reducing the need for multiple machines.

Marimuthu said lasers were being used for a wide variety of materials processing operations at the MTC, including cutting, hollowing, drilling, cladding and additive layer manufacturing.

"In fact, lasers are used in every department at the MTC in some form or another," he said.

The MTC opened in 2010 and is a partnership between some of the UK's major global manufacturers and three universities.

FUNDING

Bridge to market

Fund to invest in mechanical engineering

The Institution of Mechanical Engineers (IMechE) has launched an initiative designed to help companies bridge the gap between initial innovation and bringing a product to market.

The £2m Stephenson Fund will invest in innovative companies engaged in mechanical engineering in coming years.

"These investments by the Institution of Mechanical Engineers are not just about providing monetary investment, but about connecting these and other companies to the vast resources and network of the Institution and its membership," said Stephen Tetlow MBE, chief executive of the Institution of Mechanical Engineers.

"The fund fulfils the Institution's original purpose to give an impulse to invention and also help companies overcome the investment hurdle between research and development, and bringing a product to market."

The fund's first five investments are blade compressor company Lontra; fuel cell catalyst developer Amalyst; sensor company Oxsensis; fusion energy company Tokamak Energy; and space technology business Oxford Space Systems. ***AW***

ADVERTISEMENT FEATURE

Introducing a new wireless remote switch device to complement WERMA's "WIN" Andon wireless status monitoring system

WIN Slave Control offers new functions

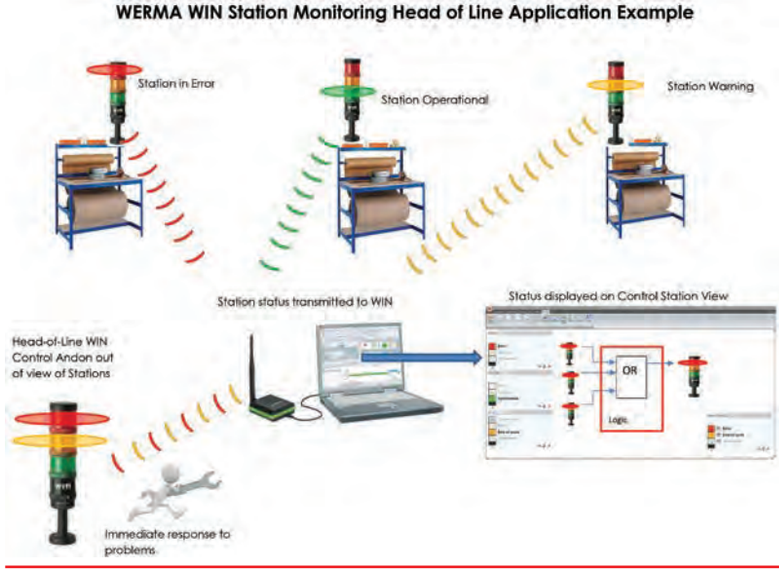
The standard transmitter unit supplied with the WIN wireless monitoring system transmits the status change in the Andon light to the WIN software, allowing you to collect machine or workstation performance data.

Now the new "Slave Control" receiver unit offers a "command" function for the first time.

Typical applications for the new unit include:

Head of Line function

Using simple rules in the WIN software, the Slave Control receiver allows you to remotely activate individual lights on an Andon light tower, according to the status of monitoring Andon lights out in the production area. In this way, a supervisor at the "end of the line" can be immediately notified by a single "repeater" Andon light located in his line of vision, when any of the Andon lights on multiple production lines change status. This ensures a prompt response to local problems, and increased productivity.



Sending commands to machines and process systems

When Slave Control receives commands to change the output of attached Andon lights, it is also able send these outputs to external switched terminals. By using these outputs, external systems can receive control signals according to the status of the Andon lights on machines and workstations in the production area. So as examples, a machine could be started if one or more other machines went into an error status, or a process control action could be triggered directly when a series of other machines have completed their processes, or a system could be shut down to save energy, if other machines are not in use.

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An engineer applies an advanced coating to Bloodhound's fuel pump

AUTOMOTIVE

Cool coatings

Ceramic coatings will help Bloodhound with internal temperature control

BY CHRIS PICKERING

Engineers on the Bloodhound SSC project have turned to Formula One-derived ceramic coatings to help the 135,000bhp land speed record challenger keep cool.

The jet- and rocket-powered car is due to make its first test runs in a matter of months and tight packaging within the design means that heat soak is a constant concern.

One of the more unusual facets of Bloodhound is the rocket motor's fuel pump, which is driven by a 550bhp supercharged Jaguar V8. This sits next to the tank of high-test peroxide (HTP) used to feed the rocket. The consequences of putting too much heat into this 1,000-litre container of highly volatile rocket fuel are potentially explosive, so temperature control is a major issue.

To reduce heat transfer, the V8's exhaust pipes were coated using Zircotec's ThermoHold material. This was applied using a plasma spray technique, where an electrically generated plasma is used to heat particles of a zirconia-based material to extremely high temperatures (circa 10,000°C), before it's shot towards the surface at around twice the speed of sound.

The concept itself isn't new, but, more recently, Zircotec has developed a technique for applying the same material to composite surfaces.

One example of this comes with a load-bearing rib that sits on the upper part of the rear structure, just beside the after burner petal of the jet engine.

"We weren't able to use aluminium because of the temperatures involved. In theory, a machined titanium part was an option, but that would have been extremely expensive and heavier than we'd have liked," explained George Morris, senior composite design engineer for Bloodhound SSC. "Using composites provided the strength we needed, but there's no way we could have done that without the ceramic coating to control the temperature."

Elsewhere on the car, the front brake discs can reach more than 600°C, but thanks to the thermal barrier coating the team was able to package a major carbon-fibre structural component less than an inch away from their surface.

"At 1,000 mph the air pressure alone on that structure equates to about 18 tons. We just can't risk any degradation in performance by taking the material above its glass transition temperature," concluded Morris.

AUTOMOTIVE

Up to the test

Investment will be used to upgrade engine test cells in Bedfordshire

BY HELEN KNIGHT

Millbrook, a vehicle testing and engineering specialist, is investing nearly £2m to upgrade its powertrain facility.

The £1.83m investment will be used to upgrade the 12 engine test cells at the Millbrook Proving Ground in Bedfordshire.

The investment will allow Millbrook, an independent technology centre for the design, engineering, test and development of automotive and propulsion systems and low-carbon vehicles, to provide a full exhaust emissions and fuel-efficiency testing and development service.

In particular, this includes testing vehicles' ability to start in the cold, in temperatures as low as -40°C, and advanced road load simulation modelling, the company said.

The investment will also fund new equipment for carrying out advanced direct injection gasoline and diesel development work.

In addition, test-bed software will be upgraded, to allow it to run even extremely complex tests accurately, and to improve the efficiency and reliability of operations.

As well as funding new testing and development technology, the investment will also support Millbrook's growth strategy, by allowing for the creation of three new highly skilled positions within the company's powertrain department.

Millbrook, which works with companies in the automotive, transport, petrochemical, defence and security industries, has recently been awarded a major contract with a large OEM, who the organisation has been collaborating with for many years, according to Stephen Ratley, head of powertrain at Millbrook.

"We have a number of other key customers that are keen to utilise our independent and impartial knowledge and expertise," he said. "This latest investment enables us to meet the requirements of our customers and the growing demands for modern engine test and development."

AUTOMOTIVE

Direct approach

Technology has been set up to provide low noise and vibration electric motors

Magnomatics has received a £99,900 Smart Award to develop its Pseudo Direct Drive (PDD) technology.

The grant from Innovate UK for the £167,000 project will allow Yorkshire-based Magnomatics to further develop the PDD, to provide next-generation low noise and vibration electric motor technology to urban and suburban rail markets.

Magnomatics has so far produced prototype quantities of its motors, but the grant will allow them to be developed further beyond the largely first-generation designs used so far.

Magnomatics' PDD motors are claimed to offer a significant advance over conventional permanent magnet motor technology and can displace incumbent machinery such as gearboxes, while maintaining high efficiency, offering low maintenance costs and high reliability.

The advantages of the PDD are said to have already been demonstrated in two Innovate UK-funded projects under the LCV IDP programme with Volvo Powertrain and a consortium, including Dennis-Eagle and MIRA, in which the motor showed significant efficiency and packaging advantages. ***JF***

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Africa shows big potential

UK construction firms need to act quickly to tap into the African continent's future growth says the CEO of Spencon

In a globalised world where UK construction firms compete not only with their European counterparts but the new wave of Chinese and Middle Eastern firms, finding untapped or under-served markets for entry is increasingly important for bottom line. Most recently, Africa has been that market.

This trend is particularly evident in the construction and engineering industries as Africa begins to address its widely acknowledged physical infrastructure backlog. With most of the continent still lacking access to basic infrastructure such as adequate roads, sufficient water supply, functional power grids, formal housing for its growing population and public transport networks such as rail lines, plugging the infrastructure deficit has been a key opportunity for investors.

In 2014 alone, more than $4bn (£2.6bn) was raised by private equity funds for investment in Africa, with a significant chunk of that targeted towards infrastructure. A recent report by Deloitte remarked that "in a short space of time, the continent suddenly resembles a massive construction site".

For forward-thinking British engineering firms, the influx of capital for infrastructure projects on the continent should be of great interest. Regions such as East Africa are a hotbed of opportunity in desperate need of international building expertise that the UK construction industry can supply. At Spencon, we've been working with international firms and development agencies to deliver regional infrastructure projects in East Africa for more than 35 years and continue to work to identify opportunities for international firms.

> **"In 2014, more than $4bn was raised by private equity funds for investment**

Power instability remains a key issue in Africa with most governments keen to address the problems to support long-term economic growth. Over the last five years, there have been a wealth of new power projects across Africa and, in particular, East Africa, awarded to international construction firms. This includes the $684m power-plant in Tanzania to plug regional energy shortages that will be built by China National Machinery & Equipment Import & Export Corporation (CMEC) and German engineering group Siemens. As Kenya, Uganda and many other African nations focus on improving their power networks, more of these contracts will be available to international firms with significant expertise. UK firms with experience in delivering such large-scale projects on time and on budget will prove invaluable to local and national governments who need hand-holding through the process.

Furthermore, with many of these projects funded by international investors or development agencies such as the World Bank, the requirements for adequate reporting and corporate governance are substantial and again are aspects that UK firms will be well-versed in handling.

Adequate provision of clean water to communities is a priority for many African nations, as well as development agencies investing in the continent. As water and waste management will play a critical role in the near to medium, and long-term future of the continent and world at large, UK construction firms are well placed to invest in the sector as it is expected that the number of projects is likely to grow by two or threefold.

In East Africa, we've been involved in numerous water and sanitation projects working with international companies for the design, construction, supply, installation, testing and commissioning of water and wastewater treatment plants. Recently, Spencon, in consortium with Degrémont, completed the design and construction of a 90,000m^3 per day water treatment plant in Lower Ruvu, Tanzania.

Business and economic growth in Africa has driven the urgency for a complete revamp of the continent's crippled transport network. In our 35 years of operation, we've seen a surge in demand for implementing road projects to improve East Africa's transport networks.

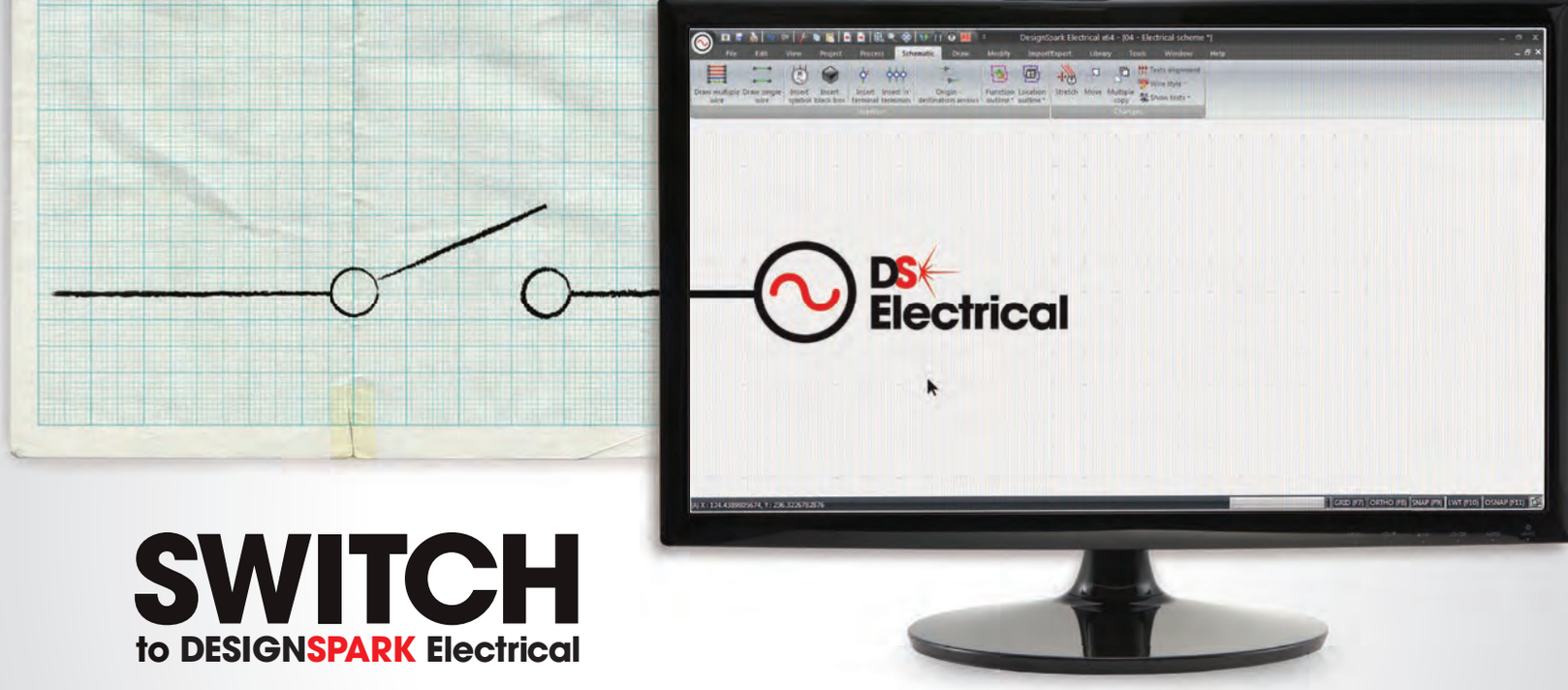
Firms across the world are already taking advantage: for example, the Portuguese construction giant Mota-Engil, Engenharia E Construcao SA won a €60m (£44m) contract to construct the second phase of the Kampala Northern Bypass in East Africa.

While many make the mistake of viewing Africa as one indigenous entity, its true potential lies in the diversity and variety. The continent has varying climates, economies and, with that, different challenges to overcome.

Much of the continent's infrastructure is a reflection of its colonial past, with roads, ports and railroads built for extracting valuable resources and to aid political control, rather than to integrate territories together economically.

Rapid urbanisation, a rising middle class and continued economic growth have created an ample environment for the construction industry. UK firms have a significant language advantage with most international contracts being based on British versions. With the rest of the world and China, in particular, honing in on the opportunities available, UK firms need to act quickly or risk falling behind its international competitors in taking advantage of Africa's growth story.

Andrew Ross is the CEO of civil engineering firm Spencon



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thehottopic

Faslane – is the UK clinging to past glories?

Our coverage of the UK government's £500m investment in the Faslane submarine base prompted a heated debate on the rights and wrongs of Trident renewal

Pic Credit: CPOA(Phot) Tam McDonald

As with much of what goes on in 'international politics' the ownership of nuclear weapons by the UK has much more to do with the UK trying to cling on by its fingertips to a role and influence at the top level of various world bodies than any kind of potential real use (or deterrent) as a weapon. It could almost be seen as a form of 'luxury good' for part of the 'establishment' in that, while keeping some sectors of industry going, it does nothing in the productive sense (and probably little in spin-offs) and merely proves that much of the UK is still living as if it were in the 1950s.
Paul Reeves

Isn't it about time the UK stopped being the eastern arm of the US military and gave serious consideration to independent protection? Surely the brilliant minds in this country should be invested in and not overlooked in favour of the US? After all, haven't some of the greatest military inventions originated in the UK?
Chris Johnstone

We don't need WMDs to protect our food banks. The real enemy is terrorism... nuclear weapons don't defend us against that. Britain is no longer a world power, it should stop acting like one. It can't afford Trident and needs to spend money on maritime patrol aircraft, and proper and effective conventional defensive weapons. As for Trident being independent, we all know it's the Americans that have the codes. Britain only wants to retain WMDs to retain its seat at the UN.
Henry Hooper

The risks of accidental initiation or escalation associated with nuclear weapons are high but rarely commented on. The consequences of a single incident would make Chernobyl and Fukushima seem insignificant. The Chatham House Report of 2014 – *Too close for comfort: cases of near nuclear use and options for policy* – describes near misses and shows how some controls have broken down. The Royal Navy's able seaman William McNeilly identified many other losses of control in June and was sacked for his efforts, rather than thanked for exposing serious deficiencies. Trident should not be replaced but, given the threats we face, the money should be used to strengthen conventional forces and advanced non-nuclear weapons such as drones and cruise missiles.
Mark Harrison

Given any land-based nuclear weapon system is essentially useless in a defensive role, the nuclear-powered and armed subs are the only current solution. It seems worth noting that we are living in the longest period in modern history in which we have not been involved in a 'global' conflict. The only differentiating factor is our nuclear deterrent. Why on earth would we abandon this highly effective peacekeeping system? As for Faslane versus an English base: keep it at Faslane. If the SNP dies of self-inflicted injuries it will show those more moderate Scots we are with them in a Union.
JohnK

inyouropinion

Shorehamtragedy

Readers were divided on whether last month's tragic accident should lead to a ban on aerobatics by vintage aircraft

■ The immediate ban on vintage aircraft performing aerobatics is a reasonable precaution, not wishing to pre-judge the outcome of the enquiry. I suspect that the tragedy was not, however, a result of aircraft fault. I hope that vintage aircraft will be allowed to resume their place in the skies. Better control of flight paths would be a good measure.
Ian Deaville

■ I think this is a knee-jerk reaction. Certainly the immediate grounding of the jet in question is sensible. Looking closely at where these displays are taking place is sensible. Banning air shows and limiting the manoeuvres is using a sledge hammer to kill a wasp. We should await the outcome of the inquiry.
Gordoun Flint

■ I have flown vintage aircraft that are capable of aerobatics. These aircraft are rigorously inspected and accidents involving them are therefore very rare. Unfortunately Shoreham has come at the end of a number of air crashes and all flying will be considered dangerous in the public's eyes despite evidence to the contrary.
Chris

■ I was at the air show and saw the crash, the reaction from the crowd was one of disbelief and then sadness as news came through regarding the fatalities. I have put flowers on the Toll Bridge as a mark of respect for those who have sadly lost their lives. My home town is in mourning and there is still an air of disbelief. The air show should continue but we do not need the 'older' aircraft to perform stunts, just to see them fly past is rewarding enough.
Mick Jones

■ It makes good sense to put necessary temporary controls in place to protect the public while the investigation is carried out. However, in general, air display safety should be assessed in the same way as motorsport events and there will always be a risk to the public. Aircraft are either airworthy or they are not. They are capable of operating within the design envelope or not. The question is really whether these controls are effective. To ban

thesecretengineer

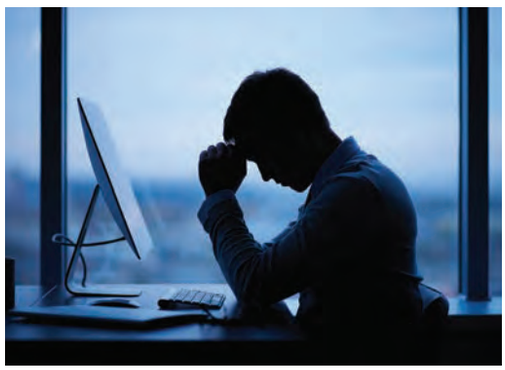
Public recognition of the value of engineering is one thing, but industry itself also needs to give its most skilled practitioners more credit, writes our anonymous blogger

We often bemoan the status and pay of engineers but why are these important?

We could always do with more money in the capitalistic world we live in, but I think both issues actually relate to a sense of appreciation and self-worth. By no means do we need thanking every day for what we do, likewise we know that we are employed to perform at a certain level. However, we are also human and, from my experience, when required, put a lot of time and effort in 'beyond the call of duty'. Two particular incidents from the past year have reinforced to me the general disdain or dismissive way in which we are viewed.

As you may be aware, I left the world of Widget design over a year ago, what you may not know is that it was just as the new Glow-Widget 2000 was being introduced. I had been working on this, as a part of the engineering team, for the previous two years and had put quite a bit of effort into it. Post launch, our baby has picked up a number of prestigious awards including the Widget world's 'Oscar': a prize so notable that representatives of the project team flew into mainland Europe to pick it up. Naturally my name was listed among the others on the parchment scroll solemnly presented. Subsequently this was returned with the request that I be struck from it, the reason being that I no longer worked for the company. This seems a tad petty to me. After all, I had left on good terms and it's not like my input had magically been erased upon my departure. I cannot help but wonder if this would have happened had I been part of a different department.

The second relates to my recent time at the



Great Lakes Metal Foundry and Glass Works where I had a new product foisted upon me, a particularly tricky stained-glass Double-Linked Jigger incorporating many novel features. This was needed on a short time scale and would result in serious problems for the company if commitments weren't met, something regularly reinforced to me by various members of senior management. I put a lot of hours in as the sole design engineer and the first parts came in, were assembled and went straight through testing before being immediately shipped to the customer – just hitting the deadline. My boss was actually moved to suggest that I was one of only two design engineers within the company who could have achieved his. Was I thanked or shown any appreciation? Quite the opposite as it happens.

I have as many faults as the next engineer but I don't think I can lay such apparently dismissive actions at the feet of any of them. Is it too much to ask that we have a bit of respect shown for our professional commitment and achievements?

Join the debate at **www.theengineer.co.uk**

such aircraft from operating within their certified design envelope tells me that airworthiness approvals are in question.
Maurice Jones

Settingsun?

China's economic slowdown sparked a debate on possible consequences for the UK

■ This could work out very well for UK manufacturing.
Mike

■ Sadly it will have no effect. Anyone needing 10,000-plus of any product goes to China, period. Automation will make Chinese factories even cheaper – making mid-tech manufacturing in the UK even more perilous.
Marcus Gibson

■ It does not follow that "anyone who needs 10,000-plus of any product goes to China, period". We manufacture many tens of thousands of high-value products in the UK. China is an important export market for us and UK manufacturing can compete. Competing effectively needs good products, manufactured to high quality and supplied at an acceptable cost – going into a protectionist trade war will help no one.
Edward

■ The vast majority of the 'leaders' of the Chinese nation are trained technically, as are those in Japan and South Korea – and it shows. I believe that development of a middle class almost as large as that of Europe combined is unstoppable. Occasional blips – but otherwise onwards and upwards.
Mike Blamey

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The tomorrow people

Recent surveys are showing big jumps in the numbers of young people seeing engineering as a desirable career path

Two years on from the Perkins review of engineering skills and just as we all pull together plans for the third Tomorrow's Engineers Week, something rather exciting is happening. The public is starting to appreciate engineers and plans to reach one million young people with great engineering in schools means they might even want to join us when they enter the workforce.

Findings from our annual perceptions survey, to be published later this month, show that 27 per cent more 11–14 year olds believe a career in engineering is desirable than five years ago. The proportion of 15 and 16 year olds who would consider a career in engineering has increased from 37 per cent to 49 per cent in the same period.

And for 17–19 year olds, the number that have considered an engineering career has risen from 23 per cent to 37 per cent, with the proportion of girls of that age who have considered the industry rising from 12 to 28 per cent.

This year's survey shows a massive jump in the proportion of teachers who see engineering careers as desirable for their students. This stands at 79 per cent compared to 57 per cent in 2014 and the number of teachers saying engineering is undesirable for their students has halved since last year, falling from 17 to 8 per cent.

The Perkins review called for a coordinated approach to inspiring the next generation. By delivering engaging activities in schools you can showcase real engineers and real engineering, and bring the industry alive for young people. Why bother? Because we need to attract new talent to the 1.82 million engineering roles we will need before 2022. That's where you come in.

During Tomorrrow's Engineers Week, 2–6 November, we want schools and employers across the UK to work together on events and activities to inspire future engineers. We need you to tell young people about your amazing job, either attending or hosting events/activities for young people. While we will lead on the public relations for the week, its success depends on active input from engineers and engineering employers across the UK.

To support this year's campaign we've also recruited two young vloggers (video bloggers), who will feature on the Tomorrow's Engineers YouTube channel to help dispel myths around engineering and inspire young people to study STEM subjects.

If you're new to Tomorrow's Engineers Week, we can help. You can get inspiration from the website or contact one of the Tomorrow's Engineers team. That team is currently headed up by Chris Binnie, who follows in the footsteps of National Grid's Vicky Higgin, joining us on secondment from BAE Systems. This strong support from business is a huge boon for the programme, which now has employer support managers working with employers in the South east, North East, South West and West Midlands

> **"We need to attract some new talent to the 1.82 million engineering roles that we will need before 2022**

That active engagement at local and regional level to improve the reach and impact of schools outreach activity feeds into a national picture that will continue to improve as employers across the country join the network. Together we can deliver on the plans to reach a million young people with positive messages about engineering each year. That's an inspiring thought.

Paul Jackson is chief executive of EngineeringUK

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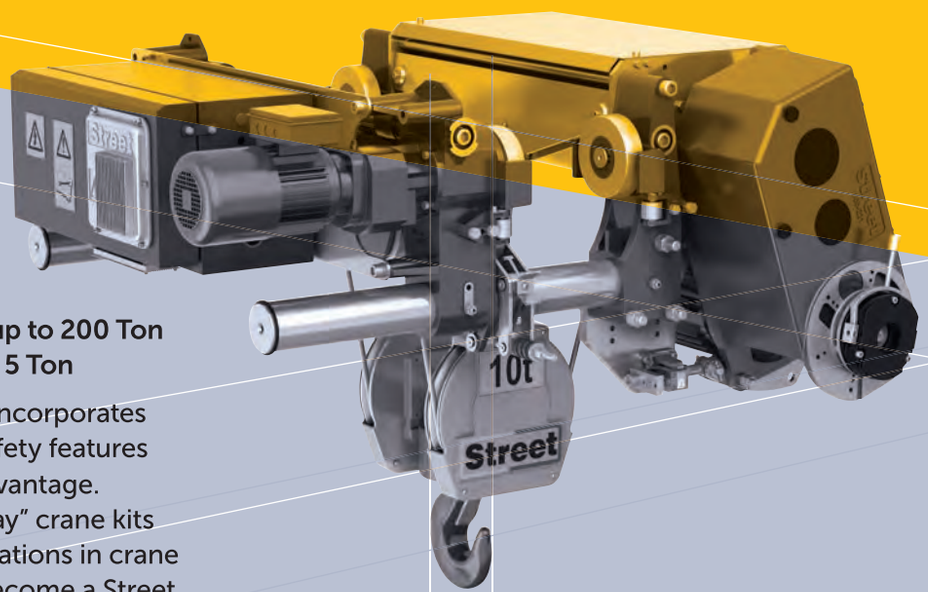

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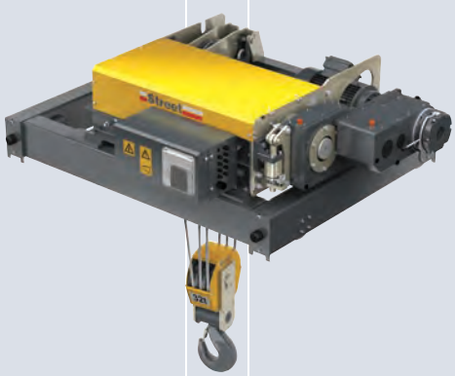

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Let there be light

The defence industry is working intensively on lighter body armour. Helen Knight reports

Have you ever complained at having to walk to work in summer in a suit and tie, carrying a moderately heavy bag with your laptop and a few files?

Imagine what life is like for a soldier, marching for hours on end through desert in countries such as Iraq, in blistering temperatures of 60˚C or higher.

Just to keep moving in this heat must be almost unbearable, but you also have to carry equipment such as a heavy weapon and ammunition, a radio and batteries, and your water.

To make matters even worse, you are wearing a heavy helmet and body armour designed to keep you safe from ballistic impact, which add even more weight to your load.

To reduce the burden on infantry soldiers, the Ministry of Defence recently announced it will be introducing a new body armour system, known as Virtus, to replace the existing Osprey system.

Virtus is designed with an even distribution of weight and reduced bulk, to make it easier for soldiers to carry. An integral spine, known as the dynamic weight distribution system, is linked to the wearer's waist belt and helps to spread the load across their back, shoulders and hips.

But perhaps most significantly, Virtus will be 4.7kg lighter than Osprey, and will become lighter still once new armour plates, which are in development, are introduced.

Modern armour consists of two layers, a hard strike face that disrupts the structure of the incoming armour-piercing bullet, and a backing layer that catches all of the high-velocity fragments created by the ballistic impact.

To reduce the weight of body armour and improve its performance, defence industries around the world are investing heavily in their efforts to develop better ceramic materials and production techniques.

One of the enduring problems with ceramic armour panels is that the boron carbide often used to produce them can be inconsistent, according to Colin Roberson, director of Advanced Defence Materials, based in Southam in Warwickshire.

Boron carbide is the third-hardest material available to man, with a relatively low density that is similar to window glass and about one-third that of steel. It is a strong crystalline substance that has no capacity to yield, so it cannot deform in front of a bullet, making it the perfect substance for producing armour.

However, the material does not always live up to these expectations, and under very-high-intensity ballistic impact the crystals can cleave at far lower energy levels than expected.

"The problem with boron carbide is that it is essentially carbon substituted into the boron lattice, so it can have a range of compositions between 13.5 and 21 per cent carbon content," Roberson said. "Several crystal arrangements occur within a grain of boron carbide, including one arrangement that contains a graphite-like plane."

If the boron carbide is subjected to forces above a certain ballistic threshold, it can break up prematurely along this graphite-like plane, he said.

These problems often mean that engineers have to "over-design" the armour, making it heavier than would otherwise be necessary, in order to compensate. "So there is a real interest in both the UK and US in making better boron carbide," said Roberson. "And the community has come to the view that the way forward is to modify the material, in order to produce the lightest possible armour."

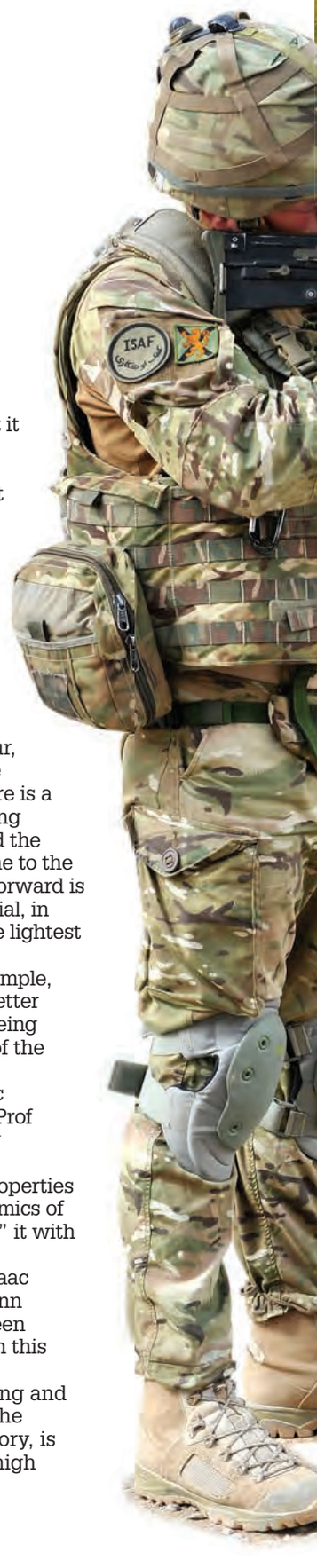
> **"The community has come to the view that the way forward is to modify the material to produce the lightest armour**

In the US, for example, efforts to develop better boron carbide are being carried out as part of the Army Research Laboratory's Materials in Extreme Dynamic Environments (MEDE) programme, led by Prof Kaliat Ramesh at Johns Hopkins University in Baltimore.

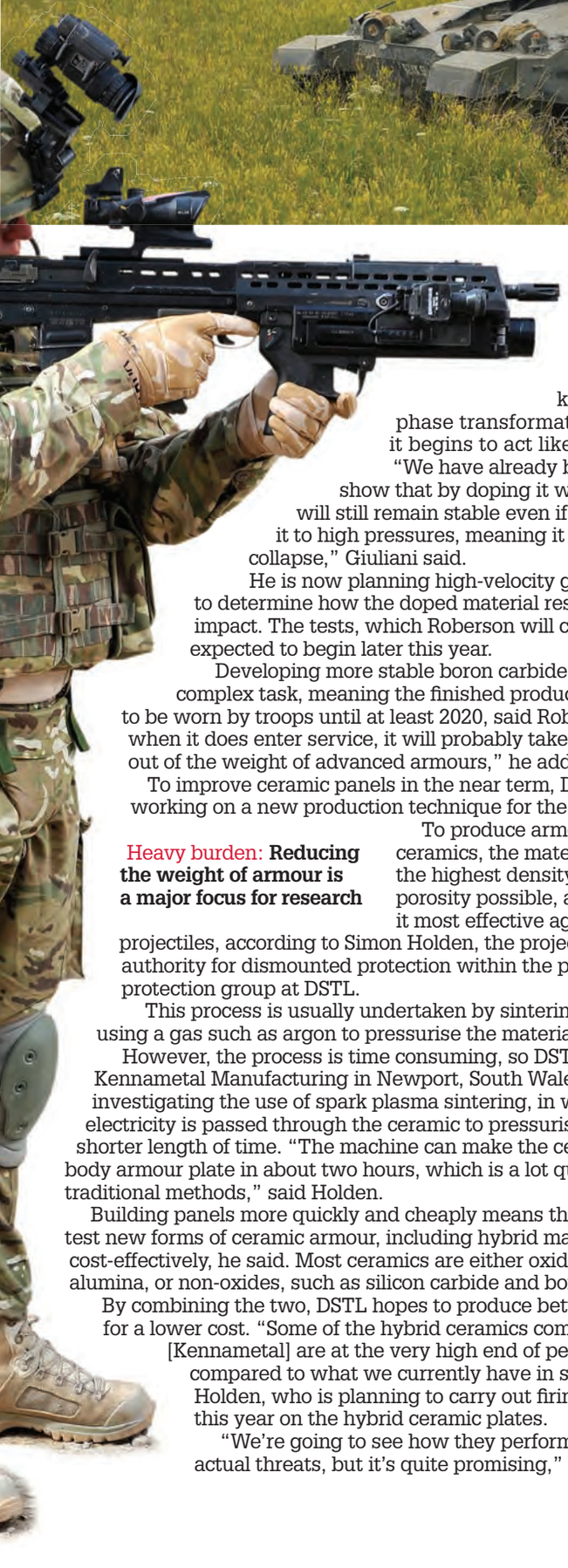
One option for improving the ballistic properties of boron carbide is to alter the thermodynamics of the crystal structure by adding, or "doping" it with silicon, Roberson said.

In the UK, a collaboration between Dr Isaac Chang at Birmingham University and Dr Finn Giuliani at Imperial College London, has been investigating the effects of adding silicon in this way to alter the chemistry of the material.

The research, funded by the Engineering and Physical Sciences Research Council and the Defence Science and Technology Laboratory, is aiming to prevent the material failing at high



Heavy metal: **The weight of armour used to protect vehicles has been steadily increasing**



pressure or impact, and undergoing what is known as a phase transformation, in which it begins to act like a liquid.

"We have already been able to show that by doping it with silicon it will still remain stable even if we compress it to high pressures, meaning it doesn't collapse," Giuliani said.

He is now planning high-velocity gas gun tests to determine how the doped material responds under impact. The tests, which Roberson will carry out, are expected to begin later this year.

Developing more stable boron carbide armour is a complex task, meaning the finished product is not likely to be worn by troops until at least 2020, said Roberson. "But when it does enter service, it will probably take 10 per cent out of the weight of advanced armours," he added.

To improve ceramic panels in the near term, DSTL is working on a new production technique for the material.

Heavy burden: **Reducing the weight of armour is a major focus for research**

To produce armour from ceramics, the material must have the highest density or lowest porosity possible, as this makes it most effective against projectiles, according to Simon Holden, the project technical authority for dismounted protection within the physical protection group at DSTL.

This process is usually undertaken by sintering in a kiln, using a gas such as argon to pressurise the material.

However, the process is time consuming, so DSTL and Kennametal Manufacturing in Newport, South Wales, have been investigating the use of spark plasma sintering, in which electricity is passed through the ceramic to pressurise it in a much shorter length of time. "The machine can make the ceramic for a body armour plate in about two hours, which is a lot quicker than traditional methods," said Holden.

Building panels more quickly and cheaply means the team can test new forms of ceramic armour, including hybrid materials, more cost-effectively, he said. Most ceramics are either oxides, such as alumina, or non-oxides, such as silicon carbide and boron carbide. By combining the two, DSTL hopes to produce better ceramics for a lower cost. "Some of the hybrid ceramics coming out of [Kennametal] are at the very high end of performance, compared to what we currently have in service," said Holden, who is planning to carry out firing tests later this year on the hybrid ceramic plates.

"We're going to see how they perform against actual threats, but it's quite promising," he said.

The industry is also attempting to develop better and more lightweight backing materials to absorb the energy of fragments.

The lightest backing layers consist of high modulus fibre composite – a laminated textile pressed into a hard laminate with a small amount of plastic binder.

In the past, this has been based on aramid composites such as Kevlar, but over the past 20 years this has gradually been displaced by Ultra High Molecular Weight Polyethylene (UHMWPE) fibre composite laminates, said Roberson.

The fibre is produced using a process known as gel spinning, in which the fibre is forced through a spinneret in a semi-molten gel form and then stretched. This process results in polymer chains that remain tightly bound together and are highly orientated, creating fibres with very high tensile strength.

"It is the only fibre that has the theoretical specific strength to span the distance from Earth to the moon," said Roberson.

The fibres are laid up in unidirectional layers and pressed, then alternately cross plied, to create a composite backing, which, when combined with a ceramic front, produces armour with the lowest weight and maximum bullet stopping power.

However, the level of orientation achieved by the gel spinning process to date means that we can only harvest 10 per cent of the potential of UHMWPE fibre, said Roberson. Further improvements in the backing layers could be made by improving the UHMWPE fibres and better laminate structures, he said.

Aluminium infiltration

Another range of materials for use in armour that Roberson has investigated, with funding from DSTL, are known as Interpenetrating Composites (IPCs). These consist of ceramic foams infiltrated with molten aluminium.

The resulting composites have a mixture of ceramic and metal properties, which can be varied depending on the application, by altering the composition and density of the foams, or infiltrating different metal alloys. The composites are lightweight and can be manufactured into a range of shapes.

Adding the composites as the interface at the back of the ceramic within a composite body armour plate could help to improve performance by diffusing the tensile forces in the ceramic caused by overlapping stress waves following an impact. When armour is hit, it creates a compressive wave that travels through the ceramic, causing it to ring like a tapped wine glass, said Roberson.

But if the wave then hits a medium with a lower impedance – or ability to withstand the motion caused by the force – it changes from a compressive to a tensile wave. The returning tensile waves form at the outside surfaces of the ceramic tile then overlap, causing the material to fail.

The longer the ceramic material survives without failure during a ballistic impact, the more effective it will be in destroying the incoming armour-piercing bullet and protecting the soldier, he said.

Replacing conventional adhesive with an IPC, which has a higher impedance value than composites such as UHMWPE, could help to prevent such failures, Roberson added.

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> **"We have been looking for some time at trying to lighten vehicles without degrading the protection**
> Prof Steve Burnage

Adding additional functions to the armour tiles could also help to reduce the weight burden on soldiers, by reducing the need to carry separate devices.

To this end, DSTL has designed a concept body armour vest made up of a mosaic of ceramic composite tiles that also act as antennas.

The tiles, which are fitted together in an array to form flexible rifle protection plates, would prevent soldiers having to carry both body armour and antennas for communication.

The technology would also create a more robust communication system, since transmission could be switched to a different antennae in the case of one tile receiving damage.

A group of the tiles could be activated at the same time to form a single, larger antenna. This would make it possible to switch the polarisation of the device depending on the position of the soldier – whether they are standing up or lying down, for example – to improve the communications link.

Explosive search

The antennae could also form a so-called active electronically steerable array, such as those used in aircraft radar systems, allowing them to be used for search applications such as detecting nearby improvised explosive devices.

Similarly, the organisation has designed a helmet to reduce the burden on soldiers – in this case from heat, while also acting as a sensor.

Most military helmets are made of metal or polymer composite matrix materials, which tend to trap heat inside rather than allowing it to evaporate away from the scalp.

This can be a significant problem, since evaporative cooling is the only method humans have of losing heat, once their bodies reach a certain core temperature.

So DSTL has designed the concept helmet with openable vents within its structure to allow air to flow through it and allow heat to escape from the soldier's head.

If the soldier comes under attack, however, the vents can be closed automatically, Holden said. "Each one of the vents has a solid-state actuator on it, so that if the soldier comes under fire, you can close it, and it becomes a conventional helmet," he added.

The actuators could be built from piezoelectric crystals.

"If you use piezoelectric crystals as the solid-state actuators, then the incoming boom from the rounds would activate the crystals [automatically]," Holden said.

In this way they would also act as an array of microphones, he said. "So they could also tell you where the round came from."

What's more, since the vent covers are designed to hinge outwards from the helmet, they could still provide protection from projectiles coming from in front of the soldier, even when open.

It is not just in body armour and protection that weight savings are needed, however. The weight of armour used to protect vehicles from ballistic impact has also been steadily increasing, according to Prof Steve Burnage, Lockheed Martin fellow, who is based at the company's site in Ampthill, Bedfordshire.

This makes it particularly difficult when fighting vehicles need to be transported by air, for example, for use in rapid reaction forces, he said. "We have been looking for some time at trying to lighten the vehicles as best we can, without degrading the level of protection that is needed, not only to protect the troops, but also the mission that they are on," Burnage added.

In 2012, for example, the company announced it had developed a method to improve the way ceramic armour tiles stick to their backing material or other objects. "The tiles are notoriously poor at sticking to other objects, particularly supporting steel frames and other metalwork, and under more than one round you tend to have the tiles falling off due to shockwave propagation," he said.

The process, developed with researchers at the University of Surrey, involves treating the adhesive and 'activating' the ceramic surface before bonding by exposing the tiles to a high-energy laser.

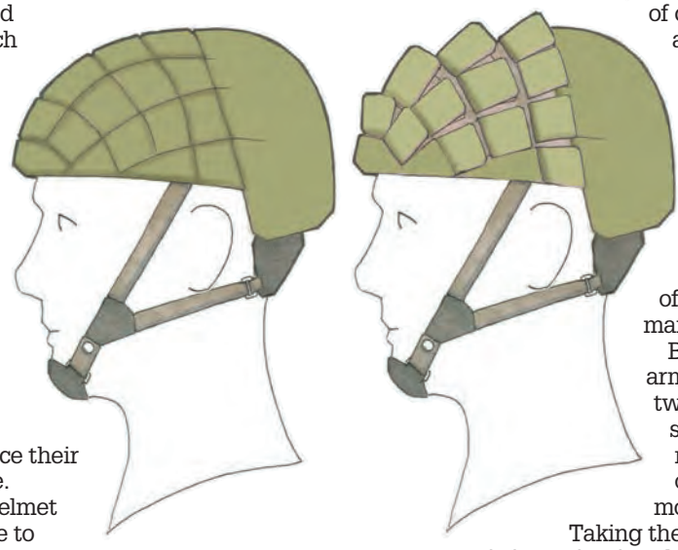
"The tiles have since been tested under fire at the Ministry of Defence's COTEC firing range, and been shown to work very well," said Burnage. "So we are moving the process on a pace, and looking to fabricate these composite ceramic armour panels for use."

The company is also investigating the use of additive manufacturing to grow sections of metal armour. Using a process known as wire arc welding, the company deposits steel layer-by-layer to form the piece of armour.

This allows it to grow even complex shapes, which would be extremely difficult to produce from flat panels of steel without degrading the mechanical properties of the armour, said Burnage.

When the team took its prototype plates to the MoD's COTEC firing range for testing, under the sponsorship of DSTL, it found that they had 98 per cent of the impact resistance of conventional rolled homogeneous armour – or armour hot rolled from a single steel billet.

"I think we are quite confident in saying that we can now replace any cast armour, even complex corners of shapes, by the use of this additive manufacturing technique," he said.



Top hat: **DSTL's concept helmet features ventilation flaps that close in response to gunfire**

By growing one single corner piece of armour rather than having to intersect two sections together, the technique should help to reduce the amount of material needed and therefore its overall weight. It should also be much more resistant to impact, said Burnage.

Taking the process a step further, the company is investigating the possibility of growing steel armour around ceramic panels, to create a sandwich system.

"We would get the benefit of the hardness and lightness of the ceramic, and the toughness, support and resilience of the additive layers," he said.

Some vehicle armour panels can be up to 50mm thick, said Burnage. "So if we could replace 50 per cent with a lighter-weight ceramic and then just have thinner skin panels on the outside to support them, we would have a considerable weight saving."

Ultimately, developing lighter, more durable armour systems should allow troops and vehicles to move around more easily and quickly, while keeping them safe from bullets and explosive devices.

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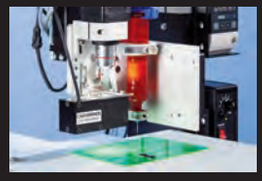

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Sea change

The Royal Navy's new Type 26 frigates will build on the legacy of its Type 23 forerunners. Jason Ford reports

Royal Navy frigates are designed to fight wars but more normally fulfil peacetime roles that involve policing the seas and helping with the provision of humanitarian relief.

A notable example of the frigate's utility can be found in HMS *Argyll*, the oldest of the Royal Navy's Type 23 frigates.

Commissioned in 1991, *Argyll* notched up notable successes in October 2014 when her crew helped in a four-day clean-up of Bermuda following Hurricane Gonzalo, an act followed swiftly by the seizure of cocaine valued at £10m from a yacht in the Caribbean.

Before landing back in Plymouth on 18 December, *Argyll* and her crew thwarted more drug smugglers during a night-time operation that saw the ship hit full throttle to make up 70 nautical miles in pursuit of a small, highly manoeuvrable boat carrying £36m of cocaine by the time it was intercepted.

The Type 23 is assisted in her quest by the multiple systems and personnel embarked upon her to fulfil her remit, including Lynx helicopters and crew, detachments of Royal Marines, and small patrol boats that together help – in these particular instances – to prevent profit from the sale of controlled substances.

Furthermore, a new addition to the Royal Navy's reconnaissance team recently saw Type 23 HMS *Richmond* deploy a ScanEagle unmanned aircraft to help in the seizure of heroin in the Indian Ocean.

One facet that links the achievements of *Argyll* and *Richmond* is the demonstration of a frigate's requirement to work alone or as part of a larger group and the Type 23 replacement, the Type 26, will be no different in that respect.

Geoff Searle, Type 26 programme director at BAE Systems explained that while the tasks required of the Type 26 won't change, her ability to so will be greatly enhanced, a point of concurrence with Rear Admiral Alex Burton, RN – Type 26 Programme.

Above: **The Royal Navy's Type 26 frigate is expected to enter service in 2022**

"The T26 GCS [Global Combat Ship] design is inherently flexible, allowing greater choice in operational tasking through the incorporation of modular systems," said Burton. "These include the flexible strike silo – able to host anti-submarine, anti-ship and, if required, land attack strike missiles – and the modular mission bay, as well as increased accommodation to support additional mission teams from specialist ASW teams to communications and mine counter-measure specialists."

Searle added: "If you look at the Type 23s, they do fantastic work all around the world in a wide range of roles, but fundamentally they were designed as Cold War submarine hunters and over their lifetime their role has changed significantly… they have been used in a wide variety of different roles and military tasks that they originally weren't designed for."

"If you look at the Type 23s… they have been used in a wide variety of roles that they originally weren't designed for

The Type 26s will still maintain the role of specialist anti-submarine warfare (ASW) frigate to provide anti-submarine protection to Carrier Task Groups and other Task Groups and key ASW features will include bow sonar, an ASW Merlin helicopter equipped with its own sonars and torpedoes, and the Thales Sonar 2087 system aft of the ship.

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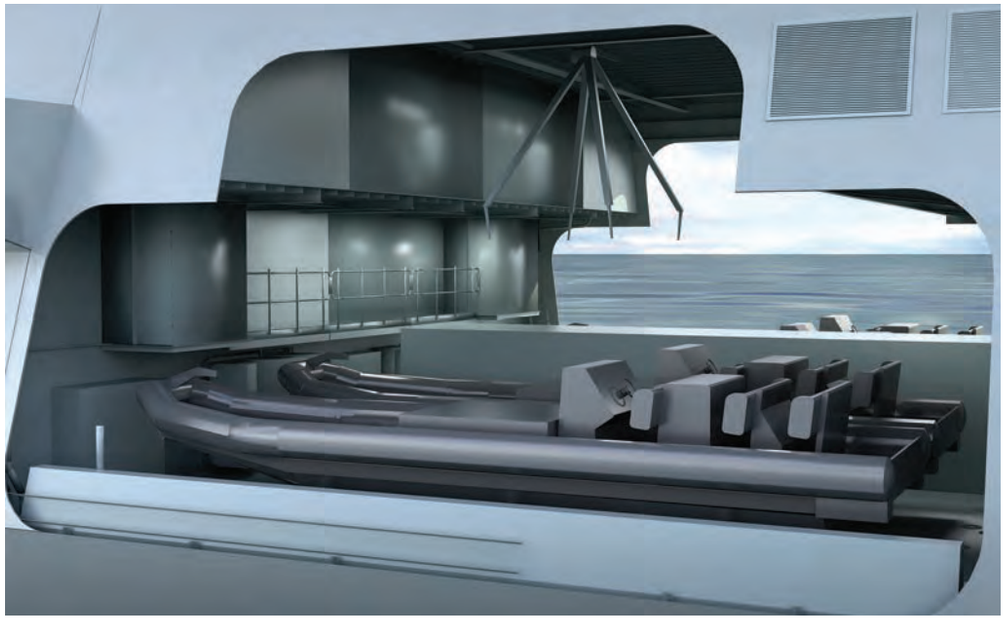
"Since its introduction into service with the Royal Navy in 2005, Sonar 2087 has been the mainstay of the Royal Navy's Surface Ship ASW capability on Type 23 frigates," said Burton. "It therefore represents an optimal choice for the Type 26 due to its proven high levels of both active and passive performance, the low risk of integrating it into Type 26 and a well-defined product development roadmap, making it viable for the Type 26's role for the foreseeable future."

Add multi-helicopter capability – the new ship will be able to embark a Chinook – plus the new mission bay and the Type 26 presents the Royal Navy with a multi-role, multi-mission frigate that will serve into the 2060s and be adaptable enough to react to threats and challenges that emerge in that timespan.

"I think [a] step change with the 26 is the dedicated facilities to support that wide range of future payloads, whether it is unmanned aerial vehicles (UAVs), unmanned underwater vehicles (UUVs), Offboard Mine Countermeasure systems, or large boats for maritime security – so it can take up to 12m ribs rather than the standard PAC 24s or PAC 28s – with the facilities to properly handle it, [then] properly maintain and service those different payloads," said Searle. "As an example, when they embarked ScanEagle on *Argyll*, there were months of work to prepare to embark it, then safely launch and recover it. A Type 26 would inherently have the ability to embark unmanned vehicles with effectively 24 hours' notice to re-role."



Above and right: **Alternate views of the frigate's mission bay, which has been designed to support a range of payloads**

Burton added that a 'tailored-mission' approach to operations would allow both equipment and crew to be reconfigured to meet rapidly changing operational requirements.

"The idea is that a mission load [including containerised cargo including field hospitals, modular accommodation, or disaster-relief stores] can be flown out to wherever the ship is, embarked within 24 hours and then be off and undertaking that task, and that is a capability the 23s just don't have because they were never designed to do it," said Searle.

In August 2015 BAE Systems announced a major milestone in the Type 26 programme with the award of seven manufacturing contracts for the first three ships, including Babcock for the ship's air weapons handling system, GE Power Conversion for the electric propulsion motor and drive system, plus testing facility, and Rolls-Royce for the supply of MT30 gas turbine (GT) packages.

"The design for the Type 26 GCS is a CODLOG [Combined Diesel Electric or Gas] Propulsion System providing electric motor drive for cruise speed – and ASW stealth – and utilising the gas turbine for sprint," said Burton.

Richard Partridge, chief of naval systems at Rolls-Royce, added that although GT/hybrid arrangements will normally conduct low-speed/transit and ASW operations on the electric drive and high-speed operation on the 'boost' gas turbine, the GT can also support operations at ship speeds below normal electric drive/gas turbine threshold speed, when required by the operational scenario.

Numerous systems on board the Type 26 have been designed to reduce the acoustic signature of the ship, whose electric drive system – powered by the diesel generating sets from Rolls-Royce Power Systems – provide the ultra-low-noise machinery state required to successfully conduct ASW operations.

"That said, the MT30 GT is housed in an acoustic enclosure designed to ensure low levels of airborne noise in the machinery space even at high ship speed/GT operation, which contributes to providing an acceptable ship-noise signature across every operating mode, and, of course, provides acceptable levels of crew habitability," Partridge said.

While designed to give the Type 26 its sprinting legs, the MT30 also provides the MoD with value for money as it is designed to maintain its rating throughout the life of the ship, regardless of the weight she might gain following refits. This, said Partridge, has a lot to do with the MT30s evolution from the large-core Trent 800 aero engine.

"The MT30 has been conservatively rated at a nominal 36MW, with up to 40MW available on a project-by-project basis as required, which even at the enhanced rating still ensures generous thermal margins and allows a unique rating philosophy with retention of the rated engine power throughout engine life/in-service, despite the inevitable wear and tear on engine seals and so on through-life," he said.

It looks very likely that the MoD will order 13 Type 26 Frigates for the Royal Navy and talk has turned to exporting the platform.

"We're at the early stages of responding to the procurement process of Canada and Germany for future surface combatants," said Searle. "It's no secret that there's interest from potentially Australia and its Sea 5000 future surface combatant."

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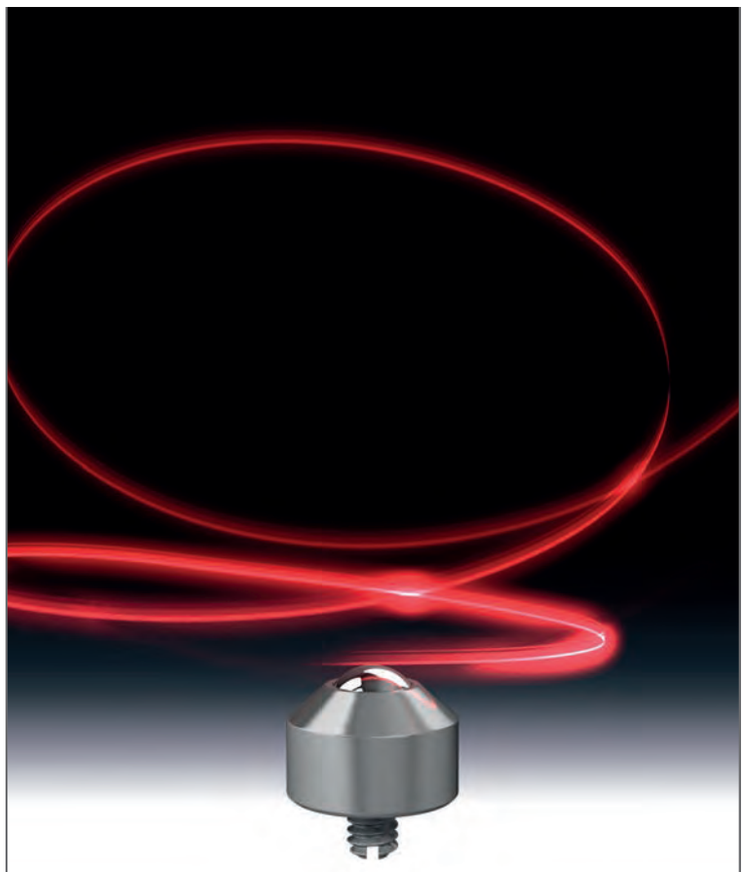

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Centre stage

Tony Pixton

Chief executive, Advanced Propulsion Centre

Education
1976 MEng in Automotive Engineering and Design
1985 Completed graduate course in Automotive Manufacturing Programme at INSEAD in Fontainebleau, France

Career
1999–2003 Director at Ford Motor Company, leading an international team developing a medium four-wheel drive platform
2003–2006 Platform director at Volvo, leading a team to deliver a large four-wheel drive platform
2006–2009 Executive director at Ford, leading integration of global product development activities and advising chairman
2009–2012 Representative director and senior managing executive officer, Mazda Motor Corp
2012–2013 founded and operated own consultancy
2014–2015 appointed chief executive for launch of Advanced Propulsion Centre
2015 Remains on APC board when he is succeeded by Ian Constance as chief executive

The Advanced Propulsion Centre's outgoing CEO discusses how the APC is helping new technology bridge the 'valley of death'. Stuart Nathan reports

The Advanced Propulsion Centre (APC) is housed in one of the many smartly modern buildings on Warwick University's campus, next to (but not physically or organisationally attached to) the bulky grey oblong of Warwick Manufacturing Group, and a small vegetation-packed pond patrolled by ill-tempered geese. Within, the bulk of the ground floor is taken up by a showcase centre, opened two months ago, which sets out on movable fabric panels the goals and procedures of the APC, punctuated by exhibition-style stands housing examples of technologies the centre has helped develop.

Tony Pixton, who has led the opening and establishment of the APC over the past 18 months and will shortly step down as chief executive while remaining on the board, is a hugely experienced figure at the high levels of the automotive sector and a knowledgable engineer in his own right. The roots of the centre, he explained, showing me around the exhibition space, go back to the efforts of the Labour government, headed by then-business secretary Peter Mandelson, to bolster the automotive sector, which then had several large companies with facilities here but a hollowed-out supply chain, a legacy of industrial decline in the 1970s and 1980s. The idea, said Pixton, was to develop technology areas where the UK had a lot of potential, both in terms of expertise and in market growth, and use that to help businesses become more established and also attract the large multinational players to choose the UK as the location for their R&D and technology development.

"The National Automotive Innovation Growth Team did a study that looked at the future of the UK automotive industry in 2009," Pixton explained. "That resulted in a report whose key recommendations included the formation of the Automotive Council to bring government and industry together." One of the first results of this were a set of industry roadmaps, including a whole suite of them that addressed the area of vehicle propulsion: not just the traditional internal combustion engine (ICE) powertrain but taking in the development of electric and hybrid systems as well. "This identified strategic technologies that the UK could potentially lead the world in, because of the strengths of the research base here and the background in manufacturing."

The UK's strengths in many of these areas was already apparent. "For energy storage, lithium batteries were invented in Oxford and they are still very strong there in battery chemistry. We have numerous well-established centres of excellence in ICE; Nottingham University is one of the world centres for power electronics; and in lightweighting, carbon fibre was pioneered in the UK thanks to our capabilities in motorsport: McLaren built the first carbon-fibre Formula One chassis."

Developing these areas was, and is, seen as a way of anchoring capability in the UK. "Clearly that's good for the economy, but the Automotive Council saw this as a matter of competitive edge," Pixton said. "Global players, even the ones that are based in the UK such as Jaguar Land Rover, can put their R&D wherever it makes sense to do it, and they can put their manufacturing wherever they want to as well. The best way to make sure they come here is to have that technical capability; that's even more important than financial incentives — although they play their part too."

Hence the formation of the APC in 2014, acting as a hub for work in the four technical areas mentioned above. The main goal of the centre is to work with companies developing propulsion-linked technologies and help them to

Hybrid: **GKN and Williams' Gyro-drive flywheel technology**

bridge the dreaded 'valley of death' between developing a prototype and making this into a product they can manufacture in the numbers that the automotive industry needs from their suppliers – tens or hundreds of thousands per year, under tight cost control and meeting stringent quality standards. "We provide support for companies who maybe had a project funded by InnovateUK but need to go from a one- or two-off prototype to a production-ready product. InnovateUK does a fantastic job but only supports development of concepts from research bench to prototype," Pixton explained. "In terms of manufacturing, we go from a state where you have a basic feasibilty study of materials and the manufacturability, but you don't have a process. We go up to having a production-line design worked out and ready to put in a pilot line to build pre-production samples."

Often, the companies APC works with are SMEs or university spin-outs, but not always. "Sometimes, it's surprisingly large companies who developed technology so new they haven't been able to develop a compelling enough business case to push it through the development process internally. We've been able to provide assistance with structuring the project with a consortium of companies then provide funding through the government to bridge the gap."

One way this is done is through competitions. "We run competitions twice a year, we have £1bn to spend on them over 10 years, half from government in cash, half from industry in kind. We get applications that fit the technologies and are consistent with the roadmaps. So far we've funded 10 projects through three competitions, with a fourth one just closed and going through the independent assessment process. Those 10 projects have directed £174m-worth of investment in the UK, with maybe 4,500 jobs involved in those projects. We think 12 million tonnes of CO_2 will be saved by these 10 projects over a 10-year cycle. That's equivalent to taking 6,000 conventional cars off the road."

One example of such a project is the Gyro-drive flywheel energy recovery system, derived from the KERS flywheel system developed by Williams F1. The company worked with GKN, which subsequently bought the technology, to link the flywheel to energy storage, power electronics and a motor, allowing it to capture, store and release braking energy. It's particularly suited to the stop-start motion of buses, and, according to Pixton, can cut fuel consumption by some 25 per cent on most routes. "This was demonstrated by GKN and Williams as a system with potential for buses, but it didn't go any further until GKN applied for one of our project fundings, and we've supported its development into a retro- or OE-fit for buses. Alexander Dennis is part of the consortium. It shows how we're building links between motorsport and manufacturing. It builds prototypes, races them and scraps them; we turn them into products that can be manufactured."

Another way APC works is to develop SMEs, sometimes very small ones, into organisations equipped to run projects with big players. "We have a specific programme for small companies called the technology development accelerator programme [TeDAP]," Pixton explained. "We'e putting 10 SMEs through a three-stage programme to get their technologies to a prototype concept that can go into a larger project with a Tier One or OEM. It helps them understand their product and develop a business plan."

The alignment of competitions with the roadmaps is crucial. "We're trying to ensure our projects fill in these streams of activity," Pixton said. "The competitions are designed to ensure the right technologies are being worked on at the right time."

APC acts as an organisational hub, and is establishing 'spokes' in its various technology areas. These are intended to act as centres of excellence and coordinating points that companies can consult if they need expertise in that area for a project. So far, there are three: power electronics at Nottingham University; electrical energy storage at Warwick, and, due to open next March, digital engineering and test at Loughborough University's graduate study centre on the Olympic Park in London.

Summing up the APC's role, Pixton said: "Our role is to help rebuild the supply chain, and we focus on that in our projects. We insist that a UK-based SME is involved in every project. Even when multinationals are involved, the bulk of the work has to be in the UK to anchor the capability for the next project. That way, new projects can flow in, because the capability will be there. Is it having an effect on the supply base? Clearly it is. Is it good enough yet? Nowhere near. We have a long road to work on."

> **"We provide support for those who maybe had a project funded by InnovateUK but need to go to a production-ready product**

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Marcus Burton
Group managing director, Europe, Yamazaki Mazak

Alan Mucklow
Group product manager, Europe, Yamazaki Mazak

Andy Hodgson
Head of motion control, Siemens Digital Factory

Ben Taylor
Assistant chief executive, Renishaw Plc

Dr Graeme Philp
Chief executive, GAMBICA

Guy Mollart
President MTA/ managing director – Mollart Engineering

Getting to grips with Industry 4.0

Is the much-trumpeted Industry 4.0 just a new way of labelling things or a key factor in our industrial evolution? Stuart Nathan reports

Engineering is a discipline that thrives — indeed, depends completely — on precision. If you can't define your terms, then it's going to be very difficult to complete your task, or to communicate it to the team that is almost inevitably going to be working on it. So it was somewhat disconcerting to convene our recent roundtable discussion on Industry 4.0 in the salubrious surroundings of a book-lined room at London's Royal Institution and to find that none of the invited participants could agree on a definition of what Industry 4.0 actually is.

"Is it really anything?" asked editor Jon Excell. "Is it a definable concept or is it a group of technologies?"

It might be useful here to look at the Wikipedia definition of Industry 4.0, which says it's a collection of technologies and concepts for defining and operating 'Smart Factories', where the machinery of manufacturing – machine tools, the sensors monitoring them and suchlike – can communicate with each other, with the systems overseeing the factory and the people who work in it to fine-tune the manufacturing process and enable such things as product customisation, while increasing productivity and flexibility.

Originating with Bosch and generally seen as being a German-led trend (although it has other incarnations and names in other regions), it gets its name because it was seen as being a fourth Industrial Revolution.

As head of motion control at Siemens – one of the driving forces behind the concept – Andy Hodgson should be among the best placed to offer a definition, and, in a telling comment, he split the definition into two areas, one of which was Industry 4.0 as a commercial product. So is it just a way of labelling things as a marketing strategy, to sell it to manufacturers who may have no better understanding of it than anyone else?

No, Hodgson insisted. For him, Industry 4.0 represents a move of manufacturing away from the physical reality of factories and into the virtual world, "where you can configure change and move items thousands of times a second, and simulate things in a factory many times".

Attempting to clarify this statement, he added: "If you look at cars, for example, in the design process they used to be sculpted out of clay, and people could walk around it. Now you can see it from all angles on a computer, virtually sit in it, and virtually manufacture it. That allows you to make it quicker, cheaper and better, cutting the time to market and making the economy it's used in much more viable.'

So is it just simulation? Prof Ken Young helpfully broadened the definition out to the use of digital technologies to give a competitive advantage, "that can be in the

Rahman Jamal
Technical and marketing director, Europe, National Instruments

Prof Ken Young
Technology director, The Manufacturing Technology Centre (MTC)

Lee Hopley
Chief economist, EEF

Jon Excell
Editor, *The Engineer*

Stuart Nathan
Features editor, *The Engineer*

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design phase, in the manufacturing phase where you're monitoring what's happening better and using that to improve simulation models so you can make the next lot better".

Marcus Burton, European group managing director of roundtable sponsor Yamazaki Mazak was in the 'it isn't anything' camp. "There are lots of technologies, and I'd almost congratulate the Germans on coining the phrase that allows us to link the technologies in our minds," he said. "And these discrete technologies will link more as time goes on, communicating and merging with each other. That's why nobody can say what it is."

Yamazaki Mazak is in an unusual situation, said Burton. It's a producer of machine tools, the very devices that are expected to be among the main vehicles on Industry 4.0, communicating with each other and their owners' enterprise resource and planning (ERP) and manufacturing execution systems (MES) to optimise their output. But it's also a manufacturer in its own right and one that has frequently been a pioneer in new manufacturing processes, so can expect to be a beneficiary of Industry 4.0, as well as an enabler for its customers.

Ken Young's response about digital technologies prompted another question: is it a fourth Industrial Revolution at all? Our location at the Royal Institution gave a good context to look at the history of industrial revolutions. The first is generally accepted as starting in the mid-to-late 18th century with the introduction of steam power, the advent of mechanised production and the beginning of the shift from economies – in Europe and the US at least – from an agrarian basis to what we'd now recognise as industrialised. The second revolution, sometimes called the 'technological revolution', started with the introduction of the Bessemer Process for making steel in bulk in around 1840 and ran until the early 20th century, and was characterised by the replacement of steam power with electricity, and the accompanying changes on the landscape, lifestyles and the economy which that enabled. And the third revolution, sometimes called the 'digital revolution', was brought about in the wake of the Second World War by the invention of the transistor, leading to the evolution of microprocessors and the increasing capability and availability of computers. Some people think we are still in the third revolution. So, going by Young's argument, isn't Industry 4.0 just a further development of digital technologies?

National Instruments' Rahman Jamal offered some useful clarification. Educated and now working in Germany he said that 25 years ago computer-integrated manufacturing, generally abbreviated to CIM, was the buzz-word, and that was supposed to usher in an age of connected machines. "But it never really took off, because we didn't have the internet,' he remembered. "We ended up with a collection of protocols and fieldbuses, but the idea of the factory of the future started there, and Industry 4.0 is a good way of packaging and focusing on the technologies that enable it." ->

Ken Young agreed that the internet was an important factor and perhaps the key to seeing Industry 4.0 as a revolution. "If we agree that the internet is revolutionary in the way we live our lives, then I suspect we'll find that what's happening in manufacturing is going to be a revolution," he said. "Objects, machines, parts of the automation and software around businesses are going to be joined up whether you want them to be or not. Not because you've bought an integration package but because they just are joined up as part of their nature, in the same way that the internet links things together."

The idea of linked technologies proved to be a more useful one than focusing purely on the virtual world. That brought in another concept vital to the understanding of Industry 4.0: data.

> **"Objects and software around businesses are going to be joined up whether you want them to be or not**
> Prof Ken Young

"Data really is at the crux of it," said Andy Hodgson. "We all run these very powerful ERP systems but we only use 5 per cent of all the data they generate. The idea of the factory of the future is to get closer to real-time data so you're using live information dynamically to be able to inject into a machine tool – or indeed a customer build programme – what we're trying to achieve in a way that's more reactive to the needs of the business."

And this isn't just about what happens in the factory, he stressed. Gathering data after-market – that is, when the products have actually been sold and are in use – is just as important, because it helps both to fine-tune products, making changes to make them run more smoothly and perhaps avoid problems encountered by early users by feeding into subsequent redesigns. Injecting a metaphor into the conversation, Hodgson spoke of weaving the data into a "tapestry of information you can use to modify and enhance your processes, change demand cycles to meet what the end customer wants".

Renishaw's Ben Taylor was particularly keen to talk about data. "If you use a dataset to optimise your manufacturing process, you might want to decide which machine has the accuracy capabilities to make the parts that [you are] going to make this morning," he said. Where that data comes from can be crucial, and what distinguishes Industry 4.0 is that previously the main origin for such data would have been the machine's manufacturer, in terms of its nameplate capacity and what it was supposed to be able to do when it was purchased. But that doesn't take into account variations caused by things such as the cumulative effects of tolerances and any adaptations that have been made. "Sometimes the data doesn't come from the machine manufacturer; it's what we now understand it can do," Taylor said. "I find you have to make sure you have credible data to make all the decisions."

This sort of data gathering can be crucial in making decisions on factory maintenance and operation, Taylor added. "What used to happen was that you'd design something, such as a chemical plant or refinery, then just build it. But the engineers know that decisions were made during the building that deviated from the plans. So now they go back and scan what they've built, so they have the actual data set to be used in the future for maintenance work. In the past they couldn't do that, they only had the drawings, and you ran into problems because what had been built didn't match the drawings. So the data is used to build it originally but then you have to get the actual data of what was built." This, Taylor admitted, was more to do with digitisation of technology (perhaps a manifestation of the third revolution) than Industry 4.0.

4.0 in action

Moderator Jon Excell asked for some examples of where Industry 4.0 technologies were in use to bring the conversation back on track, and Rahman Jamal offered up a system that National Instruments had worked on at Airbus for maintaining aircraft. This is highly complex, he explained: individual subsystems on an aircraft can have hundreds of thousands of properties that have to be checked by operators. Working with Bosch and NI, Airbus developed a 'smart tooling' system, where the tools used by the maintenance engineers themselves have processing power built-in that connect to the analytics behind the maintenance systems.

"This improves the effectiveness of the operator and shows how intelligence, analytics and big data can help," he said. This could, for example, include the tool understanding what task the maintenance engineer is performing and configuring itself to adjust to the proper settings – in the case of a wrench, this might be the torque needed for bolt-tightening. The tool then acts as a datalogger, recording the adjustments made during maintenance on the management system.

GAMBICA chief executive Graeme Philp spoke about a similar system in use on BMW's MINI production line, which uses technology from Ubisense (see feature, p44) to track the positions of people or items inside a factory — a kind of indoor GPS. The position of a car on a production line corresponds exactly to the operations being carried out on it, so the process management system knows what has to

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happen at each location to move the process to the next stage. "So the system adjusts automatically, for example, the torsion setting on the torque wrench to put the wheels on," he said. "The operator doesn't have to scan a bar code to find the right setting, it's done automatically. Previously, they'd quite often forget to do this, so the tool would stay on the setting for the previous car on the line, which might be a different model."

Siemens' Andy Hodgson noted how virtuality is helping his customers. "We've installed a 3D 'cave' at Congleton," he said, "so products can be designed virtually, the customers can come and see them virtually, the work desk to manufacturing can be set up virtually, so the desk and the operations can be done with complete lifecycle management from customer design and development to manufacturing can be virtually realised before anybody's walked onto a shopfloor and screwed anything together." The advantages are tangible, he insisted, with time to market from concept to actual sale cut by 25 per cent.

The panel also discussed how new production technologies will make heavy use of Industry 4.0 technologies. For instance, Ben Taylor said that additive manufacturing will bring the process of design closer to manufacturing. Ken Young agreed: "You have to print a different shape so that it turns out the right shape with all the distortion that takes place during the process. You need to understand the process and your design software has to have that built-in so that you make what you actually need. It comes back to your virtual world; it's continuously updating simulation models as you learn by actually doing things that what you thought was right, isn't right."

Dinosaurs to mammals

Young underlined how important the ability to change processes will be by likening Industry 4.0 to Formula One racing. "You learn what went wrong in practice one, put it right for practice two and keep going. And if at any point you stop, the competition comes past you. This is going to be dinosaurs to mammals: companies without these capabilities will see their competition go past them, they won't be able to adapt to keep up and they're going to be dead."

It's data and how it's used that makes the difference here, Young stressed. "The cars are going around the track with thousands of sensors and every time it goes past the pit wall they download a load of data, and the race engineers tell the driver how to drive in response to that data. That's what we've got to do to our factories, we need to have that pit wall somewhere to make sure that your machinery, your systems are working better than the next guy's."

This mention of competition brought the roundtable to an important point: what Industry 4.0 can do for the UK; and, in particular, whether it was larger businesses that could expect to see the biggest benefits or whether small and medium-sized enterprises (SMEs) should look for its advantages as well. Ben Taylor commented that experimentation with new technologies is risky, and many SMEs simply can't take the risk of investing money in a system which doesn't improve profits. "In the UK we have to have manufacturing be successful rather than try things out and fail," he said. Ken Young pointed out that

> **"In the UK we have to have manufacturing be successful rather than try things and fail**
> Ben Taylor

the Catapult Centres, established by the previous government are intended in part to derisk technologies and prove to potential users that they can invest without wasting money.

Alan Mucklow, European product manager for Yamazaki Mazak, added that one of the key advantages of Industry 4.0 is that its ability to help customise products for specific markets makes it less compelling for businesses to consolidate manufacturing in a single factory that might be remote from their markets, and will enable manufacturers to use localised production to get their products onto the market fast.

More local production not only cuts shipping costs – and therefore also the carbon cost of the business – but also means that big enough markets (and the UK is certainly big enough) can have their own production, even if staff costs are higher. "That strengthens the supply chain," said Mucklow, "which has been hollowed out in the UK, and that in turn helps SMEs. We start with a blank sheet of paper, rather than Germany, which has a whole Industry 3.0 infrastructure it has to dismantle."

The EEF's chief economist Lee Hopley pointed out that SMEs are often more able to respond to new technologies than larger ones. "Many might be better equipped to be nimble and flexible, and be able to attract the finance and investment to move into this sphere than companies with a cumbersome culture that needs to change," she said.

UK strategy

But SMEs also have difficulties, as Guy Mollart, who combines his role as head of the Manufacturing Technology Association with the chairmanship of drilling machinery specialists Mollart Engineering, explained. Being a smaller company can make securing funding for research projects difficult, he said. While Germany spent more than €200bn two years ago on setting up technology clusters to address the issue of implementing Industry 4.0, that drive has not been seen in the UK. "My problem and frustration, coming from an SME mindset, is that we have lots of things we want to do," he said, "but because my name isn't Rolls-Royce or Siemens I have no chance of getting the funding. There's no industrial strategy in the UK to kick that off."

Lee Hopley commented that it seemed that Industry 4.0 might change where value was created in the manufacturing sector. "It seems that the process of making things will be less important than the other bits of the value chain,' she said. That's important for how we see manufacturing, because the value is in design and data gathering, and being responsive and developing new business models. From that perspective it's really important to see that this is something we can take a lead on, because we already have challenges for the skills pipeline; this might be an opportunity to develop a new set of skills."

Andy Hodgson thought that this view risked repeating some major mistakes that had damaged UK industry. "The old idea that we can do the clever stuff around manufacturing was a complete sham that, unfortunately, a lot of politicians bought into," he said. "If you can reverse that and say manufacturing is part of the modern world and supports our design and high-added-value efforts, it's fundamental to the economic success of the future."

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Aerial revolution

‘Drones’ look set to become a valuable inspection tool for a range of applications. Andrew Wade reports

EasyJet is exploring the potential of drone inspection

Remotely operated aerial vehicles (ROAVs) – often referred to simply as ‘drones’ – have been in the news recently for all the wrong reasons. One week, a drone is spotted 50ft from a passenger jet landing at Heathrow; the next, some misguided teenager has armed one with a handgun. But while the emergence of ROAVs is undoubtedly raising issues that need to be addressed, there are also major benefits to be gained from this aerial revolution.

Buoyed initially by the media sector, commercial drone use has been on the rise since ROAVs became readily available. More recently, however, the commercial market has expanded to include more inspection and survey work, with energy, defence and transport all embracing the technology. Just a few months ago, EasyJet revealed details on its plans to use drones to inspect aircraft following lightning strikes. According to project manager Mark Bunting, the technology could speed up the inspection process.

“Today the lightning-strike inspections take several hours and it can take longer to identify the limits within the aircraft maintenance manuals,” he said. “The drone inspections will reduce this and by capturing accurate footage we can share it with the aircraft manufacturer and speed up the assessment process as well.”

Since announcing its plans for drone technology in May 2014, EasyJet has conducted a number of trials. Initially it explored the feasibility of operating a flying craft in a working hangar, looking at key safety features such as unaided navigation, protected rotors, and system redundancies. In May 2015 it successfully completed its first trial with an automated drone, with no input via remote control.

“We have also put one EasyJet staff member through the RPQs – Remote Pilot Qualification – training programme,” said Bunting, “to ensure that we have a good understanding of what will be required of the people operating the drone, and allow us to ensure that they are introduced safely.”

The final system is expected to incorporate automated flight, supported by a pilot where required. Images will be fed to a qualified engineer, who, in consultation with the manufacturer, will be able to make decisions regarding the aircraft’s eligibility to return to service. By the end of 2016, EasyJet hopes to have drone inspection capability up and running in 10 locations across Europe, including Luton and Gatwick.

“It is projected that drones could help reduce inspection time from several hours to just half an hour

It’s projected that drones could help reduce inspection time from several hours to just half an hour. Aircraft in good working order could be back in service in a fraction ->

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of the time, avoiding costly delays. In the cut-throat world of budget airlines, minutes can equate to millions, and drone inspection could help EasyJet develop a competitive advantage over its rivals.

"By performing an inspection in this way, we allow our operations centre to decide how to adjust the flying programme with the least amount of disruption," said Bunting.

While EasyJet is developing its own in-house solution and expertise for inspection, several companies offer tailored ROAV services across a range of industries. One such company is Cyberhawk. Formed in the UK in 2008, it operates globally in multiple sectors, with clients including BP, Maersk, Shell, Exxon Mobil, and Siemens. There are four levels of training within the company, with offshore oil and gas being the highest.

"We've really focused on having excellent engineers, excellent surveyors, excellent pilots, that can deliver results in these kinds of challenging environments," explained Cyberhawk's commercial director Philip Buchanan, who is also a mechanical engineer.

Cyberhawk recently received approval from the Civil Aviation Authority (CAA) to fly drones in congested areas, including to within 10m of vehicles, structures and people not under its control. It said this permission will enable it to carry out a host of projects that have previously been prohibited under standard CAA permissions.

The company now also counts Network Rail among its clients, having succeeded in a recent bid for asset inspection and assessment work, as well as other projects such as surveying land for possible line extensions. Network Rail put out the tender after it became aware that several operators around the country were undertaking their own drone inspection work, in a piecemeal approach that it felt could lead to difficulties.

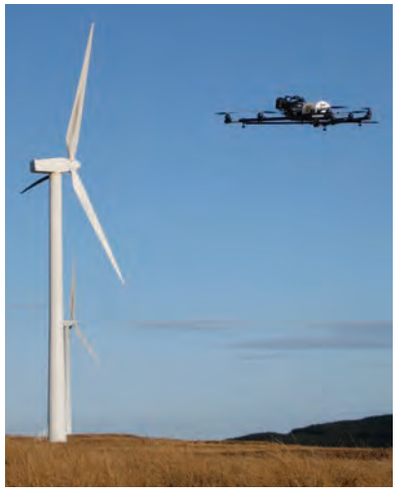
"Network Rail is quite forward thinking, so it could see the benefits of ROAVs for inspection and surveying their network," said Buchanan. "But they became aware of lots of different operators doing lots of different things, to probably lots of different standards, close to their network and assets."

The result was a contract that brought all the ROAV work under Cyberhawk's roof. Buchanan said the company's end-to-end approach helps it stand apart from the competition, and it has developed a software platform called iHawk in an effort to add more value to the drone services it provides.

"We don't just capture pictures, we don't just capture data and deliver it to the client," Buchanan said. "We're all about providing information to the client to actually make decisions. Part of that has been software development as well. So we now have a software platform that can deliver powerful asset information to our clients, rather than just raw data."

Cyberhawk may be reaping the rewards from early adoption of drone technology, but the past few years have seen a host of new players enter the market. Like any technology in its infancy, teething problems are inevitable, and the bad press that follows can be damaging to the industry as a whole. It's a problem that Adam Bailey is all too aware of. As well as being the founder of Kingfisher APS – a company that uses drones for close proximity surveys – he is also vice-chairman of ARPAS-UK (Association for Remotely Piloted Aircraft and Systems in the UK).

Formed in 2013, ARPAS originally consisted of just a dozen members who recognised the need for a professional body to represent commercial manufacturers and operators. Bailey said the 400-plus members it has today make up the bulk of the industry. A key component of this growth has been ARPAS's non-profit status, along with relationships with industry bodies, regulators and pilot associations.



Above: **EasyJet's inspection drone**
Left: **UK firm Cyberhawk is also eyeing inspection applications**

Away from ARPAS, Bailey's work with Kingfisher includes an inspection project on Neath Port Talbot Hospital, as well as recent survey work near Grosvenor Place in Victoria. Getting permission to operate drones in cities can be difficult, and flying in central London provides unique challenges.

"It was 500m from Buckingham Palace, so obviously, there was a lot of issues with getting clearances because it's highly restricted airspace," explained Bailey. "But because we've got a long history of working in those environments, and because we've got safe systems of working in place, we can act to get it done."

According to Bailey, one of the biggest challenges the industry faces moving forward is maintaining a positive public image, and preventing the regulator from overreacting to negative press.

"We need to engage the public and stakeholders on the positive aspects of drone use and the message of 'Drone for Good', rather than the press-led negative agenda, which circles around a few headlining stories that don't actually reflect the landscape at large."

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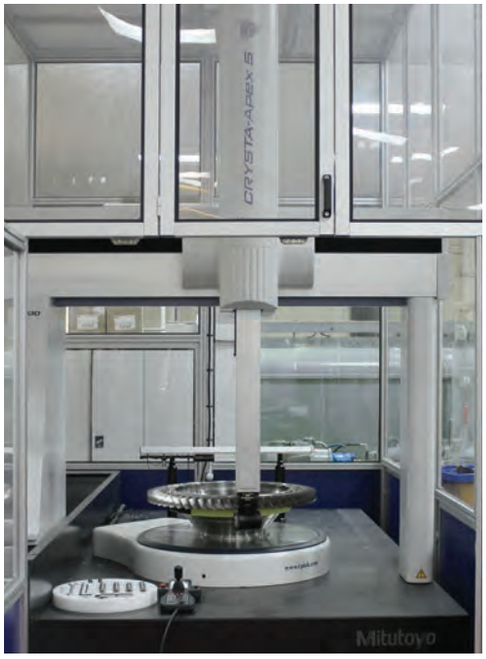
Blisk business

A CMM is helping a jet engine manufacturer keep pace with the demands of the production line



The Mitutoyo system has helped boost manufacturing precision

Today's advanced machine tools enable the global aerospace industry to produce parts faster than ever before.

However, these increased production levels can often put pressure on other areas of the manufacturing process and lead to bottlenecks in the inspection process. To address this challenge, aerospace manufacturers are increasingly turning to advanced inspection techniques

One such manufacturer is Midlands jet engine manufacturer ITP Engines, which recently invested in a high-speed, high-accuracy measurement system for its blisk and IBRS (aero-engine components consisting of a rotor disk and blades) production line.

Based in Lincoln, the firm, descended from Power Jets, the firm, founded by the father of the jet engine Frank Whittle, turned to measurement specialist Mitutoyo to provide a system that could keep pace with its demanding production volumes.

The resulting solution is based on one of Mitutoyo's advanced Crysta-Apex C Coordinate Measuring Machines. Built using lightweight materials and boasting a moving-bridge type machine structure, the system is claimed to provide excellent motion stability and high accuracy.

Rather than using a conventional probing system, the CMM was supplied fitted with a Renishaw REVO, five-axis measuring head that is able to perform continuous surface scanning to deliver full 3D geometry in a single scan.

According to Mitutoyo, this measuring head is able to overcome the limitations of three-axis scanning methods.

The system uses synchronised head and machine motion when scanning, rapidly following changes in part geometry without introducing dynamic errors. It can also move

> **"This measuring head is able to overcome the limitations of three-axis scanning methods**

at a constant velocity while measurements are being taken, without impacting accuracy.

The speed and accuracy of the installation is further enhanced by the use of a specially designed rotary table that can be used to hold and manoeuvre the blisks and IBRs.

Explaining how ITP settled on the system Rafael Castro, ITP advanced manufacturing facility factory manager, said: "In addition to other metrology technologies we considered non-contact optical systems, although the physical nature of our blisks and IBRs, and the potential for reflections from the materials we use, meant that this technology was not suitable for our needs."

Castro added: "Customer requirements demand that all airfoils on all Blisk and IBR components are measured. An average part has about 60 airfoils and each airfoil needs to be measured in at least six sections, each one with around 200 points. With a future production greater than 1,000 blisks and IBRs a year, optimisation of our inspection process was vital.

"The Revo scanning head on our Mitutoyo CMM features continuous surface scanning, capturing full 3D geometry in a single scan, which is a major improvement when compared to the traditional technology of intermittent single-point touches. In addition, the use of a high-precision rotary table allows us to use a smaller and more precise Mitutoyo CMM.

"As the increased amount of points we are now scanning had the potential to make post processing more time consuming, a software tool was developed by the ITP UK´s controls team in Whetstone to reduce data analysis time.

"Now fully operational, our new method is up to six times faster than our previously used conventional system. In addition, our Mitutoyo CMM system has further enhanced our already impressive accuracy capability."

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inbrief

Space for a scanner
UK 3D scanner reseller Central Scanning Limited has introduced the Artec Space Spider: the latest addition to a range of highly accurate, compact and easy-to-use scanners. Suitable for a range of different environments, the rugged device was developed through a collaboration with NASA, which asked Artec to develop a scanner that could withstand the rigours of being used in space. The device also incorporates an enhanced cooling system that helps it capture data more rapidly, and a temperature control system that enables it to maintain its operational temperature, regardless of the external temperature.

Kind of blue
Designed specifically for shiny, highly polished surfaces, as well as transparent materials such as plastics, glass, optical components and film/substrates, a new range of 2D/3D blue laser profile sensors (laser line scanners) are now available from precision sensor manufacturer Micro-Epsilon. The scanCONTROL BL series of blue laser profile sensors are designed for high-precision profile and dimensional measurements on a variety of materials where red laser diode sensors do not perform well.

Quality time
In order to simplify the measurement of compressed air quality in accordance with ISO 8573, CS-iTEC GmbH has just released new products that incorporate a 5in full-colour touchscreen graphical display. The new display has been added to the existing S 120 oil vapour sensor and S 130 particle counter to provide direct user feedback without the need for external devices, making it suitable for portable monitoring.

Keep your balance
Marposs is set to launch a new electronic unit for machine tools that can provide a CNC interface to a wide range of ancillary devices at EMO 2105, Hall 7 Booth E05. The unit, which has the title of BLU, will allow the connection to Marposs measuring systems, balancing systems and sensors of many types, including acoustic for gap and crash detection.

Making a show of it

Simplifying the use of its products and making precision more accessible to a wider range of manufacturers is the thinking behind many of the products that UK metrology specialist Renishaw will be bringing to this year's EMO show (see preview, p54).

Among the new systems on show is Primo, a machine tool probing system with an innovative charging model that allows customers to 'pay as they probe', making the advantages of highly accurate tool setting more affordable for more companies. "Our research showed that customer concerns, including investment cost, ease of use and durability, have held some companies back from using probes," said Jean-Marc Meffre, president of Renishaw's far east business, where Primo was launched last year. "Amid rising wages, skills shortages and fierce global competition, the move to high-value manufacturing has become an economic imperative for many companies and countries. Precision measurement and machine tool probes are key to achieving the level of quality required to compete."

Primo is a two-part system, comprising a radio part setter that locates a workpiece prior to machining and a radio 3D tool setter that accurately measures the length and diameter of curing tools. Users buy a renewable six-month credit token that allows unlimited use of the system during that period; this can be upgraded to indefinite use, or further six months of credit can be added.

Also at EMO, visitors will be able to see Renishaw's INTUO gauging software, which is designed to simplify the measurement of parts using the company's Equator metrology equipment. INTUO can predict the form of a feature on an object, such as a bore, from the operator selecting just a few points on the feature using a new push-button interface, building up a digital schematic of the part without the operator learning a complex programming language. Parts can then be measured and verified without using manual measuring equipment.

> **"Cost, ease of use and durability have held some companies back from using probes**

The company is also introducing its MODUS 2 software for co-ordinate measuring machines. With features such as off-surface motion and automatic reporting, MODUS 2 is also intended to make advanced equipment accessible to those without specialist training.

A matter of precision

A research project at the Manufacturing Technology Centre has used metrology to deliver ultra-accurate robotic automation.

The Metrology Assisted Robotic Automation (MARA) project at the Coventry-based MTC has solved a longstanding manufacturing problem with robotic accuracy, and will result in major improvements in the precision and consistency of robotic operations.

Industrial robots have been used for repetitive tasks for many years, with good results, but the increasing use of offline computer programming has underlined the fact that industrial robots are generally not accurate devices. Previous robot calibration fixes have improved accuracy to better than 1mm, which is adequate for most tasks. However, applications requiring a very high degree of accuracy have presented challenges.

The MTC project combines the robot with a high-speed, ultra-accurate laser tracker from Hexagon Metrology that can make real-time corrections to the robot's path during a process. The result is accuracy of better than 0.2mm for a robot working at a speed of 50mm a second.

MTC project leader Richard Kingston said the new process had the potential to transform precision, accuracy and consistency in robotic manufacturing operations, resulting in higher quality and a much lower defect rate. "By combining the robot, the laser metrology device and a real-time controller, we were able to ensure that the robot could follow complex paths with an extreme degree of accuracy not previously achievable. The project has proved that it is possible to correct a robot's path in real time, which is another first.

"We are now continuing our work to improve accuracy and reliability still further, but this is a fantastic result."

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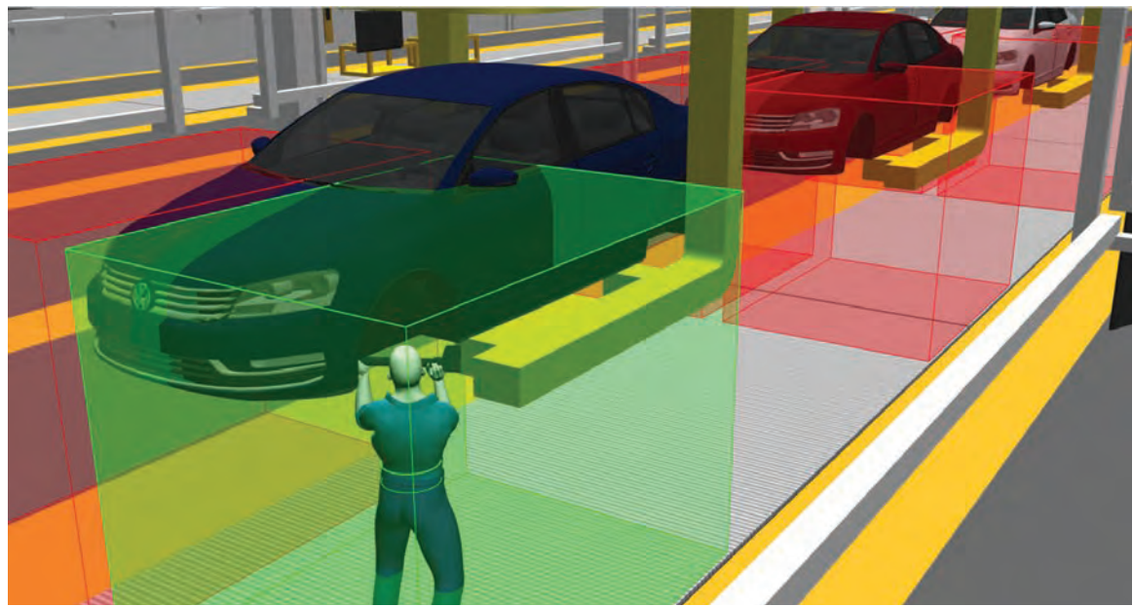
Smart investment

Innovative UK sensing technology is being adopted by some of the world's big companies. Jon Excell reports



Over two decades ago, while researching for his PhD at Cambridge University, Dr Andy Ward had a bright idea. If he used tracking technology to monitor the position of people in an office, he reasoned, then it should be possible to automatically re-route incoming phone calls to employees wherever they were in the building.

It was a neat idea that was never destined to have an impact in the office environment. The rise of the mobile phone put paid to that.

But fast-forward 20 years and the concept Ward developed is now at the heart of a smart factory system that's been embraced by some of the biggest names in manufacturing: including BMW, Volkswagen and Airbus.

Marketed through rapidly growing Cambridge University spin-out Ubisense – of which Ward is the chief technology officer (CTO) – the technology enables operators to use an extensive network of tags and sensors to track and monitor in real-time the position of everything in their factory: from tools and manufacturing equipment to the components that are being machined and assembled. The idea is that all this data can be used to enable sophisticated levels of automation and help factory operators carefully analyse and refine their processes.

Ward – who recently won the Royal Academy of Engineering's coveted Silver award for his troubles – explained that while the concept has some similarities to other tracking systems such as the RFID (radio frequency identification) technology that has been used throughout industry for some time, it is, in fact, substantially more advanced.

Ubisense's smart factory system is helping usher in new levels of automation on the shopfloor

While existing RFID systems typically use passive tags for short-range point detection – i.e. to detect when a particular item arrives at a particular point in a process – the Ubisense system, he explained, is underpinned by ultra wideband (UWB) radio, an active technology that can be used to carry far larger amounts of data over greater distances than RFID. Thus, rather than simply providing an alert when an item passes through a specific 'gate', the system is able to tell operators precisely (to within 15cm) where anything is at any time, a capability that has profound implications for the production line.

The technology has had a striking impact in the automotive sector; where it's helping manufacturers juggle the twin pressures of increased production and the growing demand for customisation.

Increasingly, Ward explained, car manufacturers are producing multiple models and variants on the same production line, which means that tooling must frequently be adjusted to suit whichever vehicle is passing along the line.

Typically, these adjustments are made by a tool operator, who will scan a barcode on the component in order to find out the correct tooling settings, all of which takes time. The Ubisense system, however, is able to continuously track these tools and components, and automatically adjust the tool settings, dramatically reducing the time taken between tool adjustments, and removing the potential for human error.

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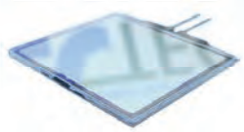

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Automotive automation: **BMW has installed the system at five plants**

Automated tool control systems supplied by the company are now used by, among others, BMW, Daimler and VW, and Ward estimates that around two million cars per year are made using the technology.

But this isn't the only application of the system. For instance, the aerospace sector – which has much slower production rates and little requirement for customisation – has been attracted to the process visibility offered by Ubisense and the firm has a number of projects with Airbus.

One of its biggest initiatives here is on the A380 programme, where nine European sites have been kitted out with its technology.

"The A380 is built by creating various different components at different points in Europe," explained Ward. "The sheer volume of these components means it's very important to ensure inventory is kept as low as possible – there isn't the space to hold 40 sets of wing while you wait for the fuselage components to come along. You have to have exceptionally good visibility about the production states of all of these different items, and from the physical location of the item we can tell where it is in the production state. By monitoring all of that automatically and updating it on a real-time basis, you can see how likely it is that these things are going to arrive at the same time giving the manager visibility of everything that's happening in Europe."

Ubisense's technology is regularly identified as a tangible example of Industry 4.0, the much-vaunted emerging industry trend that is predicted to shape the future of manufacturing (see roundtable report, p30), and although Ward's work predates the emergence of that particular concept he's comfortable with the association. "Industry 4.0 a broad thing," he said, "but there's a smart factory element of it which is all about improving efficiency, building things in a smarter way, mass customisation; the sort of things we've been doing in the automotive space for getting on for 10 years."

It's also a useful illustration of the fact that embracing a more sophisticated approach to process improvement doesn't necessarily require wholesale reinvestment in manufacturing infrastructure. Indeed, said Ward, Ubisense systems are entirely compatible with existing equipment.

"These sensors hang off an Ethernet network that is fairly prevalent in factory's today. It's perfectly retrofittable – and although we do have customers who are now building new factories and designing it in, for most [projects] we're adding it to an existing line," he added.

Nevertheless, despite its advantages, persuading a naturally conservative industry to adopt the technology has been a lengthy process. And it's only now, said Ward, that the momentum is really beginning to build. "We've always found that at the first of the customer sites they'll take a long time to investigate but once they see the benefits of the technology they'll order it again and again. We're in at least five BMW plants now and we expect the same pattern to happen with lots of other manufacturers."

Given the pedigree of Ubisense's customers, it's difficult not to share his optimism.

productnews

Relec Electronics has helped develop an emergency back-up power system for a new range of LED surgical lighting products. The team supplied a DRU30-24 DIN Rail Mount UPS Controller, that interfaces between the power supply, back up battery and load to maintain the battery in prime charged condition and ensure a seamless transition to battery power in the event of mains failure.

Linear Technology has announced the LTC5549, a double-balanced mixer that can operate either as an upconverter or downconverter, with a very wide RF frequency range from 2GHz to 14GHz. The mixer's performance is said to enhance a range of microwave applications, including microwave backhaul, high unlicensed band LTE-Advanced base stations, satellite broadband radios, radar systems, X-band and Ku band transceivers, test equipment and satellite modems.

Mouser Electronics is now stocking Si88x2x dual digital isolators from Silicon Labs. The Si88x2x modules integrates proven digital isolator technology with an on-chip isolated DC-DC converter to provide regulated output voltages of 3.3V or 5.0V at peak output power of up to 5W with external power switch. The isolators include a DC/DC controller with user-adjustable frequency for minimising emissions, a soft-start function for safety, a shutdown option, and loop compensation.

Silicon photomultipliers, commonly referred to as SiPMs, are replacing conventional low light detectors such as vacuum PMTs and avalanche photodiodes in a wide range of low-light applications. SensL Technologies C-series SiPMs, available from **AP Technologies**, are low-cost devices available in surface mount packages with active areas of 1x1mm, 3x3mm and 6x6mm. C-series SiPMs are supplied on tape and reel for easy integration into RoHS compliant PCB assembly lines.

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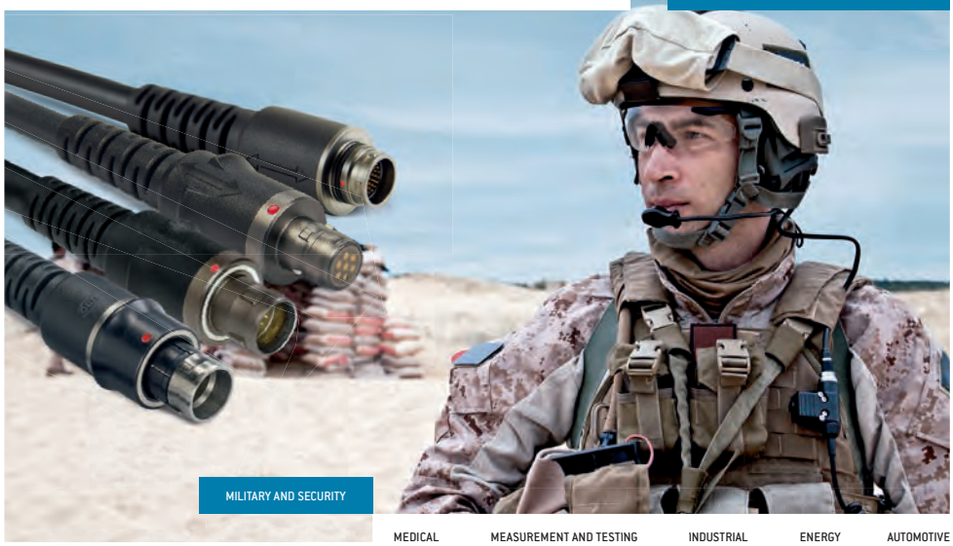

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Fast talk

Is there a future for supersonic passenger aircraft? Our expert panel weighs up the options. Stuart Nathan reports

NASA and Airbus are among the organisations that have recently revealed that they are working on concepts for supersonic passenger vehicles, but after the commercial failure of Concorde, is there really a future for ever-faster transport? And if there is, what technical challenges will engineers have to overcome to make it a reality?

We asked readers of *The Engineer* for their questions and put them to an expert panel, including representatives from Lockheed Martin, Rolls-Royce, Reaction Engines and Imperial College London.

- **Anthony Pilon** (AP), Lockheed Martin technical fellow
- **Ricard Varvill** (RV), technical director – Reaction Engines
- **Paul Bruce** (PB), senior lecturer in aeronautics, Imperial College London
- **Alan Newby** (AN), chief engineer, future programmes and technology, Rolls-Royce

What's the business case for reviving supersonic flight?

RV: The business case for supersonic flight is weak. Generally speaking, the reduction in lift-to-drag ratio due to shock wave formation and more complex engineering of supersonic aircraft, tends to increase costs. This goes against the long-term trend of decreasing ticket costs and, in the near term, will exclude the majority of the travelling public, apart from the rich and businessmen. Nevertheless, rising living standards will eventually make supersonic travel affordable for long-distance travel, providing that engineering and environmental challenges can be solved.

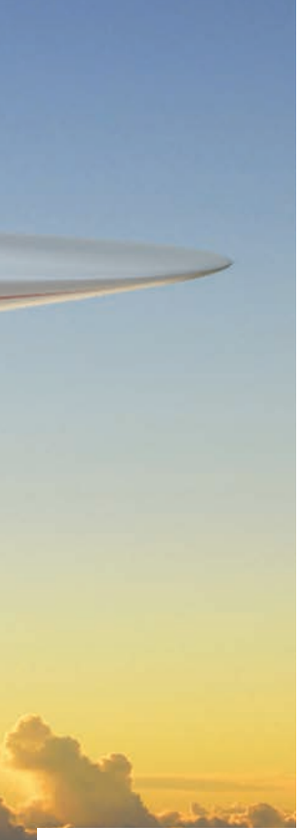
PB: Despite recent tragic events, air travel remains the safest form of long-distance transportation and I think the public does appreciate that all aircraft manufacturers take this seriously. The excellent safety record of the aviation industry stems from rigorous testing and certification of new aircraft, exacting maintenance of existing aircraft and thorough training of personnel. I see no reason why any of these should be compromised when developing faster aircraft. The safety implications of cruising at 500mph at 30,000ft are not so different to cruising at 2,000mph at 100,000ft.

I believe there is definitely a public hunger to travel faster – whether it be supersonic or hypersonic. However, I also believe it is difficult to imagine a scenario where supersonic air travel is not significantly more expensive than today's economy-class travel

How much of an appetite is there within industry to bring back supersonic passenger flight?

RV: The aerospace industry is sceptical about the commercial viability of a supersonic airliner. However, a small supersonic business jet is subject to less-stringent economics and may be built within a few years, providing the sonic boom operational limitations can be overcome.

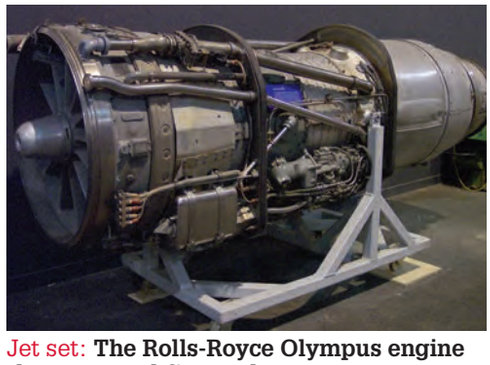
PB: It is always possible to make a business case at some level for supersonic passenger flight. I firmly believe we will see the first supersonic business jets — Mach 1.6 cruise with a capacity of around 10 passengers — from companies such as Aerion, Spike



Mach attack: **Lockheed Martin's concept N+2 supersonic passenger jet**

Concept business jets by Aerion (left) and Spike Aerospace (above)

Aerospace and Gulfstream appearing in the very near future. It is much harder to make a business case for a larger commercial supersonic aircraft. However, I think the recent interest we have seen from big industrial players such as Airbus reflects the fact that industry is well aware that the development of technologies for travelling fast has other potential applications beyond making a profit transporting fare-paying civilian passengers. This includes, perhaps obviously, applications with a military purpose but also more future-looking concepts such as developing vehicles that could provide more affordable access to space.



Jet set: **The Rolls-Royce Olympus engine that powered Concorde**

The environmental regulations and noise and emissions targets facing the aviation sector are more demanding than ever. Is it possible to design and operate a supersonic airliner that meets these targets and, if so, how will this be achieved?

AP: Yes, we believe it is possible to develop a supersonic airliner that is compatible with existing and planned future regulations governing noise and emissions. Take-off and landing noise is addressed through variable cycle engines [VCE] and advanced nozzle concepts. VCEs are optimised to provide the high specific thrust required for supersonic cruise, while lowering jet exit velocity to minimise take-off noise. Advanced fan and compressor technologies employed in VCEs, along with acoustic liners, help minimise fan noise on approach. Airframe noise is minimised by keeping the airframe as clean as possible, eliminating slats, multi-slotted flaps, fairing landing gear and so on. On the emissions side, the lower-pressure ratio inherent in supersonic engine designs minimised NOx emissions compared to current subsonic designs.

PB: There is no getting around the fact that flying faster will always burn more fuel, no matter how well designed an aircraft is. Recent developments in engine technology and aerodynamics can go some way to lessen this disadvantage but it will always be an issue.

Noise, on the other hand, is an area where we have made significant progress since the days of the Concorde. Airbus has suggested some clever tricks to reduce the impact of noise during take-off – where regulations are particularly stringent – and also to lessen the strength of the sonic boom produced during supersonic flight. Specifically, it mentions using conventional engines during take-off, minimising aircraft weight and volume, careful shaping of the fuselage, flying at very high altitude and an unconventional flight path during climb and descent.

RV: Meeting noise and emissions targets is more difficult with a supersonic airliner than a subsonic airliner, and is one of the most difficult obstacles to be overcome. Take-off noise can possibly be solved by incorporating a high bypass fan to reduce the exhaust velocity providing the increased frontal area and supersonic wave drag are not too great. At high Mach numbers, NOx generation becomes an issue due to the high combustion temperatures, particularly since the vehicle will be flying in the ozone layer. Consequently, advances will be required in combustion chamber design. Reaction Engines has designed and tested a novel concept that promises to solve this issue.

AN: Future commercial supersonic aircraft will have to meet the same stringent airport noise – take-off and landing – standards as contemporary subsonic aircraft. Meeting such noise standards will likely require propulsion systems of bypass ratios higher than optimum for supersonic performance, compromising capability.

'Conventional' supersonic aircraft flying above the speed of sound create a sonic boom at ground level that is deemed unacceptable in many areas of the world, resulting in restrictions on supersonic overland flight. The market potential of supersonic aircraft will be limited unless they can be designed to mitigate the sonic boom and be certified against agreed regulations permitting supersonic overland flight. Such regulations are yet to be defined. ->

> **"Supersonic aircraft above the speed of sound create a sonic boom at ground level unacceptable in many areas of the world**

The challenge will be to produce an aircraft that meets the regulations on airport noise and sonic boom while delivering the supersonic performance and capability required by the market. Novel variable geometry propulsion system configurations incorporating the most advanced engine technology present the possibility of overcoming the challenge on performance. Research is ongoing into aircraft configurations that mitigate the sonic boom to a level expected to be socially acceptable and encouraging results have been widely reported.

Furthermore, Concorde with Rolls-Royce Olympus 593 engines was designed before the era of computational fluid dynamics. This, coupled with advances in aerodynamics and flow control, mean a reduction in sound pressure on the ground is achievable today. If we just take reductions in noise on commercial subsonic aircraft the improvements over the past 40 years have been considerable. We only need to look at the advancements made in subsonic flight in recent times. Rolls-Royce understands a lot about quiet powerplant, the noise levels of the Trent 1000 are the quietest in class and represent significant reductions since earlier RB211 generations. Rolls-Royce continues to invest in the engineering and science of noise; and, with our academic partners at Southampton University, we continue to make progress with every new product both for civil and military applications.

The aerospace industry will need take a more integrated approach during early design phases if it is to achieve an acceptable commercial supersonic aircraft solution. We have to recognise that aircraft and powerplant noise have different impacts on overall noise during take-off – near airports – and supersonic cruise whether overland or oversea. These challenges will only be overcome by airframers working with powerplant manufactures to achieve an optimum solution. Reductions in noise are required from both the propulsion system and aircraft. As with many breakthrough technologies, costs in early years with small volumes can be significant, which inevitably adds to the overall cost.

Above left: **Boeing's X-51 WaveRider**
Below left: **LAPCAT II, a concept hypersonic jet**
Above: **Boeing's concept supersonic airliner**

What technologies will be key to the next generation of supersonic airliners in terms of engine design, materials, and aerodynamics.

AP: Variable cycle engines [VCEs] and high temperature combustors for engines; lightweight composite materials for structure; and laminar flow for aerodynamics. Recently developed low boom design tools also hold promise for dramatically reducing the loudness of supersonic cruise flight and may open up supersonic flight to a much larger audience by allowing supersonic flight overland.

RV: Engine design and technology is the most challenging aspect of supersonic or hypersonic flight. In particular, handling the high air inlet temperature with low fuel consumption to give long range. The main challenge on the airframe is handling the high skin temperature requiring careful materials selection and thermal insulation. If very high range is required – for example, Europe to Australia – then hydrogen fuel is mandatory that can assist engine design but complicates the airframe further.

PB:
- Hydrogen fuel is significantly more mass-efficient than conventional hydrocarbon fuels. New technologies for its production on the ground and storage – cryogenic fuel tanks – will be necessary to unlock its potential.
- Development of a tandem turbofan/ramjet engine will be necessary to enable flight at low speed (take-off and landing) and efficient supersonic cruise. This could be in the form of two separate engines that can be retracted/deployed or a single adaptable engine something more like the Lockheed SR-71 Blackbird engine.
- Thermal heating will necessitate extensive use of reasonably exotic materials – for example, titanium alloys – and careful design to account for thermal expansions and so on. This mainly applies to airframes, but may also be the case in engines; scramjets and ramjets have no moving parts, but may require heat-resistant liners in their combustion chambers.
- A 'wave-rider' wing design is likely to offer the greatest potential for aerodynamic efficiency for a cruise around Mach 4.
- The shape and surface finish of all aerodynamic surfaces should be designed to ensure the airflow remains laminar wherever possible. This is an important feature for small supersonic business jets.

AN: Through the development of revolutionary design concepts and application of advanced technology, it is possible that an environmentally acceptable and commercially viable supersonic corporate jet could be produced in the medium/long term. Development of a large supersonic passenger aircraft that meets environmental and commercial targets is even more challenging, but the knowledge acquired and technology developed for the smaller corporate supersonic vehicles will provide a considerable stepping stone towards such an aircraft, that could be viable in the very long term.

A supersonic corporate jet will create a new paradigm in aircraft capability, and will be the most fuel-efficient and environmentally friendly supersonic aircraft ever built. However, the penalty for that revolutionary capability in aircraft performance and productivity will be in fuel efficiency relative to a subsonic vehicle of the same technology standard.

The engineering, environmental and economic challenges to scale from corporate to large passenger aircraft should not be under-estimated; however they do offer a unique opportunity to achieve what is one of the most difficult engineering problems to resolve in the 21st century. These challenges won't just be at aircraft and engine level but will stretch the minds of engineers and scientists in areas of material science, aerodynamics, computational design and thermodynamics to name a few. We have to consider whether there is a large enough demand for supersonic travel and whether society is prepared to pay a premium for such a service while acknowledging the trade off with environmental penalties. ->

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If by comparison with traditional aircraft we mean will it achieve the same fuel mass per passenger-mile as an Airbus A350 powered with Trent XWBs, then the answer is no. The physics of flight hasn't changed since Concorde's day; clearly we can achieve a step change in efficiency compared to 1970s, but we have to be aware that subsonic turbofan engines have significantly improved fuel burn, thus the challenge is even greater if we are to make fair comparisons.

There are more elements than just fuel efficiency per passenger in the business case evaluation of a new airframe and one of them is time required to destination. It is true that this is not only a function of flight time, but airport and flight management operations also have a big impact on this, but supersonic flight can offer significant block-time reductions over widebody airliners in long-haul flights.

What are the main lessons – from a technology perspective – to be learned from Concorde?

AP: Concorde was a point design – Mach 2.0 cruise. Future supersonic airliners or business jets will need to be designed through a multidisciplinary approach so that cruise performance, sonic boom, noise, emissions, and operating costs are all addressed simultaneously. Without that, we'll have another Concorde.

RV: Concorde was a superb aircraft but suffered from high take-off noise and low range. This excluded it from a large number of routes such as trans-Pacific, limiting potential sales and, in conjunction with its small number of passengers, giving high ticket costs. A future supersonic aircraft needs to reduce costs, increase range and meet future environmental legislation.

PB: There are simply too many to try and list. Technologically speaking, Concorde was and still is an engineering masterpiece. No other aircraft has come close to replicating its capabilities – not just in terms of ultimate performance but also in terms of its reliability and robustness to operate day-in-day-out.

Top Cat: **Reaction Engines' LAPCAT A2 supersonic concept aircraft**

As the speed of a given aircraft increases, its energy requirements increase. At what point would this law of diminishing returns set an upper limit on the speed an aircraft could travel while still being affordable?

AP: I would estimate that the limit, with today's technology, is probably around Mach 2.0. Above that, the design space collapses because of cabin pressurisation issues – the aircraft will need to cruise above 60kft and losing pressurisation there is catastrophic and also for issues such as aerodynamic heating. There is also an inherent difficulty in designing an engine that can operate quietly and efficiently at both low and high speeds beyond about Mach 2.0. It isn't feasible to develop a propulsion system that can provide high cruise efficiency and meet Chapter 14 airport noise regulations. In reality, the sweet spot from a multidisciplinary perspective when including all environmental constraints is probably closer to Mach 1.8.

RV: Simple Breguet range and propulsion theory shows that the achievable range of an aircraft is relatively independent of the cruise Mach number. The technical difficulty increases greatly with Mach number due to rising inlet air temperature. Practical engineering considerations and economics suggest that there is little point flying faster than Mach 4–5 since the duration of the longest flights becomes shorter than the rest of the journey to and from the airport.

> **"Designing an efficient propulsion system to travel at speeds above Mach 5 becomes a massive headache**
> Paul Bruce

PB: Although flying supersonically does incur a significant penalty in aerodynamic efficiency relative to low speed (subsonic) flight, research has shown that there is actually very little further reduction in the aerodynamic efficiency of a well-designed aircraft once the Mach number exceeds around 5. What this means is that from an aerodynamics perspective, if you are willing to accept the efficiency penalty to fly at Mach 5, you may as well be flying at Mach 10 or 20. On the other hand, designing an efficient propulsion system to travel at speeds above Mach 5 becomes a massive headache as current options, i.e. rockets, are far too inefficient to be considered for long-range travel.

What kind of changes would have to be made to existing airport infrastructure around the world to ensure that airports can support supersonic airliners?

AP: There probably would not be too many changes for the airports themselves. I would expect any airport equipped for a 787 would be able to handle a supersonic airliner; although there may be some additional infrastructure needed for cooling of the airframe and systems after flight. The real infrastructure challenge would be in air traffic control [ATC] – the benefits of a supersonic airliner fade away if ATC slows you to 250kt 300 miles from your destination. This is happening now with high-end business jets.

RV: Hypersonic or long-range airliners will require hydrogen fuel that necessitates large investments in airport infrastructure and results in a very long aircraft, due to the low density of liquid hydrogen. This would require further investment in modified taxiways and departure gates.

PB: The short answer is: very little. Supersonic aircraft will generally be smaller than current commercial aircraft – maybe a bit longer but much thinner – so there should be no issues with accommodating them at existing gates and so on. It is likely they would take off using conventional – turbofan or turbojet – engines so should not present more of a noise problem than existing aircraft. As with Concorde, they may require higher take-off and landing speeds but this would not be a problem owing to their smaller size and relatively powerful engines.

Would it make more sense for industry to concentrate on refining the technologies required for hypersonic flight?

AP: No. There are multiple technical challenges to hypersonic flight that preclude this, for example, thermodynamics, cabin pressurisation, *g* forces and so on.

RV: Some engineering studies are already underway to study and develop the technologies for hypersonic flight. A notable example was the LAPCAT study part funded by the EU and managed by the European Space Agency.

PB: No. I think it makes a lot of sense to aim at supersonic travel first. Most engineers in the aerospace industry would agree that sustained hypersonic travel is probably an order of magnitude harder than supersonic travel. There is a long list of reasons for this, including the need for some very advanced materials to withstand high heating levels and advanced new engine technologies that are still a long way from successful flight testing. From a passenger point of view there is relatively little motivation to travel hypersonically in terms of reducing point-to-point transit time.

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Being positive

With continued growth in European machine tool production, suppliers and buyers can expect a lively few days at EMO

This year's EMO exhibition, which runs from the 5–10 October at the Fiera Milano exhibition centre in Milan, Italy, takes place at a positive time for the European machine tool sector.

With the latest report from CECIMO, the European trade body for the sector, pointing to increasing business confidence and continued growth in European machine tool production, suppliers and buyers alike can expect to have a lively few days at next month's event.

According to CECIMO – which also promotes the event – visitors to EMO 2015 can expect to see a wide range of cutting-edge manufacturing equipment and advanced metal working systems.

As always, exhibitors at this year's event, which alternates between Hannover and Milan, include a number of firms with a major presence in the UK.

For instance, Yamazaki Mazak, which has its European headquarters in Worcester, will be using the show to showcase the capabilities of 22 of its machines – including its Smooth Technology CNC range – a group of machines underpinned by a new concept for programming and controlling multi-axis machine tools.

Added value: **The Integrex i-400AM will be a highlight on Mazak's stand**

One particular highlight on the Mazak stand is likely to be the new Integrex i-400AM which uses an additive process to generate near net shape components before finishing them with multi-tasking machining.

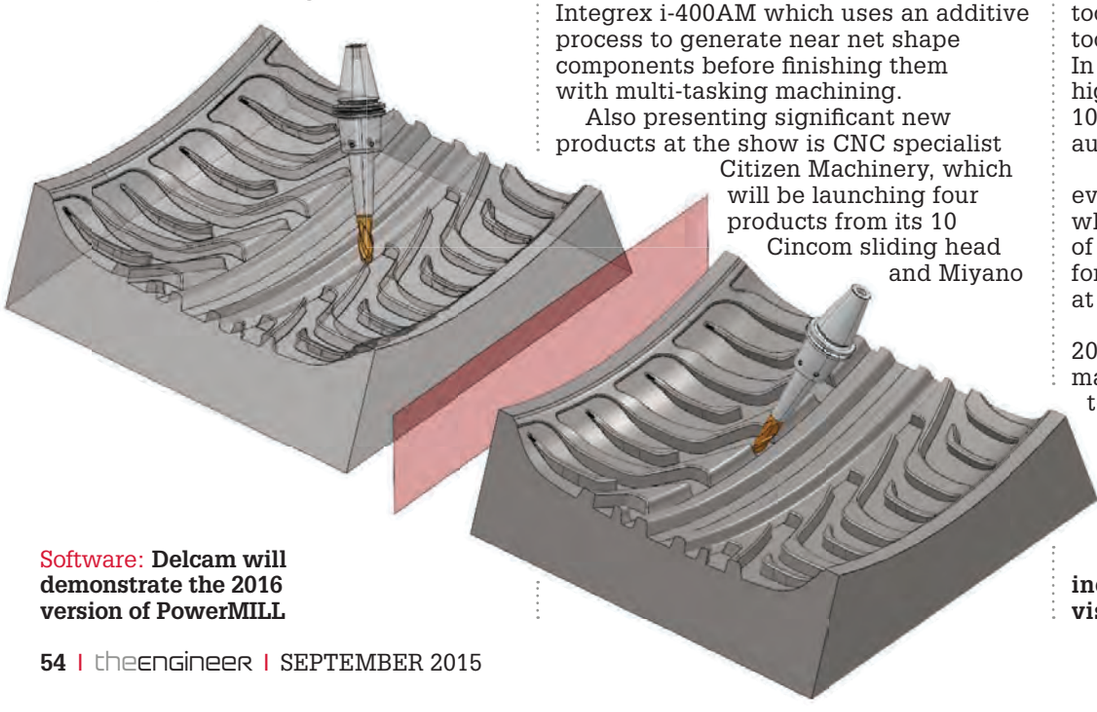
Also presenting significant new products at the show is CNC specialist Citizen Machinery, which will be launching four products from its 10 Cincom sliding head and Miyano fixed headstock turn-mill product ranges at the EMO 2015 exhibition in Milan.

Key new products in this range include the L-Series, which is now built on a modular platform with improved lift-up access guarding. The new machines will be represented with the series topping seven-axis L32-XII and the six-axis L20-XII both equipped with B-axis for driven tools, a back tool post with Y-axis feed, 40 tool capacity and detachable guide bush. In addition, a five-axis L12 will feature high-speed 15,000revs/min spindle and 10,000revs/min driven tools, plus fully automatic part unloading.

Another major UK presence at the event is CADCAM specialist Delcam, which will demonstrate the 2016 version of its PowerMILL programming software for five-axis and high-speed machining at the EMO exhibition.

The main enhancement in PowerMILL 2016 is the ability to mirror complete machining projects in one operation and to maintain automatically the machining characteristics, for example, to choose automatically whether climb or conventional milling should be used. Previously, only individual toolpaths could be mirrored.

For more information on the event, including on how to register visit www.emo-milano.com



Software: **Delcam will demonstrate the 2016 version of PowerMILL**

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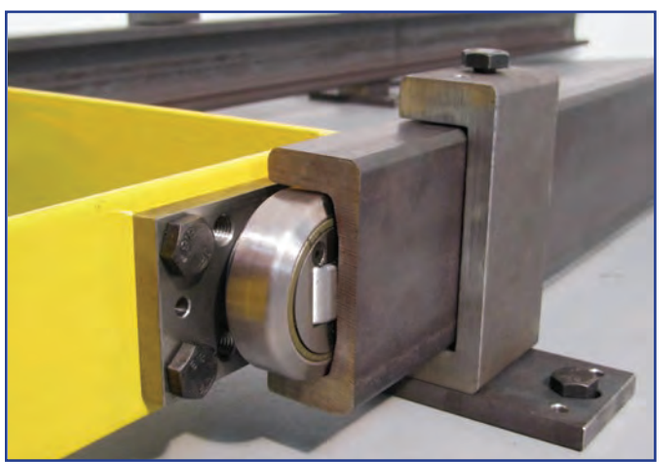

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Another dimension

One of the UK's leading events for seeing the latest innovations in 3D printing, additive manufacturing and product development

Running from 30 September to 1 October at the NEC, Birmingham, TCT Show + Personalize is one of the UK's leading events for 3D printing, additive manufacturing and product development.

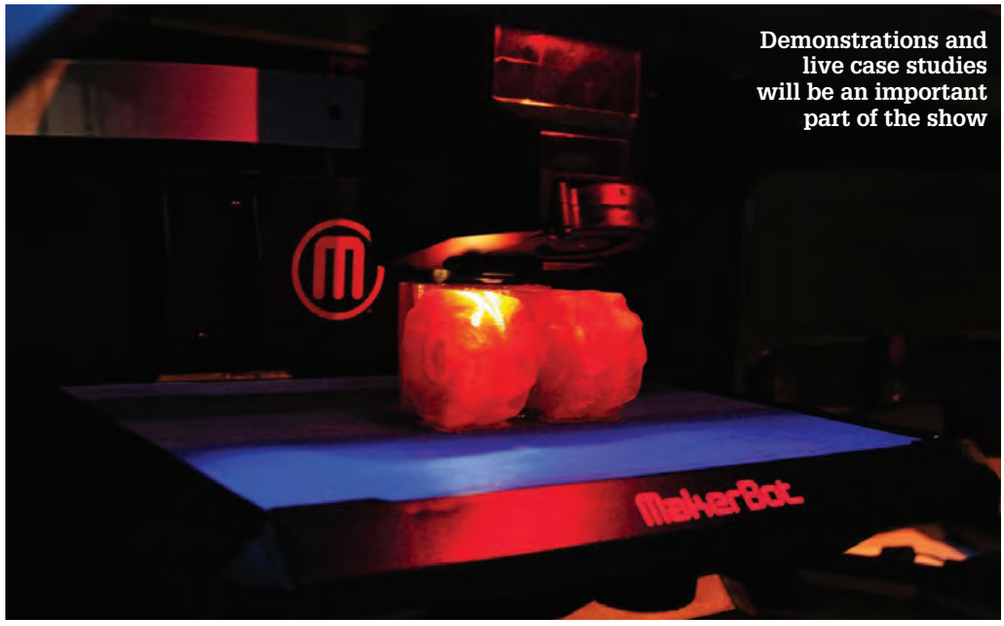
Aimed at every level of interest, from home users of the technology to captains of industry, the event, now in its 20th year, is expected to attract around 10,000 attendees and will play host to more than 200 exhibitors from across industry.

The event features the entire spectrum of 3D printing and additive manufacturing machines in action, as well as supporting technologies and software for scanning, digitising and inspection, and for design and manufacturing.

One of the biggest names exhibiting, Stratasys, will present live cases of how AM is driving time and cost efficiencies in the world of automotive, aerospace, medical, dental, consumer goods and more. The firm will also have its own on-stand presentation theatre offering daily seminars for visitors to learn about the very latest technology and materials.

Meanwhile, UK 3D printing specialist CREAT3D, will exhibit a range of machines, including Xeed by Leapfrog, a dual-head wireless 3D printer designed for ease of use in the business environment, the much larger MakerBot Replicator Z18 and the company's latest addition, the Markforged Mark One Composite 3D Printer, will be on hand, demonstrating its ability to produce nylon-based parts that can be reinforced with carbon fibre, fibreglass or Kevlar, for high strength, functional 3D-printed parts.

Elsewhere, in a reminder that 3D printing technology, is often used in a complementary manner to existing techniques, Hybrid Manufacturing Technologies will be showcasing the millGrind, the world's first hybrid grinding machine on the market. The millGrind is a continuous-dress creep-feed grinding machine made by Elb-Schliff WZM GmbH, equipped with Ambit laser cladding and milling capabilities. This system sets a new standard for precision feature addition by integrating surface and profile grinding with additive manufacturing in a single set-up.



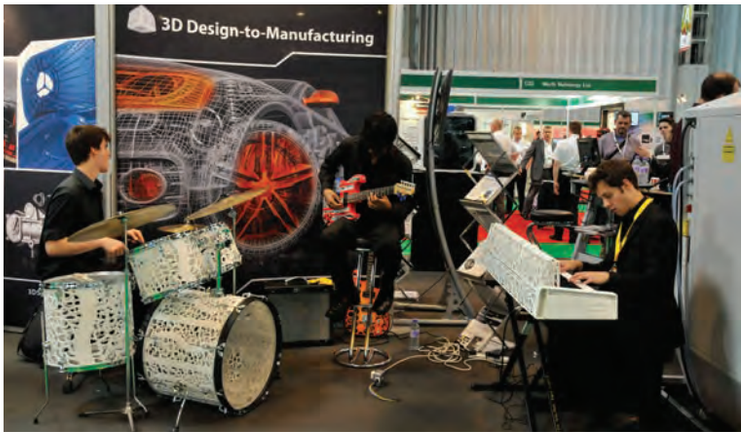
Demonstrations and live case studies will be an important part of the show

Running alongside the show, a packed conference programme will play host to a mix of international speakers from every part of the world of designing and making.

The 2015 line-up features: Al Siblani, CEO, EnvisionTEC; Scott Schiller, worldwide director, 3D Printing, Hewlett-Packard; Max Lobovsky, CEO, Formlabs; Conor MacCormack, CEO, Mcor Technologies; Todd Grimm, president, TA Grimm Associates; and Andy Middleton, president EMEA, Stratasys.

Other innovative initiatives at the show include the Startup Zone – which will showcase some of the most exciting emerging companies – and the RepRap Hub that will bring together various members of the grassroots makers community.

Meanwhile through this year's Inspire Minds initiative, around 300 schoolchildren will have the opportunity to get some hands-on 3D printing experience.



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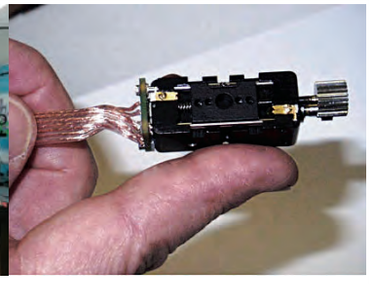

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Cross technological borders with Océ

Océ – A Canon Company at the forefront of digital printing technology, is looking for bright and ambitious engineers to work in an exciting, multidisciplinary environment.

Based in the high tech corridor of the Netherlands in Venlo, Océ is eyeing Champions' League-style domination of the global printing sector.

Already, it offers one of the industry's broadest range of printing technologies, products and services, backed by best-in-class service and support organizations. Moving forward, Océ is aiming for growth in graphic arts markets, business services industries and industrial printing markets including:

- Enterprise printing for corporate print rooms
- Large format printing of technical documentation, signage and display graphics
- Production printing for marketing services agencies and industrial printing industries
- Business services for document process outsourcing

Like all tech companies at the top, Océ needs engineers – domain architects – to expand on this portfolio, including the development of new products and technologies aimed at digitizing commercial print and targeting the burgeoning 3D printing market.

A print system architect has the challenge of working within projects with various product development teams, and could be an engineer with a mechanical, electrical, or software applications background. Out of the box thinking is required to create business value from cross-discipline technology concepts.

"We like our multi-disciplinary domain architects to work with all corners of the company and with engineers of all relevant technical disciplines – and we don't expect people to remain fixed in their original engineering teams," explains Paul Hilkens, Océ vice

"We like all our multi-disciplinary domain architects to work with all corners of the company and with all relevant technical disciplines"

Océ vice president of R&D, Paul Hilkens

president of R&D.

"In order to innovate, we need engineers that are happy working across borders – because we're determined to develop the most advanced digital printing technology on the market globally."

In 2D printing, the challenge is to digitise analogue processes, and replace offset printing in industry with inkjet alternatives. 3D printing, or additive layer manufacturing as it's sometimes known, is at an early but much hyped stage of its evolution. The potential prizes are huge, however. Here too, digital technology plays a critical role. But finding engineers that are capable of filling the demanding, modern role of domain architect is not easy, according to Hilkens.

"Of course, there is a wider trend in engineering towards multidisciplinary working," he says. "But the domain architects are more difficult to find and that's why we are focusing on recruitment across Europe now."

For example, the company recruits up to 50 new engineers a year on a rolling programme. These can be drawn from anywhere on the Continent, including the UK, where domain architects are attracted to the hi-tech corridor around Eindhoven - one of the leading technological hubs in western Europe.

"In our research labs, 3D printing technology is of course one of the topics we are working on" says Hilkens, "but we also prioritize digitising analogue print – this too is a huge challenge."

Engineers at Océ are taking that technology to the offset printing industry, where it has the potential to reduce cost, increase flexibility, and produce short runs of prints more efficiently.,

"Digital printing technology will help to avoid overproduction," he says. "It also enables customisation for different regions and different markets, rationalised paper assortment, and improved printing quality and colour matching standards."

"We have developed a technology that is able to directly deposit molten metals using a new proprietary inkjet technology"

These improvements are critical for international consumer brands that cannot afford to have any deviation in quality between print runs, while at the same time optimizing flexibility across different regions.

"It is digitisation where the challenges lie," continues Hilkens. "We've decided that inkjet is the way to tackle the challenge. We need engineers who understand materials, micro-mechanics and precision engineering, and areas of simulation such as fluid dynamics."

The Netherlands is well-known for its quality of life, and English is spoken as a second language. But Océ is active across multiple sites in Europe, Asia and North America.

"We have a lot of disciplines – and a global engineering team: it's an international environment," Hilkens explains. "Our talented engineers and architects have many nationalities: Netherlands, Germany, France, Romania, Canada, Singapore and more."

"We consider ourselves to be playing in the Champions' League. You get your players from everywhere, and you want the best. It's a very competitive industry."

The focus is on getting the best out of engineers in an open and entrepreneurial environment. They are expected to take ownership of projects, innovating from their own initiative, with autonomy and responsibility to get the job done.

The digital technology of Industry 4.0 also has a vital role to play in Océ's continued evolution. Already it is central to the development of 3D printing in terms of design, and its influence over Océ's methods and processes will continue to grow. Meanwhile, collaboration remains at the core of the company. In the UK, Océ is working with the University of Nottingham on a number of advanced manufacturing projects, and the UK is a major part of the company's plans for the future.

"We have developed a technology that is able to directly deposit molten metals such as copper, gold and silver using a new proprietary inkjet technology, which we are researching with the university," Hilkens explains. "It has the potential to be used in the manufacturing of 3D products in the future. We do not know exactly what will result from the research, but our ambition is to find a big application for it."

"We understand the value of British engineering. If you want to work in the jet stream of global printing technology, among talented, multinational teams of domain architects, software specialists, engineers, and technicians, there's no better place to be."

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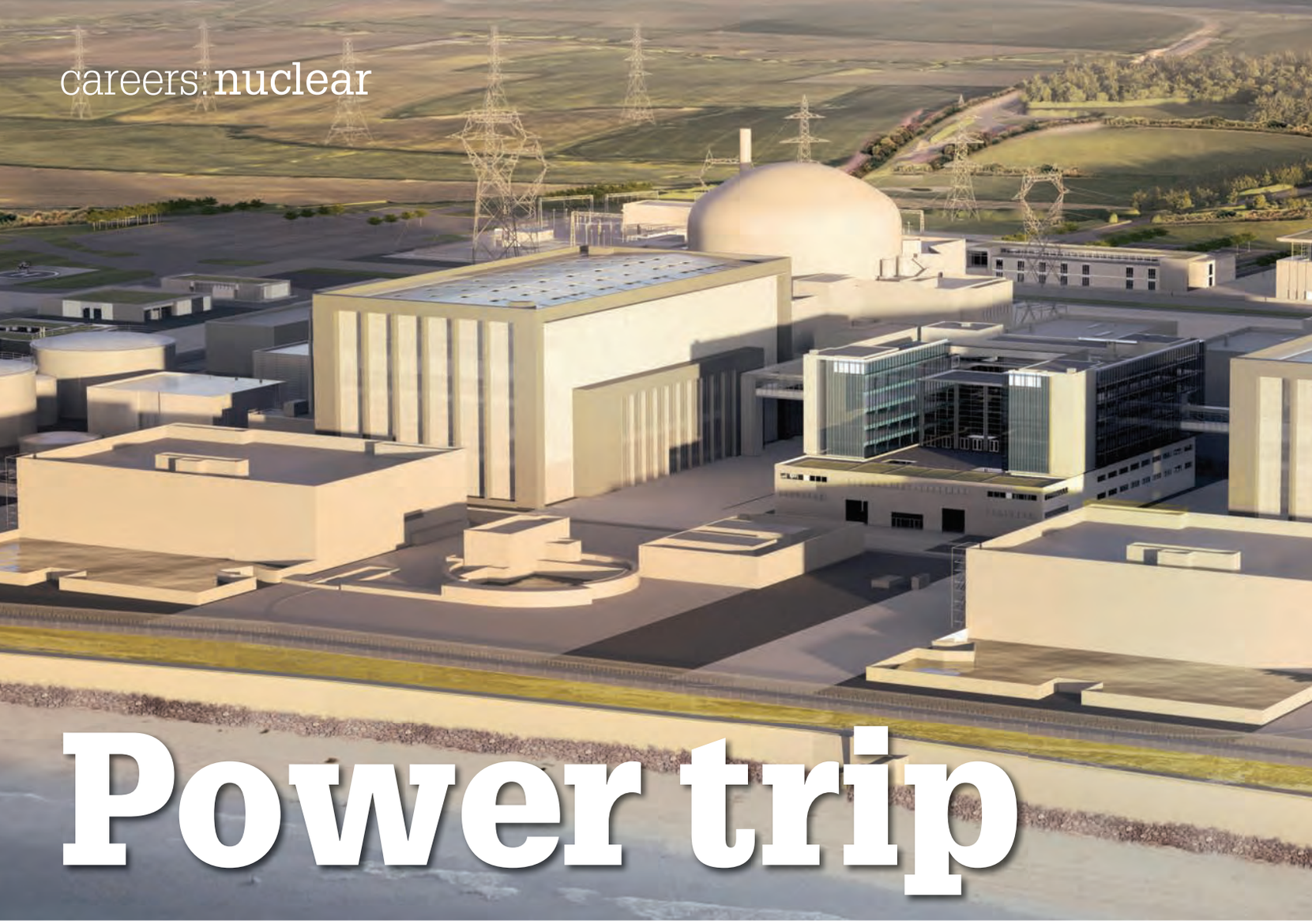


Power trip

As the UK's nuclear plans take shape, so too will career opportunities for engineers in the sector. Evelyn Adams reports

A new era is dawning for the UK nuclear industry. A deal for Hinkley Point, the planned £24.5bn nuclear power station in Somerset, is set to be signed in October. It's a major move for the UK nuclear sector, which hasn't built a new power plant since the 1995 commissioning of Sizewell B.

More deals are expected to follow. There are currently 16 reactors with a total generating capacity of 10GW of electricity in the UK. They produce a sixth of the UK's electricity – yet all but one will be retired by 2023. To replace ageing equipment, companies are investing £45bn in the first three nuclear power plants to be built in Anglesey, Cumbria and Somerset.

Overall, current proposals call for at least 11 new nuclear reactors at five sites: Hinkley Point C and Sizewell C, both developed by EDF subsidiary NNB Genco; Wylfa Newydd and Oldbury by Horizon Nuclear Power; and Moorside by NuGen. These power stations are hoped to produce up to 16GW of nuclear power capacity. But with new power stations being built alongside the decommissioning of existing facilities, the sector is in desperate need of new engineering talent.

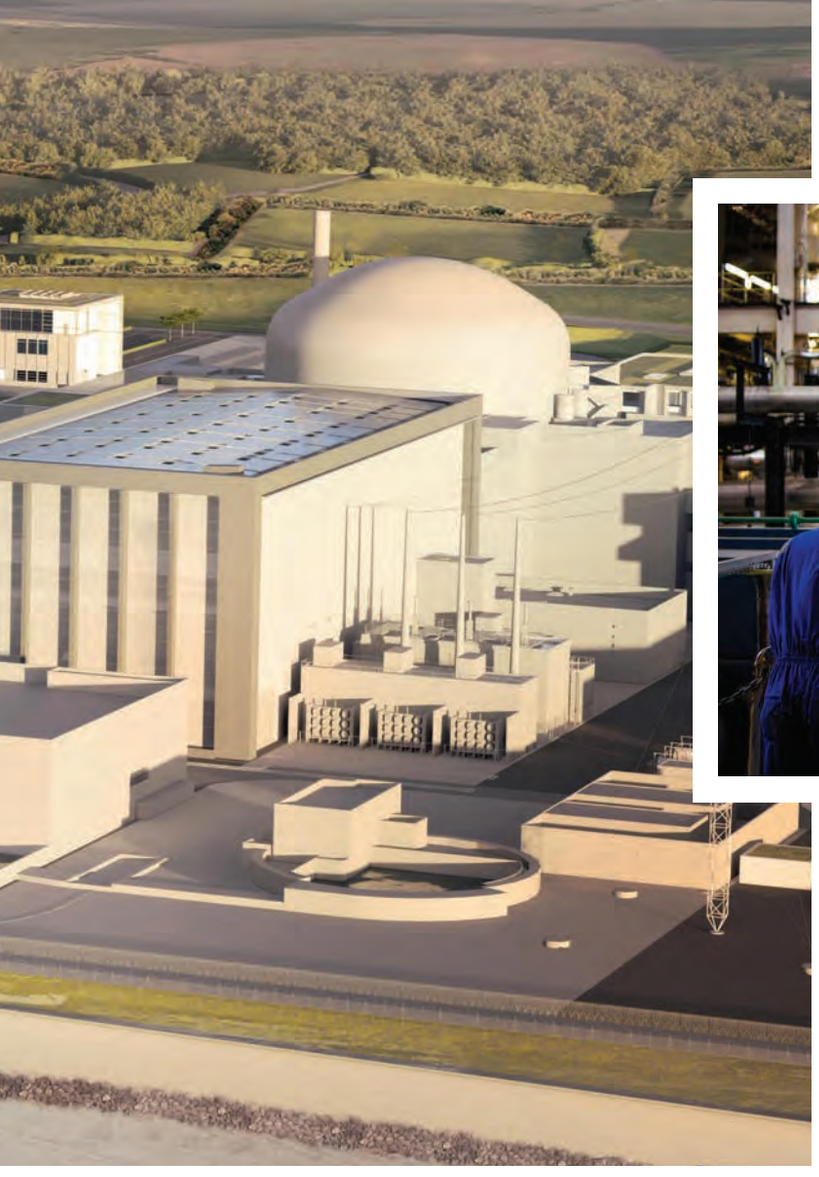
"The industry has effectively lost a generation of nuclear engineers," said Ben Hough, department manager of energy at Matchtech. "There is a demand for skills across almost all nuclear-related disciplines and there are wide-ranging opportunities for engineers in the sector. Mechanical, civil and structural, electrical and manufacturing engineers are in particularly high demand."

The workforce is expected to grow by 4,700 people a year over the next six years. During the same period, 3,900 people are expected to leave the sector. This means that companies in the industry and its associated supply chain must recruit 8,600 engineers each year to plug their current skills gap. Attracting the right talent has so far proved difficult.

There is some uncertainty on the timing and awarding of contracts, which Cogent said has led to some reluctance among SMEs to train and upskill engineers. But engineers who choose to follow a career in nuclear could reap significant rewards.

"Nuclear is a dynamic and innovative industry, and an engineer can expect to join a growing workforce with long-term career prospects, competitive salaries and crucially, challenging and rewarding work," said Hough. "In the UK, the industry will soon be entering a 'renaissance', where the projects in the pipeline offer longevity and take on board unique engineering practices not seen in engineering as a whole."

In terms of technical challenges, the industry also provides an unrivalled opportunity for engineers. Engineers will be needed to manufacture key components such as pressure vessels, heat exchangers



ABOVE: **Workers in the turbine hall at Hinkley Point B**

LEFT: **Artist's impression of twin reactors at Hinkley Point C nuclear power station**

and pipework. Other systems still need to be designed for services to support the plant and deal with its waste, and the infrastructure to manage these projects will need to be built. The major energy companies are focusing on increasing awareness of the sector by promoting STEM subjects at school.

"In the meantime, employers need to take an open-minded approach to recruitment and consider candidates looking to transfer from other sectors, flexible working options to retain and attract talent and work with their retiring workforce to ensure knowledge is passed on to the next generation of leaders," said Hough. "In essence, employers have to look to every source of talent available in order to fill the skills gap now."

Transferring between industries is actively encouraged. "These sectors are often those with complex hazards and high safety cultures, such as oil and gas, marine, defence, rail, pharmaceuticals and aerospace," said Andrew Munro, engineering operations director at Rolls-Royce. "Many design principles are similar but obviously the specific projects and nuclear applications will be different, and there are some codes and standards that are specific to the industry that people would have to learn."

Regardless of the sector, employers like to see proof of 'hands-on experience' and detailed examples of a candidates' project work, he added. For those interested in transferring, they can acquire the relevant skills by taking a specific nuclear course such as the Triple Bar, which has been developed by EDF Energy to provide individuals with a basic level of understanding about working within a nuclear environment.

"Engineering work in the nuclear industry tends to be stable, baseload and in relation to longer-term projects," added Munro. "The benefit of this are continuity and stability of work, and it provides candidates with the opportunity to become technical experts in certain areas. It often involves cutting-edge technology working on technically advanced projects. It can range from concept design through to substantiation."

There a number of disadvantages. EDF said it can sometimes be a slow-moving industry and one that is inherently risk-averse. There are also various health and safety standards that have to be adhered to. According to Martyn Butlin, corporate affairs manager for EDF, work locations are often in remote parts of the country. "Finding city life is hard to find and it can take a long time to become a subject matter expert," she added.

"Another potential drawback is the security-clearance process," said Hough. "Candidates are required to have lived and worked in the UK for a minimum of five years, depending on the level of security clearance required. This process can hinder attracting suitably skilled workers from overseas, including UK nationals who may have chosen to live and work overseas for a period of time. While the security-clearance process is in place for good reasons, there may need to be a review of the process if it continues to hinder the sourcing of talent."

"An engineer can expect to join a growing workforce with long-term career prospects

But the industry leader agrees the benefits outweigh the disadvantages for the right candidate. The problem is in communicating that to the wider public. The UK has historically relied on nuclear energy, and it could do so once again if the skills gap can be addressed. This is a tough challenge, but one the industry must grasp. If it fails, it will be doing the sector, and the UK as a whole, a disservice.

Artist's overhead view of Sizewell C

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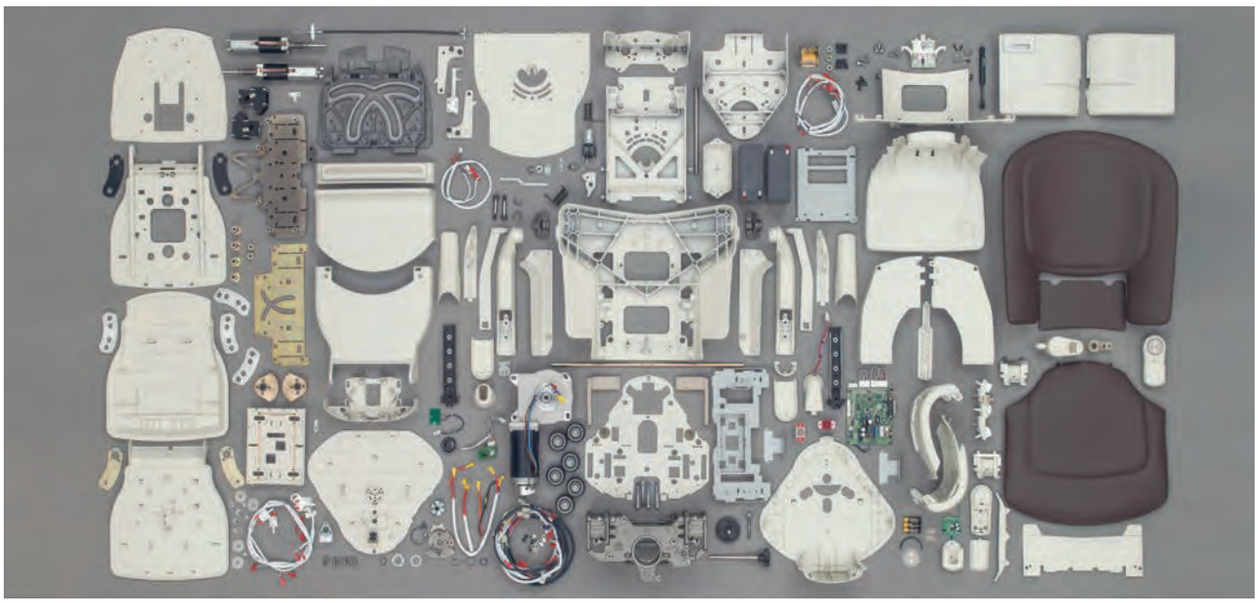

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To apply please send Covering Letter, CV and current salary details to:
Carol Entwistle, HR Manager, Amphenol Advanced Sensors,
Crown Industrial Estate, Priorswood Road, Taunton, TA2 8QY
or via email to: carol.entwistle@amphenol-sensors.com

Closing date for applications: 30th September 2015

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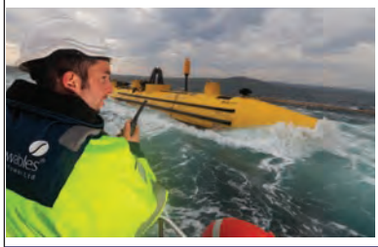


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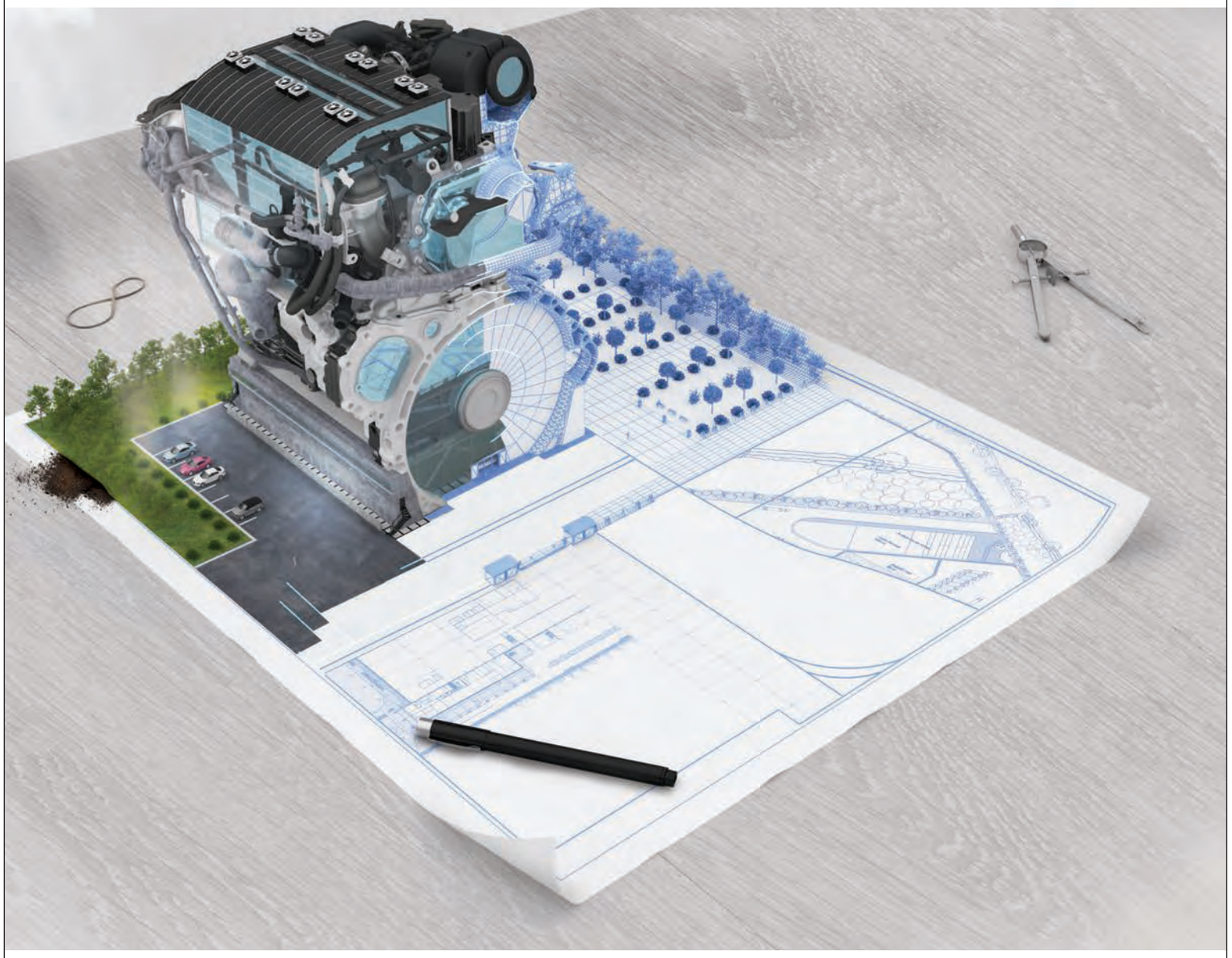
The Person

You must have:

- extensive management experience within leading edge manufacturing engineering
- a degree in Engineering
- a passion for Engineering and for learning
- the vision and drive to grow this priority area for the College.

For an informal discussion about this position with Anita Straffon, Vice Principal, please contact **Tracey Burgin** on **0300 123 7890** ext: **3495**.

JAGUAR LAND ROVER



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Experience Required

- Successful track record as Senior Business Development Manager / Director
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- Natural ability to support a broad range of clients and multiple stakeholders

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- Creation of an effective sales strategy
- Creation and management of business development and key accounts processes
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- Responsibility for the sales / bids & tenders team (4 in total)
- Mentoring and developing the senior staff in sales techniques
- Achieving and surpassing revenue targets
- Up-selling and cross selling additional services and solutions
- Bid presentation at board level
- Creation of management reports

Technical Skills/ Experience

- A technical degree or HNC (ideally engineering)
- Experience managing multiple bids simultaneously within the engineering field
- Word and PowerPoint at an intermediate to advanced level
- A good standard of literacy and numeracy is essential

Travel

Role requires UK based travel on a regular basis. The successful candidate must expect to be off site 2/3 days per week.

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To apply for the position, please contact Ben Pascall on 0161 707 1516 ben.pascall@morson.com

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This would be complicated enough, but because the pond is an aging facility, there is no detailed inventory. A standard ROV can give us access to the skips closer to the surface, but there's no way something of that size could access those at the bottom. Potentially, a major obstacle for the whole process. Finding a way around this couldn't be more important – the positive impact of safely transforming a facility like this will affect the lives of millions across the UK for generations. There's absolutely zero margin for error. Welcome to a 100-year mission. Welcome to design engineering at Sellafield Ltd.

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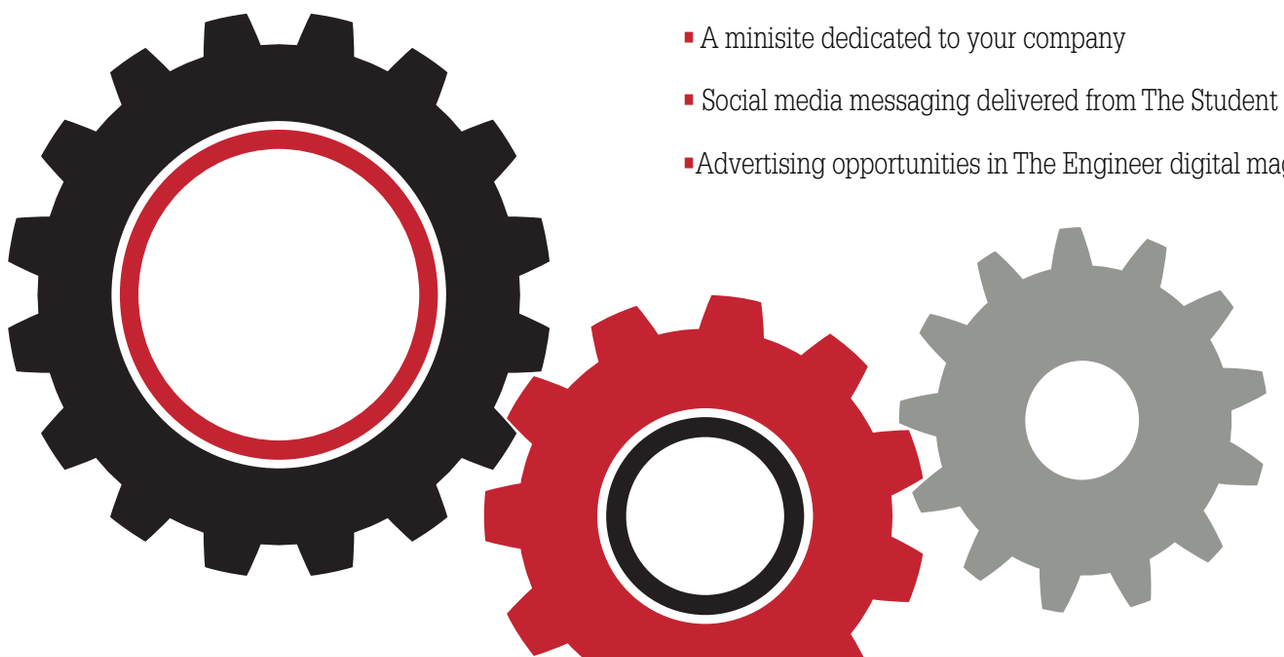

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august1915

The Engineer's opinions on the forerunners of today's Research Councils were sceptical and, to our contemporary eyes, surprisingly jaundiced

These days, *The Engineer* gets quite a few of its research stories by looking at who's been awarded EPSRC grants. One of this organisation's main forerunners, the Board of Invention and Research, was set up by the Royal Navy a century ago, and it's fair to say that our predecessors met its formation with a fair amount of scepticism.

At the root of *The Engineer*'s concerns was the composition of the board. The problem? Not enough engineers.

Unsurprisingly, all of the board members were men. The chairman was Admiral Lord John Arbuthnot Fisher who had recently retired as First Sea Lord because of a disagreement with Winston Churchill.

Fisher was instrumental in switching the navy from wooden warships to steel-hulled battlecruisers, submarines and the first aircraft carrier (and is also credited by the *Oxford English Dictionary* with the first use of the now-ubiquitous text-speak abbreviation OMG for Oh My God, so now readers know who to blame).

> **"Few have been active in applied science and still fewer are engineers**

Fisher's co-board members included such illustrious names from the period as JJ Thompson, discoverer of the electron; Ernest Rutherford, the splitter of the atom; and crystallography pioneer William Bragg.

Looking at this list today, *The Engineer*'s comments that: "They are all men eminent in abstract science but few, we regret to say, have been active in applied science and still fewer are engineers," seem churlish to say the least.

In the very same week, the Board of Education issued some "particulars for a scheme for the organisation and development of scientific and industrial research".

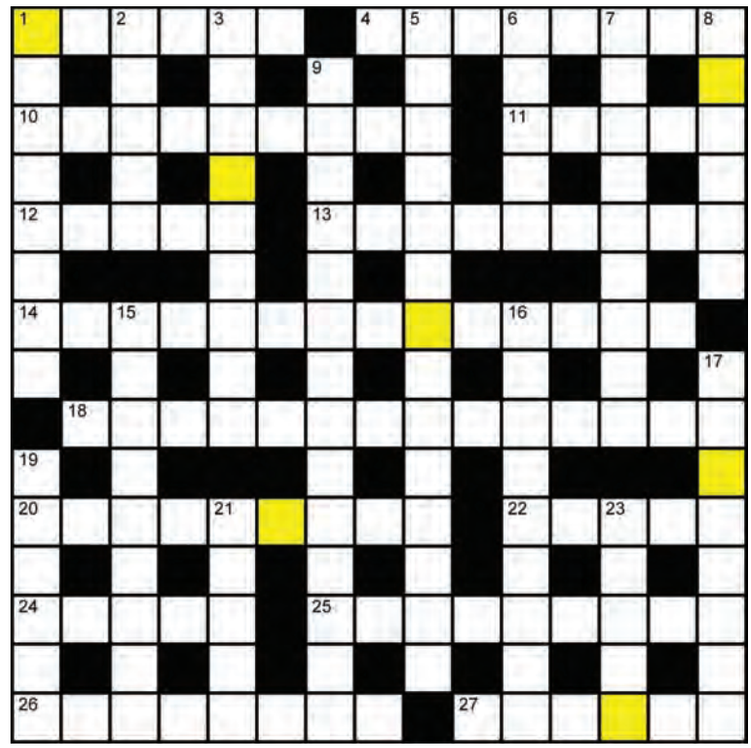
This would not overlap with the Admiralty's board, but would make proposals for specific research and for establishing institutes or departments for studying problems affecting specific industries or trades.

It must have been a bad week at the office, because *The Engineer* didn't think much of this either. "It is too soon yet to say whether this body will be of any value to the country or not," it said. "It must expect a certain amount of resistance from industries which are anxious to retain their so-called trade secrets and will do nothing to encourage research, the results of which are to be given to all and sundry." ***SN***

For more on this story visit **www.theengineer.co.uk**

prizecrossword

When completed rearrange the highlighted squares to spell out a fortress that protects a town. The first correct answer received will win a £20 Amazon voucher. Email your answer to jon.excell@centaur.co.uk



ACROSS

1 Covering that serves as a roof to shelter an area (6)
4 Moves faster (6,2)
10 Conductor used to make contact with some part of a circuit (9)
11 Organisation of employees (5)
12 Malicious burning to destroy property (5)
13 Old form of stage lighting (9)
14 Area where petrol and oil are sold and with repair facilities (7,7)
18 Maintenance of standards of manufactured goods (7,7)
20 Entrance to the back area of a theatre (5,4)
22 Of an order of classical Greek architecture (5)
24 Massive horned animal (5)
25 Not able to be read (9)
26 Spools of twisted cables (8)
27 Thin pieces of wood used to light a fire (6)

DOWN

1 A deep fissure (8)
2 Requires as useful (5)
3 Difference in electrical charge between two points in a circuit (9)
5 Noisy tool powered by compressed air (9,5)
6 Be identical or equivalent to (5)
7 Rotating entrance (5,4)
8 Container filled with toys that is broken open with sticks (6)
9 Destructive to the spirit (4-10)
15 Of a republic in south eastern Europe (9)
16 Becoming nervous or uneasy (7,2)
17 Makes loose by lessening tension (8)
19 Written agreement for contract (6)
21 Bacterium that can be a threat to food safety (1,4)
23 Swedish chemist remembered for his invention of dynamite (5)

July's highlighted solution was Warehouse

origineering

Anthony Poulton-Smith explores the origins of everyday engineering terms

Early man's mastery of fire is among the biggest evolutionary milestones. This does not mean 'fuel' is one of the earliest words, on the contrary it is surprisingly complex for a word of four letters.

Coming to English from the French foaille, the modern French fouallier means 'wood yard'. Both are derived from Latin focalia meaning 'the right to demand material for making fire', i.e. the right of every individual to cut wood (or peat) for fuel. We can trace this Medieval Latin term back to earlier forms focalia 'brushwood for fuel' and focalis 'pertaining to the hearth'. It is easy to recognise the latter from Latin focus meaning 'hearth' and also used to mean 'home' and even 'family'. Looking at this in reverse makes it easier to understand. The hearth would have been the focal point of a home or room for millennia. The word for the hearth also referred to those gathered around the heat source and what was being burned.

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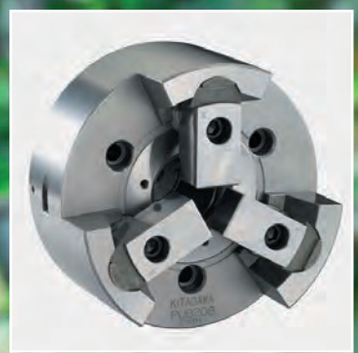

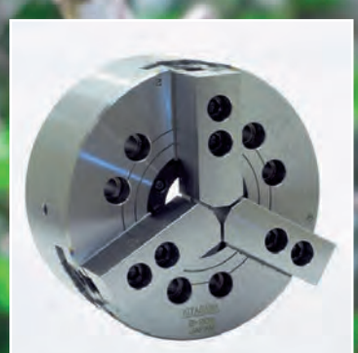

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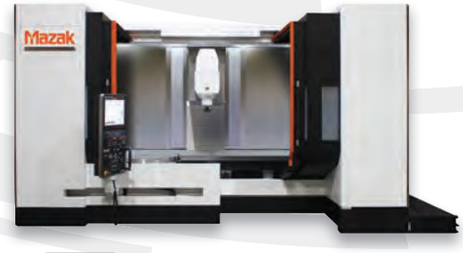

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