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Tricky business

It seems like only yesterday that *The Engineer* was heralding a new golden age for North Sea oil exploration. Rising prices, and the promise of huge untapped reserves in the deep waters west of Shetland, were, we reported, driving investment in the sector and fuelling a fresh era of exploration and development not seen since the glory days of the 1980s.

These heady predictions may, of course, still come to pass – after all, there's still thought to be around 24 billion barrels of the stuff beneath the North Sea – but for the time being, as we report in this issue's cover story (page 20), the industry's biggest technical focus is dealing with the huge amount of decommissioning work (much of which was planned before the current downturn) that must happen over the next few years.

While exploration and discovery have more than a whiff of excitement and glamour about them, decommissioning sounds like a pretty strange thing to get excited about. It carries with it connotations of industrial decline and economic stagnation rather than engineering derring-do.

But, as we report over the following pages, with almost 1,000 North Sea wells due to come out of production over the course of the next decade, decommissioning is a big and technically complex business. To pick one of the many staggering challenges discussed in our report, Shell's Delta platform – one of the cornerstone's of the iconic Brent oil field – will be removed in a single 23,000-tonne piece by a giant purpose-built lifting vessel. If that isn't inspiring engineering, I don't know what is. And by dealing with challenges of this magnitude, the UK stands to gain valuable experience in a field that's only going to get bigger in the years ahead.

"Shell's Delta platform will be removed in a single 23-tonne piece

From an industry in decline to a technology that looks set to shape our future in all manner of ways: this issue's Q&A (page 30) looks at the incredible world of 3D bioprinting, the use of additive technology to print biological tissues and organs that can be transplanted into the human body. It's an emerging area that barely existed outside the realms of science fiction 10 years ago, but, as our panel reveals, has come a long way in a short space of time, and represents a fascinating example of how engineering is increasingly crossing over with other once unrelated disciplines.

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ROBOTICS

Mapping out the future

Research could lead to development of pervasive mobile robotics

BY JULIA PIERCE

Scientists are developing situation-aware mobile robotic systems suitable for applications such as transport, logistics, space, defence, agriculture and infrastructure management.

Led by Prof Paul Newman of Oxford University's Department of Engineering Science, the programme, which has been awarded a £5m EPSRC grant, will include partners such as Ricardo, OC Robotics, MIRA, Network Rail, the Fraunhofer Institute, Amey, the UK Space Agency, BP Global and Nissan.

The project's aim is to create the world's leading research programme in mobile autonomy. To do this, it will have to overcome some of the fundamental technical issues that have so far prevented the large-scale adoption of mobile robotics by industry and society, such as a need for them to be cheap, to work co-operatively with people in large, complex and time-changing environments and to do so for long periods of time, all while remaining safe and trusted.

Using the mathematics of probability and estimation, computers in robots will be enabled to interpret data from sensors such as cameras, radars and lasers in order to form a map of their surroundings. Using this map, the robotic systems will be able to localise themselves, determining their own position in their environment. They will then be able to identify the objects around them and match live imagery with a pre-existing database to figure out where they are, where to go and what to avoid, accounting for changes such as reduced or increased lighting. The group also hopes to reduce reliance on expensive sensors by engineering technologies that lower the cost of autonomy and enable cheaper sensors to be used.

"Surveying is an important part of our work," said Newman. "Many of our algorithms rely on detailed and accurate surveys of the environment to function. The NABU [a data collection unit and map generation device] generates detailed maps so that our robots can subsequently navigate using them. However, there are other applications for this technology, which may become marketable in the near future."

The research programme will contain a number of separate Flagship projects covering applications such as personal transport, inspection and logistics.

In the automotive sector, the team will look at autonomous driving and advanced driver assist technologies such as personalised mobility pods. Meanwhile, the Inspection Flagship will concentrate on inspection and mapping from moving platforms, such as those used during the inspection of nuclear and chemical plants, roads and rail. This will create challenges, as the areas to be mapped will range from areas of a few metres to hundreds of kilometres, and the robotic systems will have to learn how to move in order to create maps of their surroundings. If successful, developments here could have a huge impact on the costs of decommissioning in the UK's nuclear industry and the North Sea.

As the research progresses and the technologies within it develop, they will be rolled out virally to all of the projects across the programme – for instance, a new surveying system could be rolled into mapping as well as the mobility pods to find out which parts of it are robust and which will need more development work.

"As always with robotics, it is the unusual events that are intrinsically difficult to solve as they don't happen very often," said Newman. "Another challenge is for the robot to have some sense of its own performance.'

The research is scheduled to start in March 2015 and conclude by February 2020.

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ELECTRONICS

Core curriculum

Faster Raspberry Pi brings low-cost computing power to education

BY STEPHEN HARRIS

Raspberry Pi has launched a six-times-faster version of its credit-card-sized computer, providing PC-equivalent power for less than £30.

The Raspberry Pi 2 has four times as many processor cores and twice as much memory as its predecessor – the four-million-selling device designed and made in Britain as a cheap way for children to learn programming – and can run Windows 10.

"It's about user-interface responses: it's just snappier; everything happens faster," said Eben Upton, founder of the non-profit Raspberry Pi Foundation that produces the computers.

"We'd like to sell a total of three million in 2015. A lot of existing Raspberry Pi users are going to upgrade, but the interesting thing about Pi 2 is it broadens the market a little bit in that we hope to stand a chance of customers using it as a second PC in their house."

Although designed as an educational tool, the original Raspberry Pi has been widely embraced, with the computer being used for a wide range of industrial and commercial applications from security systems to heating and ventilation to factory automation.

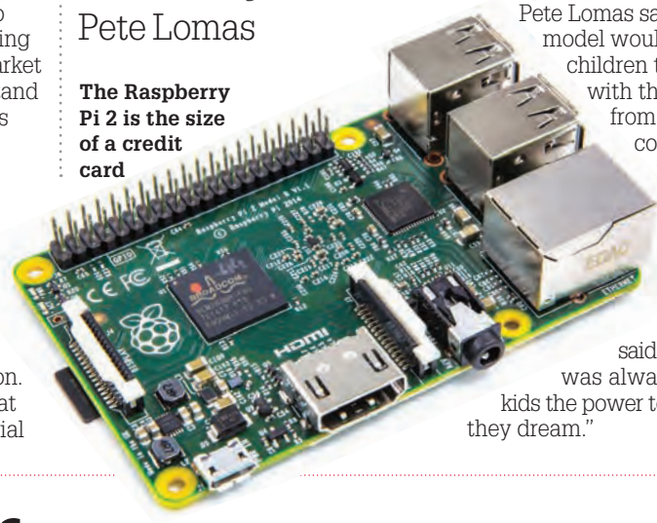
Upton said he suspected that a significant number of industrial customers would keep using the Pi 1. "Often they don't really mind how much CPU performance they get; they just want something stable and cheap that works sufficiently for them. I think there is a world of industrial customers for the Pi 2 that are doing things in vision. It's really pushing out the edges of the industrial market."

Upton said that the biggest challenge for the engineers was hitting the price point of $35 (£26), which was required to ensure it was cheap enough to be widely affordable for children and teachers.

"There was a lot of exciting engineering at the silicon level," he said. "At the board level, it was two things: one was making room for the extra silicon. Quite a lot of that cost engineering first appeared on the B+ [the Raspberry Pi 1's upgraded model], finding more cost-effective ways of combining components."

The other challenge was moving from a package-on-package system where the memory was part of the main 'system-on-chip' to a discrete system with a separate chip that could provide more memory but that required a more complex way of communicating with the rest of the computer.

> **"The aim was always to give kids the power to do what they dream**
> Pete Lomas



The Raspberry Pi 2 is the size of a credit card

Raspberry Pi hardware designer Pete Lomas said the new model would enable children to do more with their computers, from creating more complex games to controlling robots. "If anything's going to get kids excited it's robots," he said. "The objective was always to give kids the power to do what they dream."

MEDICAL

Testing for a tenner

Device can be used at home to determine kidney disease

BY JULIA PIERCE

A new £10 medical device that combines nanotechnology with a pregnancy-test-style kit could enable the day-to-day monitoring of kidney disease by patients in their own homes.

Kidney dysfunction places suffers at increased risk of cardiovascular disease and acute kidney injury. Every day, 19 people in the UK are diagnosed with kidney failure, with dialysis treatment for each of those awaiting a transplant costing the NHS more than £25,000 per year. As a whole, kidney disease currently costs the NHS around £1.4bn – more than breast, lung, colon and skin cancer combined.

At present, the progress of kidney conditions is monitored through regular testing of urine. However, these tests can't be carried out at the point of care – instead, the sample must be sent to a laboratory by a GP or nurse, with a wait of several days for the results.

Created by Bio Nano Consulting, a company jointly owned by Imperial College London and University College London, the new device – called quantitative electrochemical lateral flow assay (QELFA) – uses nanoparticles to determine the exact amount of protein in a patient's urine. The device is dipped into a urine sample, giving a result as an exact number.

The QELFA test can be used by a patient at home, and gives a result in seconds. It can also transmit the protein level to the patient's surgery via mobile technology for monitoring by health professionals.

"Like a glucose monitor, QELFA is quick and non-invasive," said Dr Paulo Actis, Bio Nano Consulting consultant and project manager. "Over the next 18 months, we will be taking the device from the laboratory to the prototype stage. Its development fits in well with the NHS five-year plan, which involves decentralising medicine."

inbrief

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Tight ship
BAE Systems has signed a contract worth £859m with the Ministry of Defence to continue with the progression of the Type 26 Global Combat Ship. Designed to replace the Royal Navy's Type 23 frigate, the Type 26 will fulfil a number of joint and multinational operations including warfare, counter-piracy, humanitarian and disaster relief operations.

Right on target
Graphene has been used to target and neutralise cancer stem cells while not harming other cells. This development from Manchester University opens up the possibility of preventing or treating cancers using a non-toxic material. The researchers have shown that graphene oxide acts as an anti-cancer agent that selectively targets cancer stem cells. In combination with existing treatments, this could eventually lead to tumour shrinkage.

Closing the gap
Ricardo has designed and built a prototype electric vehicle motor. The 85kW synchronous reluctance electric motor uses a conventional distributed stator winding and has a rotor made from cut steel laminations that are used to direct and focus flux across the air gap. By maximising this flux linkage between the stator and rotor, performance can be optimised within a low-weight and rare-earth element-free design.

Bank job
Consent has been granted for offshore wind energy at Dogger Bank in the North Sea, a development that marks the largest renewable energy project to receive planning consent in Britain to date. The 2.4GW Dogger Bank installation is also the largest offshore wind project to receive consent globally.

"Government-backed traineeships drive talent to us"

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Plane sailing thanks to vector thrust system

Breakthrough in propulsion technology could help to improve flight comfort

BY JULIA PIERCE

Shorter take-offs and landings for aircraft and better manoeuvreabilty for unmanned aerial vehicles (UAVs) are just two of the possible benefits of an EU-supported breakthrough in propulsion technology.

The vector thrust system developed by the ACHEON project is capable of directing the flow and pressure output of an aircraft engine to control its direction using a special nozzle that does not require additional mechanical moving parts, thus overcoming the main limitations of traditional vector thrust technologies, which are complex and costly.

The project involved six universities and two research organisations from across the EU, including a team at the University of Lincoln's school of engineering, which was responsible for evaluating the technology and its potential integration within aircraft. The research was funded by the 7th Framework Programme of the European Commission, which supports projects starting from academia that have promising potential industrial applications.

The nozzle's design is based on two technologies: the HOMER nozzle concept by the University of Modena and Reggio Emilia, Italy; and PEACE – Plasma Enhanced Actuator for Coanda Effect – that enhances the effects of the nozzle, created by the University of Beira Interior, Portugal.

The Lincoln team evaluated the technology for a number of potential applications, including a UAV, a vertical take-off and landing (VTOL) military-type application and both a large and small passenger transport aircraft.

As well as looking at the aerospace sector, the team is now evaluating how the nozzle technology could be used in other industrial applications, such as in the agricultural sector, where this could help farmers develop closer control of the areas sprayed with agrichemicals. It could also be used to develop more accurate printing processes.

The consortium is hoping to continue the project with the development of a fully functional flying prototype, with help from their partners, the Vrije Universiteit Brussel, Belgium, Nimbus SRL and Italy's Reggio Emilia Innovazione.

"We have proved the concept, but the technology now needs to be refined," said Tim Smith, senior research fellow at the University of Lincoln. "We are most likely to do some more work with UAVs when it comes to building a demonstrator, as the increased manoeuvrability the system provides is very attractive here."

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SENSORS

Light relief

Ultra-sensitive UV sensor could pave the way for improved fire and gas detection

BY JULIA PIERCE

Researchers at Surrey University's Advanced Technology Institute (ATI) have created an ultraviolet (UV) light detector that is 10,000 times more sensitive to UV light than a traditional zinc oxide detector – paving the way for improved fire and gas detection.

Currently, photoelectric smoke sensors detect larger smoke particles in dense smoke, but are not as sensitive to small particles of smoke from rapidly burning fires.

The ATI team transformed zinc oxide from a flat film to a structure with bristle-like nanowires. This increased the sensor's surface area and so its sensitivity and reaction speed, allowing it to detect distinct particles emitted at the early stages of fires.

As well as fire detection and air pollution monitoring, the team believes the sensor could also be incorporated into personal electronic devices, such as phones and tablets, to increase the speed they can interpret inputs.

"We grew the zinc oxide nanowires and nano-syringes directly on the electrodes of the device. The beauty of the system we have developed is that the growth can be done in situ, at low temperatures and even on plastic substrates for flexible and maybe even transparent devices," said Prof Ravi Silva, co-author of the study and head of the ATI.

"We are in the midst of talking to interested parties in a number of fields to engage with the many forms of designer nanomaterials we can produce in a manufacturable manner. By mixing these with organic materials, it opens to door for bespoke solid-state flexible and large-area devices that can be used in UV detectors, X-ray detectors, solar cells, lighting devices, transparent conductors, touch panels and so on."

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AEROSPACE

Flying start

Testing has begun on the engines for Airlander: the world's largest aircraft

Hybrid Air Vehicles has started the Airlander 10 engine programme, a series of full engine tests to bring the world's largest aircraft into commercial operation.

The 92m-long Airlander can take off and land from a range of surfaces – including water – and four 325hp, four-litre V8 direct-injection, turbocharged diesel engines help to keep the aircraft aloft for five days.

In flight, two engines are mounted forward on the hull and two on the stern of the hull for cruise operation. All four are configured in ducts with blown vanes to allow vectored thrust for take-off/landing/ground-handling operation.

The current engine tests are focused on identifying future improvements to Airlander's propulsion systems prior to a series of trials and demonstrations with customers during 2016.

The latest milestone in Airlander's development has been made possible with assistance from a £3.4m Regional Growth Fund Grant.

Innovate UK's LOCATE (Low Carbon Aircraft Technology Experimentation) programme has supported key work in aerodynamics, automation and manufacturing technologies. ***JF***

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The technology brings freedom of design to large structures

3D PRINTING

Huge printer whips designs into shape

3D technology produces concrete moulds

BY JULIA PIERCE

A giant 3D printer capable of producing moulds up to the size of a phone box will allow architects to bring their creativity to life through the creation of freeform concrete designs.

Architects have long complained that concrete forces their ideas into flat and angular shapes. However, a partnership of industrial 3D printing and 3D engineering company 3Dealise and Dutch construction company Bruil has resulted in the development of a technology that brings freedom of design and other such benefits of 3D printing to large-scale concrete structures.

According to its developers, the new technology will help architects as they are no longer constrained by technical limitations and can create irregularly curved surfaces, lightweight half-open mesh or honeycomb structures and even ornamental craftwork.

> **"The moulds can be stacked like Lego to produce larger shapes**

3Dealise's printer can create moulds with a build volume of 1,800 x 1,000 x 700mm within 24 hours. The moulds then receive a special treatment to enable later separation from the concrete, which is poured into the mould to create the design.

Bruil has created shapes from their range of concrete options including fibre-reinforced concrete, a material that enables the resulting structures to be used for real-world applications.

When the concrete has set, the mould can be removed with pressurised water. The moulds can also be stacked like Lego to produce larger shapes.

"When you cast concrete using sand, the sand sticks to the concrete," explained 3Dealise chief executive officer Roland Stapper. "We have developed a process to stop this happening. If you were pouring concrete into a wooden mould, you'd coat the surface of the mould with oil to stop the concrete sticking to it. We have a similarly developed substance here to stop the concrete sticking to the printed mould."

Stapper explained that they are refining a process originally developed for the casting of metals. "Normally, metal is cast in sand – it is a process that has been used for around 4,000 years,' Stapper explained. "Using our printer, we are essentially recreating this process, minus a step.

"As well as concrete, we can cast iron, steel, bronzes and so forth, and we are now looking at how to cast plastics and also rubbers – anything that you can pour, really.'

SOFTWARE

Suite success for design engineers

Process changes can be rendered using VR

BY JULIA PIERCE

Running a computer simulation of a 'what if' scenario on a production line or explaining a new design to colleagues is all very well – but imagine being able to explore both in a fully textured, lifelike 3D virtual landscape.

That's now possible, thanks to the development of an immersive 3D virtual reality (VR) system that can be fully integrated with process simulation.

Developed through a partnership of VR specialist Virtalis and predictive simulation software company Lanner, the technology combines Lanner's predictive simulation software, WITNESS, with Virtalis's Visionary Render software systems to create Visionary Render for WITNESS, which allows operators to connect and extend WITNESS simulation workflows directly into a full VR suite.

Here, they can import CAD models of their workplace and equipment and enhance them with textures and shadows to create a detailed environment for tasks such as performing distributed model reviews, discussing design concepts and exploring new maintenance procedures, even at 1:1 scale.

Users can work alone or in groups, or can collaborate with distant colleagues in a virtual world created from 3D object libraries and CAD/PLM datasets, all of which should allow even non-technical personnel to literally see the effects of new designs or changes.

"Visionary Render for WITNESS gives the opportunity to get inside your simulation environment and interact with it in real-time 3D/VR to provide an unparalleled method for understanding and communicating ideas, concepts and results," explained Steve Carpenter, sales director at Virtalis.

"While a WITNESS user can develop solutions to optimise facility designs or production and logistics processes, the issue of how to visually review and communicate these findings to colleagues and stakeholders has been a challenge," he added. "Using VR provides an extremely powerful and advanced communication approach to address these challenges."

HEALTHCARE

Matter in hand

Three teams set to develop assistive devices

A prosthetic hand that provides sensory feedback is one of three projects to share £5.3m in funding to develop assistive and rehabilitative devices.

The funding from EPSRC will also see the development of robotic clothing to help people with walking, and biosensors to monitor how patients go about their rehabilitation.

The three projects wil start work in the spring and are led by the universities of Newcastle, Bristol and Warwick, working with 15 other university partners.

Philip Nelson, chief executive of EPSRC, said: "These research studies will improve patients' lives, allow greater independence and benefit patients with a wide range of mobility and co-ordination difficulties.

"With the UK's ageing population and a rise in disabilities, this highlights one area of EPSRC investment in healthcare research that has a national impact."

The Newcastle-led team will develop a prosthetic hand that will give users a sense of feedback. The team will build fingertip sensors to give the prosthesis a realistic sense of touch, including pressure, shear and temperature. *JF*

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Intellectual decision

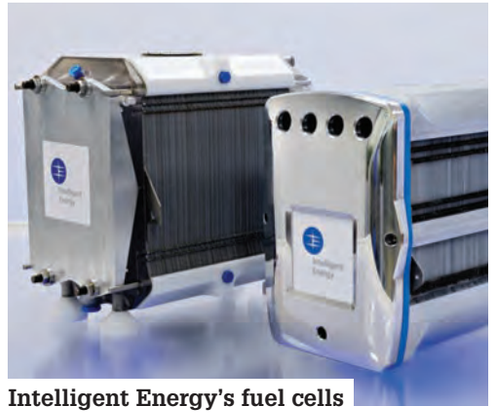
Toyota's offer of free fuel-cell-related patents is good news for everyone in the automotive sector, says James Batchelor

Toyota's announcement at CES in January certainly helped to move the needle on consumer awareness of fuel-cell electric vehicles (FCEVs). When the biggest automotive manufacturer in the world – a company that sold 10.2 million vehicles in 2014 – puts an offer of royalty-free technology on the table, it's going to grab headlines. And that's exactly what happened, with the news that thousands of fuel-cell-related patents were being made available 'for free' quickly jumping the often impassable divide between automotive technology media and mainstream consumer news, via business newswires on the way.

Those hoping for a vigorous anti-Toyota argument from the independent automotive fuel-cell sector here will be disappointed. Their marketing machine did a great job, choosing the fashionable Consumer Electronic Show instead of the obvious option of the venerable North American International Auto Show in Detroit the following week. They presented the media with a story about a huge number of patents, all available at no-cost for years to come. What was there not to be positive about?

Intelligent Energy welcomed Toyota's announcement at the time and we stand by that sentiment. This kind of visibility is exactly what is needed to stimulate an informed debate that will drive greater understanding of the benefits that hydrogen fuel-cell technology brings to the automotive sphere. First-generation FCEVs are here now, and by the time the next generation of vehicles arrives around 2020, awareness will have increased significantly. But that doesn't mean the fuel-cell technology industry can afford to sit back and wait for consumers to realise that FCEVs offer an attractive and practical zero-tailpipe-emissions solution.

Toyota's patent announcement is good news for everyone involved and that includes those of us with competing or complementary technologies. But is free intellectual property (IP) a game-changer? Should we be worried? You may not be surprised to hear that there isn't a simple answer to that, not least because there are two different aspects to Toyota's arrangement, a factor that only became apparent when the detail was scrutinised – after the media excitement had faded.



Intelligent Energy's fuel cells

One part of the deal is that Toyota will make available patents that apply to hydrogen refilling stations (HRSs), royalty free in perpetuity. So among those 5,680 patents, any of the knowledge that relates to refuelling infrastructure – essential for FCEVs to prosper – is there to be used. By anyone who wants to take advantage of it. Free of charge. Forever.

> **"By entering into the right partnership, a car manufacturer will receive the know-how it needs**

This is a lasting commitment that offers the wider industry a potential 'kick-start' as well as real long-term value. If motorists can easily refuel an FCEV, they are more likely to buy or lease it in the first place. Plans to install refilling infrastructure are gaining momentum in key markets and Toyota's offer can only be seen as a positive move that will assist the process.

The other part of the offer relates to vehicle technologies, offered royalty free until 2020. This sends more powerful signals: here is a vehicle maker prepared to share the results of research and development that probably cost billions of dollars, which had been designed to give it an edge over the competition in an exciting new area of personal transport. All true to a degree, yes, even if there is a timeline attached, but there is more here to explore.

We are in an era where all the major companies involved in automotive fuel-cell technology are working together to drive early-stage growth in the FCEV market. We work with government and other stakeholders country by country, discussing standards, addressing challenges and planning the roll-out of an FCEV future together. In Britain, this operates as UKH2 Mobility and the process is mirrored throughout the world.

So there is already a significant element of co-operation. In many ways, the offer made by Toyota is similar to one of the business models that Intelligent Energy provides: the licensing of IP and technology is our bedrock. We can offer a similar commercial framework, working with vehicle makers on programmes based around our proprietary fuel-cell technologies that deliver the highest power density available.

And therein lies the reality. Technology patents are only part of the equation. In order to implement the technology as part of an electric driveline, a vehicle manufacturer needs to have access to the full scope of development activity needed to progress the programme. The likes of Toyota, Honda and Hyundai have that capability on their own. Others will follow a different route. By entering into the right partnership, a car manufacturer will receive the know-how and support it needs from a provider that can supply experienced engineering resources to complement existing in-house capability.

In offering to share its patented fuel-cell technologies at a vehicle level, Toyota has highlighted to manufacturers the attractiveness of the technology licensing route as a way to accelerate their entry into a market segment they cannot afford to ignore. The more momentum builds towards a hydrogen fuel-cell future, the better it is for the technology leaders involved – and the greater the potential benefits to the motorist and the environment.

James Batchelor is managing director of Intelligent Energy's Motive division

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inouropinion

Why apprenticeships can't just materialise

Apprenticeships have come under scrutiny in the latest round of electioneering, but they're too important to be relegated to politicians' petty point scoring

The electioneering bandwagon rolls on, and much to our surprise draws battle lines over a subject of much relevance to engineers and manufacturers. Recently, Ed Miliband and colleagues set up their lecterns at Jaguar Land Rover's Wolverhampton factory, where they outlined a pledge for all school leavers "who obtain the grades" to be guaranteed an apprenticeship – a total of 80,000 new places. This would be funded by a levy on bank bonuses.

The Conservatives responded with a plan to create three million apprenticeships, funded by a benefits cap, while business secretary Vince Cable claimed that the fall in apprentice numbers under the Coalition concealed an increase in "more advanced appprenticeships".

While it's good to hear politicians supporting apprenticeships, which *The Engineer* has long advocated as a valuable route into engineering, it's hard to take these promises and claims at face value. The most obvious response is that only employers can create apprenticeships. Governments can't; and throwing money at employers, whatever the source, isn't going to make them appear.

"It's not enough for politicians to just talk of guaranteeing apprenticeships

It's worth going back to basic principles and looking at what an apprenticeship is supposed to be.

It isn't a company training course. It's a programme of structured learning, organised around professional tasks (apprentices are employees, after all) supervised by mentors, interspersed with appropriate and relevant education and ending with a recognised qualification.

If that then ends with a job at the appropriate level with the company that provided the apprenticeship, then that's a definite bonus; and if the apprenticeship is funded from the public purse (making apprentices effectively subsidised cheap labour), it could even be seen as a prerequisite.

It clearly isn't something simple that any employer could just throw together. It needs designing; it needs collaboration with an institute of higher education to match up on-the-job tasks with appropriate academic content. Mentors might need to be trained.

Smaller companies on important supply chains, often the repository of much expertise, are likely to be the ones that lack the resources to set up apprenticeships, yet also the most likely to offer valuable ones.

So it's not enough for politicians to just talk of guaranteeing apprenticeships. Manufacturing companies need to be told that they will be helped to establish valuable apprenticeships that bright and ambitious students will want to take; which parents can be reassured will provide real skills and prospects for their children; and which other companies will value as a guarantee of a skilled employee.

It shouldn't be just another political football. Apprenticeships are not just an educational institution; they are an important way of forging bonds between industries and communities. They were what helped make Sheffield a 'steel city' and Derby a 'railway town'. And they still fulfil that role in Germany. It would be good to see cross-party collaboration in helping apprenticeships spread and become more available, unlikely though that is when political points can be made. After all, the main parties seem to agree that they are important.

Stuart Nathan Features Editor
stuart.nathan@centaur.co.uk

yourcomments

I am tired of hearing the word 'apprenticeship' used as a description of every training course on offer. Do we really want people doing a six-week course in bicycle maintenance calling themselves apprentice trained or, even worse, 'tradesmen'. It takes years to acquire the skills that we have so callously thrown away in the race to become a service provider. I know we do not have the shipbuilders, for instance, that needed many trades now defunct, but we should have moved on and adapted our training to provide jobs in modern industry alongside those that were created in 'service'. My fear is that we are too far down the line to become a major player now and we will be restricted to niche industries. Mass employment opportunities in industry are a thing of the past.

Bryan Hyslop

Why not 'junior engineer', as in junior doctor? Just a small point – but one that goes beyond semantic quibbling – is the term 'apprentice' itself. Given how many words are written on these pages about the status of professional engineers (vs 'heating engineers' – who repair your boiler) – would the term 'graduate trainee' or (as is used by the French parent company at which I am employed) something more modern like 'intern' be less likely to put off young people. 'Apprentice' promotes images of Arthur Seaton – the 1950s machinist character in the novel *Saturday Night and Sunday Morning*.

Paul Reeves

The emphasis on 'apprenticeships' promoted by the Conservatives is purely to reduce the young jobless totals so they can claim that their policies are reducing the jobless totals and creating 'real' jobs. Employers who employ apprenticeships are paid by the government for every person taken on. They then pay the apprentice the minimum wage to 'learn' a trade. There is going to be a fall-out in the near future when these apprentices become a burden to the companies and are thrown out.

Trevor Best

Perhaps we should look back to the 60s for a little inspiration. Leave school at 16, four- or five-year indentured apprenticeship, one-year practical 'off-the-job training' to learn basic craft skills, then progression according to aptitude and ability to a Full Tech Cert, HNC or degree. This would give a full coverage of manufacturing and design, which is sadly missing at present.

This has to be started soon while there are still us 'old fogies' to impart the knowledge for the future. Without this depth of knowledge and ability, manufacturing will die.

Perhaps the government should 'invent' technical colleges with workshops, for practical and theoretical tuition, or is this not headline grabbing enough?

Steve Gardner

This is just electioneering. A political policy announcement just for the benefit of a headline. It is a successful policy because it got the headline.

In the event of another coalition, there will have to be another debate in any case.

The bottom line with apprenticeships is that both Labour and Conservative have little to differentiate their offerings.

In any case, as many observers note as far as employers are concerned, it isn't the number of apprentices that matters so much as the quality of the apprenticeships.

Three million apprentices with five gold stars on their MacDonalds badge isn't going to transform young people's employment prospects.

Anonymous

The true apprenticeship was a two-way affair. Apprentices bring in the latest technology and techniques (get a slap round the head for it), which then the tradesman adapts into established skills. I have personal experience. It needed the four or five years for a rounded experience of the chosen trade. Having been through this procedure, the tradesman appreciates what the following apprentices need. When one greedy employer chose not to participate and took from the apprentice pool, other employers resented the cost of training and gradually the system collapsed. Is it too late to find a socially responsible body to repair the damage started by Madam Thatcher?

Anonymous

Blaming Thatcher is simple but disingenuous. After all she hasn't been PM for nearly quarter of a century now. Britain actually lost more manufacturing under NuLab than under Thatcher.

I think the apolitical attitude of engineers is squarely to blame for the state we are in now. It's damn hard to find an engineer with an in-depth knowledge of politics or who wants to actively participate in politics. British engineers in general don't do politics; have a poor understanding of politics; don't like discussing politics; consider it not befitting for an engineer to be involved in politics; consider it even less befitting for an engineer to be a member of a small political party; and have faith in *laissez faire* let's-leave-it-to-the-free-market economics rather than proactive economic policies to build an engineering industry.

If engineers had been more proactive in politics rather than just leaving it to the politicians – who by and large do not come from an engineering background – then the establishment wouldn't have done half as much damage to the engineering industry as it has done. Engineers need to put an end to their snobby aversion to politics or else see the last vestiges of the engineering industry disappear forever while continuing to blame Thatcher.

Arran

Have your say at **theengineer.co.uk**

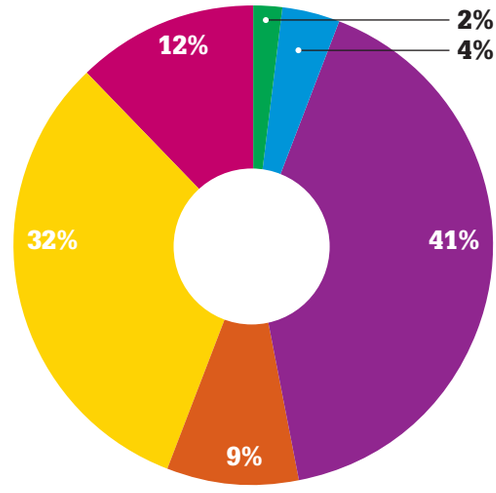
theengineerpoll

Last week's poll: The Labour and Conservative parties are competing to put apprenticeships at the heart of their industrial policies for the upcoming election. With which statement do you agree most strongly?

Last week's poll was dominated by 73 per cent of respondents dividing their opinions between the view that apprenticeships are valueless unless they lead to a structured career path (41 per cent) and those believing that a co-ordinated approach is necessary to design valuable apprenticeships (32 per cent). A further 12 per cent thought that the UK should learn from other countries, nine per cent said that companies need help – other than financial – to ensure apprenticeships are more than basic training exercises. The remaining six per cent said that funding apprenticeships via a levy on bankers' bonuses is a practical way to close the skills gap (four per cent).

Have your say at **theengineer.co.uk**

- **Funding apprenticeships via a levy on bankers' bonuses is a practical way to close the skills gap**
- **Apprenticeships are valueless unless they lead to a structured career path**
- **Companies need help – other than financial – to ensure apprenticeships are more than a basic training course**
- **A co-ordinated approach involving industry and academia is necessary to design valuable apprenticeships**
- **Other countries make better use of apprenticeships and the UK should learn from them**
- **None of the above**



thehottopic

Trials and tribulations for 'pod' cars

Our coverage of the UK's recently announced autonomous 'pod' car trials prompted an enthusiastic debate on the potential of driverless car technology.

Driverless cars will not be readily accepted by existing drivers on today's normal road system and this is a crucial factor. Just one specific reaction that every driver has made when travelling as a front-seat passenger explains the reason. This is the slamming of the right foot into the foot well to operate the foot brake when all his instincts yell "stop" even though the actual driver seems to be under control. Hands-off driving will work when a non-driver is sitting in the car, who has no experience in driving. This will probably affect the introduction of normal motoring hands free on the country's road network. The other option is to build above-head rail systems to transport people from place to place.
Trevor Best

I can't think of anything better than a driverless community, with cars sticking to the speed limit and logically sorting out traffic rather than the random selection of numpties on our roads right now. I'll happily sit in the rear of a driverless car reading the paper (or tablet these days) while I am whisked quickly and quietly to my destination without having to endure the babblings of a London/Manchester/Glasgow cabbie. And perhaps one day we will be free of the boy racers with their big exhausts and tiny engines thrashing up and down the streets. Oh, and insurance premiums should almost be a thing of the past. While they were a benefit to society in years gone by, cars are now a curse and little more than expensive status symbols, with most 4x4s never leaving tarmac and supercars a complete irrelevance because, other than the race track, there is nowhere in the world they can be driven safely (and in most cases legally) on public roads at the insane speeds they are capable of.
David Redfern

Until we get technology and processors that work in the same way as the human brain, then this driverless technology will not be full-scale adopted. Safe driving is about hazard awareness. How can a machine replicate that inner human sense of "something is wrong with this picture", leading to a heightened state of awareness (fight or flight). Yes, humans are fallible, but show me technology that's infallible. After all, who makes it? What of all those vehicles that will still have a driver? What about freedom to travel or just to drive for the fun of it? And what about getting into a driverless car when over the drink limit? Who is responsible if there is a technical glitch and there's an accident?
Alastair Brockett

The LUTZ Pathfinder will soon begin trials in Coventry and Milton Keynes

Bring it on. I can get a ride back from the boozer – technology that brings new life to pubs is welcome. And yes, I realise the law would have to change too.
Anonymous

I think the idea that driverless cars will 'reshape urban public transport' is over-claimed. All of the examples I have seen involve 'automating' existing automobiles. Driverless taxis may occur, but they are hardly a revolution. Further along the Oxford-Cambridge 'Techno Arc' – expensively taxied and interwoven cycled Cambridge will be less suitable for automated taxis. Real 'reshaping' of transport, whether urban or extra (urban will require a rethink and reshaping of roads) or things such as tunnelling below crowded historic town centres. Of course, the often unsaid 'elephant in the road' is that many increasingly influential people don't actually want fast, cheap, economy-expanding and landscape-changing transport anyway.
Paul Reeves

inyouropinion

Skillsgap

Industry needs a cultural shift.

■ The skills gap in UK engineering has taught us a valuable lesson: there is no such thing as quick fix. British engineering will only progress through sustained collaborative efforts, consistency and a cultural shift. As the Perkins Review highlighted last year, parents, teachers, employers and the government should collaborate to encourage young people from any background to regard engineering as a fulfilling and exciting career. However, collaboration is nothing without consistency. Genuine passion is cultivated in our early years. A child who regards science class as a chore is unlikely to become an accomplished engineer. Children should be encouraged and motivated to see how science can help them understand and change the world and the message should be reinforced constantly during school years. Furthermore, what our industry needs is a cultural shift to help shatter outmoded stereotypes. Engineering does not equal manual labour; it is a world of thrilling and rewarding career opportunities. Engineering is not only for men; it welcomes people from both genders, all ethnic backgrounds and any walk of life. Engineering is anything but dull; it's one of the most imaginative and creative professions in the world. Lucy Ackland, who won the Women's Engineering Society Prize at the IET's Young Woman Engineer of the Year Awards, had to work hard to persuade her teachers that she wanted to leave school at 16 to become an apprentice at Renishaw. She went on to achieve a first-class honours engineering degree and has led a project team developing our next generation of metal 3D printing machine. In theory Renishaw should have been among the first whose recruitment suffered as a result of the skills gap. However, the number of our apprentice and graduate applications has trebled in the last few years, as a result of our collaborations with schools, universities, STEM organisations, career advisers and government agencies. There is no hasty remedy for the UK's shortage of engineers. The only solution is a continuous, combined effort to make the profession more appealing to young people, their parents and teachers. It won't take one year, five or ten. It is a perennial commitment that we make to future generations.
Sir David Roberts McMurtry CBE, chairman and chief executive, Renishaw

Offshorewind

Consent for a 2.4GW Dogger Bank wind farm stimulated a number of questions.

■ For an engineer, the numbers are very interesting, but they are not defined well enough to mean anything. The numbers suggest the farm will operate at an average of 40 per cent of maximum output. This must be a very windy spot. What is the real expected useful output night or day, and what subsidy would we expect to pay for switching it off when it is very windy? Will it be DC connected over such a long distance, and what percentage is lost in transmission?
Martin Bennett

■ @Martin Bennett: The further out to sea you are, the more reliable the wind. Dogger Bank is pretty much in the middle of the North Sea – parts of the bank belong to continental countries. The yield/probability should resemble a bell curve, with 40 per cent of the area under the curve. The 40 per cent will rely on prompt maintenance. The cable will be HVDC. Transmission loss is negligible, but conversion losses may be 0.7–1 per cent at each end.
Alex

thesecretengineer

The recent cold weather has brought to the fore a specific difference between old and new cars

As with a lot of engineers, I run a tatty old car. Apart from the undoubted pleasure of not only being able to fix them, rather than buying and installing a new black box under the bonnet every time one of the myriad mystical runes displays itself on the dashboard, there is the additional bonus that they do need fixing a bit more often. With our insight, we also know that it takes less of the planet's resources to keep an old car running than buying a new one, so we can even smile smugly as we leave the latest hybrid behind in a haze of barely burned hydrocarbons. The recent cold spell has, for me, brought to the fore a specific difference between old and new cars – or rather a difference evoked in the driver.

Obviously I notice when the roads are a bit slippery; in fact, one of the reasons I enjoy driving my particular chariot is exactly because of the level of feedback I experience. I have to say that in addition it rather focuses one's mind knowing that crumple zones are less than generous and the only thing between the driver and a hasty demise is how gently you apply the unfiltered control inputs.

This morning I was heading up the dual carriageway when I was overtaken by a Golf scudding along at a rate of knots with the driver drinking a coffee. I certainly wouldn't claim to have been near the ragged edge (such things aren't for the morning commute) but the speed differential was so great I suspect her dashboard was lit up like a Christmas tree as all the electronic gee-gaws did their best to stop her from smearing herself up the central barrier. Or indeed rolling the car up into a ball as it flew off in a parabolic arc over the boondocks.

This is all well and good, in some ways demonstrating why this technology is essential for the general public. What happens though when all the computers under the bonnet breathe a collective sigh of resignation and hold up their virtual hands in resignation to the inevitable? After all, as one learned philosopher was fond of saying: "Ye canna change the laws of physics."

Miss Carefree-Commuter (the driver being female in this case, other genders of idiotic driver are available) will be unaware of just where the limits are and anyway is unengaged from actively driving as she is so cosseted in this.

Add the fact that when it all goes 'Pete Tong' she will be travelling at a high speed; then a sudden breach of the limits will make rather a nasty mess of something or other, quite possibly her. With the proliferation of the safety aids that lead to this scenario, there is little wonder new cars have so many airbags these days.

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

■ An average of 40 per cent means just less than 1GW is actually produced, but assuming that 1GW is spread equally over day and night and assuming it's circa 50 per cent each, then using these figures I arrive at less than 500MW of useable power generated notwithstanding any other losses incurred. So what is the return on investment (ROI)/CO_2 payback from making, installing and maintaining these things?
John K

Wearableelectronics

Our readers are ambivalent over wearable technology.

■ I would like to see head-up display technology on motorcycle helmet visors/glasses for satnav and other info so there is a market that exists. This would have a safety benefit for motorcyclists as well as cyclists.
David Ellis

■ I can see wearable technology such as Google Glass having application for people carrying out complex procedures such as service and repairs on anything from domestic boilers to aircraft. Linked to a computerised service manual with 3D images that can be rotated and show exactly how to perform each step, these devices could have real benefits in improved quality and standardisation. The camera would recognise what the wearer is looking at so that the system is interactive. The computer could be local to the operator with a Bluetooth link or connected over the internet. Medicine (surgery) is another obvious candidate. However, I agree that the potential for their use in everyday social interaction does seem rather limited to the few who don't mind looking a bit nerdy, but there's nowt so queer as folk. We should never be surprised at what will catch on.
Robert

■ As a wearer of varifocal glasses, the only smart glasses I want to see are ones that will provide full and effective sight correction for all distances and conditions; and by the way, they need to be waterproof. The rest I can live without.
Mike West

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The young ones

Employers have a very important role to play in delivering the careers information and inspiration needed in schools

With two months to go until the general election, we are hearing many politicians talking about engineering, including discussion around industrial training levies and the announcement of funding from the Employer Ownership of Skills Fund. In Scotland, we've heard that STEM subjects are at the heart of the government's approach to developing the country's young workforce. And at the EEF conference, Ed Miliband said he believed that manufacturing and engineering are "the wave of the future, not simply the pride of the past".

It's fantastic that engineering, as well as parts of education that are important to its future such as apprenticeships and careers education, is so high on the political agenda. We need to keep that momentum going and make sure that politicians continue to champion engineering, not just over the next couple of months but for the rest of the year and beyond.

"It's fantastic that engineering is so high on the political agenda. We need to keep that momentum going and make sure politicians continue to champion engineering

The Whitehall government has established a new careers and enterprise company for schools, whose stated aim is to transform the provision of careers education and advice for young people and inspire them about the opportunities offered by the world of work. The company will be led by CapGemini's Christine Hodgson and have as its vice-chair National Grid chief executive officer Steve Holliday. It is great to see that Holliday is involved as he is a champion for addressing the challenges our industry faces in terms of appealing to and attracting the best young talent.

Part of addressing that challenge is emphasising that the world of engineering is a great place to work and getting that message out to young people in their early years at secondary school.

This is when they are likely to form long-lasting opinions about the subjects that they enjoy and the careers that they are interested in pursuing. Employers have a massive role to play in this.

Late last month, I was joined by more than 20 representatives from a range of engineering employers at a House of Commons lunch where we had the opportunity to discuss careers education with skills, enterprise and equalities minister, Nick Boles. The consensus in that room was that employers have an essential role to play developing and delivering the careers information and inspiration needed in schools. Employers are absolutely prepared to play their part, but (and it's a big but) government cannot abandon all responsibility.

While that discussion involved many large companies, the role of employers is by no means restricted to global companies. Smaller engineering companies and those in their supply chains can and do play an important role in developing skills within the industry. Just a cursory glance at the list of six engineering projects sharing the £2.8m of match funding from the Ownership of Skills Fund confirms this. Big hitters such as Nissan feature but so too do smaller companies such as Cheshire-based Tiger Trailers. This is exactly what we need – engineering companies of all sizes doing what they can to address the skills shortages within the industry.

Paul Jackson is chief executive of EngineeringUK


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Engineering a sea-change

Over the next decade, almost a thousand North Sea oil wells will be decommissioned. Stuart Nathan explores the technical challenges involved

Brent Bravo stopped producing late last year and will be decommissioned after Brent Delta

For almost 40 years, the hydrocarbon reserves of the North Sea have been vital props for five European countries: Norway, the UK, Denmark, Germany and the Netherlands. Since the first licences to explore the region for oil and gas were granted in the mid-1960s, more than 40 billion barrels of oil (an equivalent figure that includes gas on the basis of value) has been extracted from the convoluted folds and fissures of the geology of the seabed, and most estimates say extraction can continue for another 30–40 years, with some 24 billion barrels of reserves remaining.

And while the industry in the North Sea can still look to the future with hope – and exploration continues in other regions of the Northwest European Continental Shelf, such as the regions to the west of Shetland – the industry's minds are beginning to turn to what's going to happen when the hydrocarbons run out. It's clear that we're closer to the end than the beginning. So how do we bring the era of the exploitation of the North Sea for oil and gas to an end?

There have already been several notable decommissioning activities in the North Sea. The Shelley Field, which had two production wells, was closed out in 2012. The Frigg field ceased production in 2004, and all wells were plugged and abandoned. More than 85,000 tonnes of steel were removed from the field, and dismantled by contractor Aker Kvaerner in Shetland and Stord, Norway; all the steel was recycled, much of it by resmelting and rolling. North West Hutton was taken out of service by order of the UK government in 2002, with a decommissioning programme approved in 2006. The topsides were removed to Able's Hartlepool facility, although the footings and drill cuttings were left in place; the oil pipelines were buried. Decommissioning began on Norway's Ekofisk field in 2005 and is still under way.

According to industry body Oil & Gas UK, around £1bn was spent on decommissioning activities by UK producers last year. The organisation is keen to point out the dangers of early decommissioning, triggered by falling revenues because of low oil prices. "The [North Sea] basin needs sustained, high investment – £94bn alone to recover the 10 billion barrels oil equivalent in known reserves," said chief executive Malcolm Webb.

The starting gun for decommissioning the major North Sea oil and gas installations has already been fired, courtesy of Shell, which earlier this year announced that it is to decommission the oilfield, which in many ways formed the model for large-scale exploitation of the North Sea: Brent. Some 140m below the sea's surface about 186km north east of Lerwick in Shetland, Brent was discovered in 1971, the second of Shell's North Sea oilfields, and was one of the UK's most productive oilfields, lending its name to the generic type of crude oil sold on international markets (light Brent crude) and at its peak pumping out half a million barrels a day; Shell says the field has produced a tenth of all North Sea oil and gas extracted to date and generated £20bn in tax revenues alone.

"North Sea decommissioning is a developing business that is new to many and misinterpreted by more
Nigel Jenkins, Decom North Sea

Brent has four oil platforms – Alpha, Bravo, Charlie and Delta – of which only Charlie is still producing (Brent Delta ceased production in 2011; Alpha and Bravo last November). Production from Charlie is expected to stop in the next few years. But Shell's focus is currently on the Delta platform, for whose dismantling it launched a consultation programme last month.

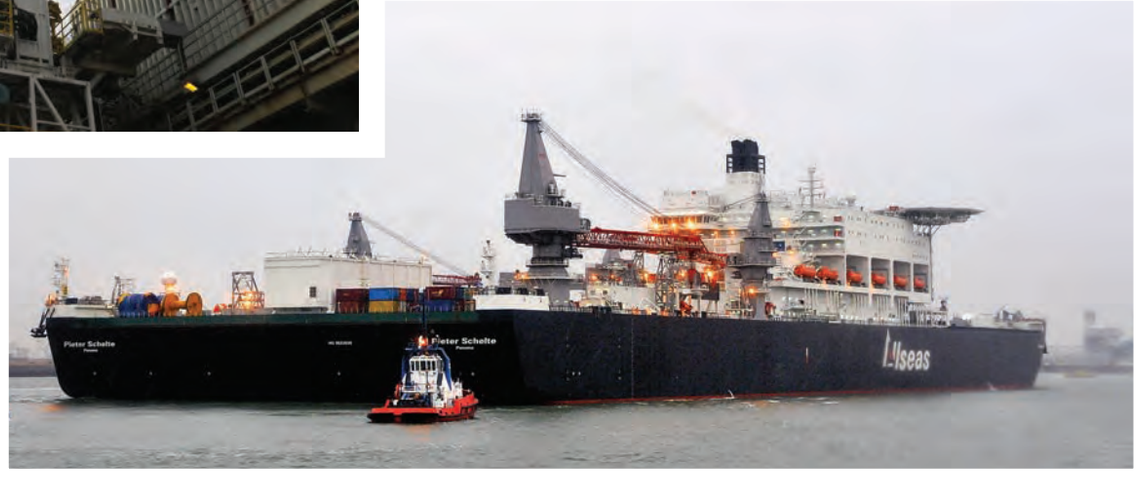
This alone is a mammoth task – one of the largest Shell has ever tackled, according to UK chairman Eric Bonino. It is proposing that the topside of the platform – the platform itself, which sits on three mammoth concrete legs – is to be removed next year in a single 23,000-tonne piece by the lifting vessel *Pioneering Spirit*, as long as five Boeing 747 aircraft, expressly built for this purpose by contractor Allseas. This will then deliver the structure to Able UK's facility in Hartlepool, Teesside, where it will be dismantled. This, Shell claims, will enable 97 per cent of the material to be reused or recycled.

Brent decommissioning has been controversial before, notably in 1995 when Shell proposed to dispose of the oil storage buoy Brent Spar by sinking it in the North Atlantic. A Greenpeace opposition campaign saw the buoy occupied by activists, and increasing opposition led to the company backracking and mothballing the structure in a fjord, eventually cutting it into rings, cleaning it and using the material to build a quay extension for ferries in Mekjarvik, Norway. Keen to avoid a repeat of this, the company is being careful to seek options for Brent decommissioning.

The remaining structures of Brent Delta – the legs, which sit atop clusters of 60m-tall concrete oil storage structures and are currently full of sediment with what's known as 'attic oil' sitting on top – will then be dismantled and removed gradually, with contaminated material taken ashore for treatment and disposal. There are also several piles of drill cuttings – rock fragments from the drilling process, which contain the lubricant drilling 'mud' – and under the seabed are pipelines whose removal and disposal is being assessed.

And this is only one platform. Brent also has the three other platforms, 140 wells and 28 pipelines, all of which will need to be removed or treated, as part of the decommissioning process. "The engineering and planning skills that led to the discovery and subsequent successful production of oil and gas over four decades are essential during decommissioning, which is the natural next stage of the field's life," said Brent decommissioning project director Alistair Hope.

And again, this is just one oilfield. According to Oil & Gas UK, ->



Above: **Archer Topaz installed at the Norwegian Heimdall field in the northern North Sea**

Right: **lifting vessel *Pioneering Spirit* will take the 23-tonne Brent Delta topside for disposal**

Archer's Topaz rig lifted into place

between 2014 and 2023 a total of 927 oil wells on the UK continental shelf (the North and Irish seas) will come out of production, representing 58 per cent of central and northern North Sea wells and 80 per cent of southern North Sea and Irish Sea wells. There are 246 topside structures to be removed from 104 platforms, weighing a total of 281,600 tonnes. Another 134,000 tonnes of subsea structures also have to be removed, while with 3,277km of pipelines will be decommissioned.

Decom North Sea, a forum set up to link together operators and contractors in the industry, estimates that between 2010 and 2040 decommissioning will cost some £30–35bn. Commenting on Shell's plans, Decom North Sea chief executive Nigel Jenkins said that "North Sea decommissioning is a developing business that is new to many and misinterpreted by even more". It's not about the premature closure of the North Sea and it doesn't mean the end of its industry, he stressed. "Shell's decision to bring forward the submission of its decommissioning process for Brent's topside to DECC was clearly not a knee-jerk reaction to falling oil prices, but a result of a long-term understanding that the field was nearing the end of its life and the structures will soon not be needed.'

Decommissioning an oilfield is a lengthy, complex process that begins before production from the field begins to decline. There are seven main stages in the process:

■ Project management, which usually starts three years before the well runs dry. This involves a review of the operator's contractual obligations; engineering analysis of the field and the operator's facilities; and operational planning, which can involve a high degree of pre-planning.

■ Permitting and regulatory compliance can also be a lengthy process, with many different regulators needing to be informed and to issue approval for the decommissioning.

■ Platform preparation includes flushing and cleaning of tanks and processing equipment, disposal of hydrocarbons, removal of platform equipment and removal of marine growth around underwater structures. During this time, the platform is still considered to be 'live' because hydrocarbons are still present, and utilities, power and safety systems must be maintained.

■ Plugging and abandonment is one of the major costs of decommissioning and involves removal of the lining of the borehole and plugging of all the points where hydrocarbons flow into it. This can be done with a temporary plug, which can be removed if it's decided to reactivate the well, but this decision must be taken before plugging commences; permanently plugged wells cannot be restarted.

■ Mobilisation/demobilisation and platform removal can be done in a single lift, as with Brent Delta, or piecemeal, with units dismantled and removed in sections. This would be assessed on a case-by-case basis.

■ Pipeline or power cable decommissioning can be carried out in place if they do not interfere with navigation or fishing, but otherwise they must be removed to below the seabed level.

■ Materials disposal and site clearance includes the dismantling and treatment of topsides, locating debris and other materials before and after removal processes, deployment of divers and ROVs to remove remaining debris and test-trawling the area to ensure that no obstructions remain.

Plugging and abandonment (P&A) is perhaps the most technically challenging part of decommissioning, as it involves intervening with the oilwell structures themselves. Increasingly, the operation is being carried out by modular rigs, designed, built and operated by specialists, which are transported to the site specifically for this task.

One such rig is the Topaz, operated by oilfield services company Archer, which is carrying out P&A on the Norwegian Heimdall field in the northern North Sea. The technical manager for Topaz construction, Geir Hagen, said that modular rigs present a good solution for drilling operations on older wells. "Many of these platforms have been in operation for decades as production facilities, but they haven't drilled for years. In many cases, including Heimdall, the drilling equipment has been taken away; when it's still there, it's usually old. Units such as Topaz are built to modern specifications, so they're compliant with all the current regulations. They're made so that they can be lifted onto the platform using their own crane, and carry exactly the machinery needed to do the job. It's a cost-effective way for the platform operators to have the technology they need available."

Brent Spar was the focus of much controversy

Topaz and its sister rig, Emerald, were both built by German offshore specialist Max Streicher, and designed to be as compact and mechanically efficient as possible, quick to set up and run by a small crew. They are particularly suited to the North Sea, Hagen said, and the company is planning to build more as demand for P&A activity increases. Emerald is currently operating on a Shell rig in New Zealand, carrying out production drilling activities. "The use of modular rigs is becoming widely accepted by all the major players," Hagen added.

> **"Many platforms have been in use for decades as production facilities, but they haven't been drilled for years**
> Geir Hagen, Archer

Drilling is often the easiest option for plugging wells, Hagen said. "The lining of the well has to be removed to below the level where hydrocarbons are produced, and they're grouted into place, so effectively we're milling or grinding them away so that we can introduce the plug to seal off the well." Temporary plugs are similar to the capping equipment used to seal wells in an emergency, while permanent ones are generally made of concrete.

Decommissioning is an industry in itself, and one where the UK is well placed to become a centre of excellence. While drilling and production continues in the North Sea and elsewhere on the continental shelf, cleaning up the remains of the process is as much a part of the industry as pumping out the hydrocarbons, and just as important.

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On the path to production

A new facility is helping small technology firms to scale up and become part of the automotive supply chain. Jon Excell reports

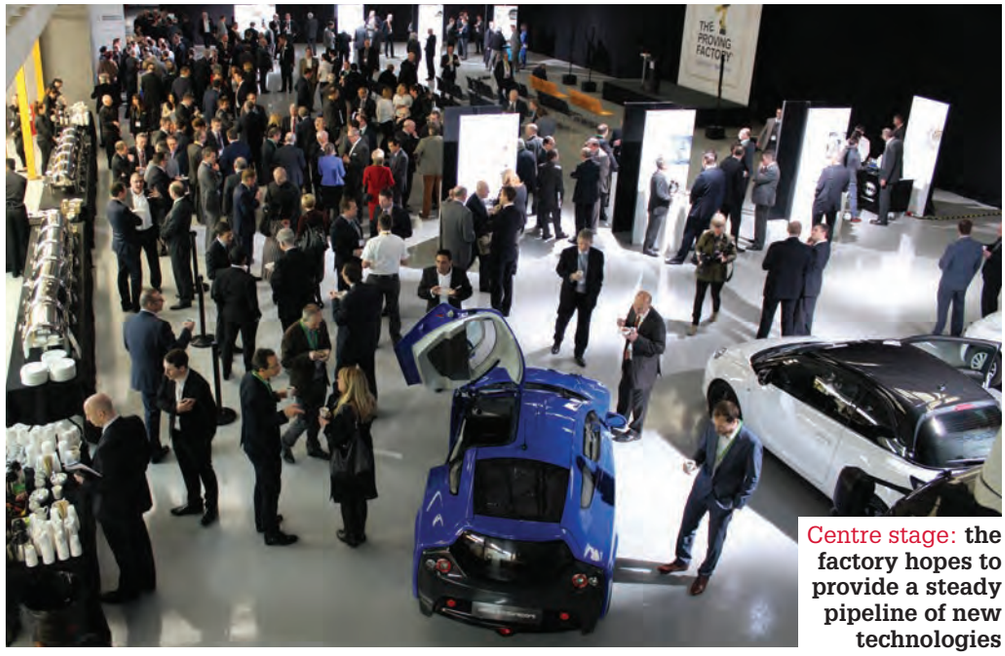
Commercialising new technology is rarely straightforward. And finding an effective way to help fledgling engineering firms safely cross the so-called commercial "valley of death" is a major obsession for industrial economies all over the world.

The UK is no exception. And while initiatives such as the government's catapult centres are helping, there are still major concerns over UK firms' longer-term ability to retain ownership of their technology and become a meaningful part of the supply chain.

It's a problem that has been particularly acute in the UK's automotive sector, where a widely reported hollowing out of the supply chain has occurred over the past two decades and where a new initiative to help small firms scale up and industrialise innovative propulsion technologies is hoped to make a difference.

Launched last month by business secretary Vince Cable, The Proving Factory – which is jointly run by engineering consultancy Productiv and Tata Steel – has been set up to help small technology firms establish production processes and demonstrate to potential customers that not only do they have interesting technology, but they've also got what it takes to become part of the supply chain.

The team behind the £22m centre – which has been established with funding from both the private sector and the government's Advanced Manufacturing Supply Chain Initiative (AMSCI) – hopes it will provide a steady pipeline of new technologies to support the UK's booming automotive sector, as well as to help reverse the aforementioned 'hollowing out' of the supply chain.



Centre stage: **the factory hopes to provide a steady pipeline of new technologies**

Talking to *The Engineer* at the launch of The Proving Factory's Coventry assembly facility, chief executive officer Richard Bruges explained that young technology companies looking to get a foothold in the automotive sector frequently face a frustrating catch-22: "To get an OEM to commit to putting my technology into a product and putting it onto a vehicle platform, I need to demonstrate that I've got the capacity to deliver that, which means I need a big factory. But I can't raise the money to do the development and build a factory until I've got the order. And I can't get the order until I've got the factory.'

The centre has been set up to get past this stumbling block, and, as Bruges put it, "to help take exciting technologies from 12 blokes in a shed to a high-volume production solution".

"We've created a pipeline into which you can put multiple technologies that will come out of the other end into high-volume production," he continued. "'Show me your factory' is what this is all about." ->

indepth

Magnomatics' gears may soon be embraced by automotive firms

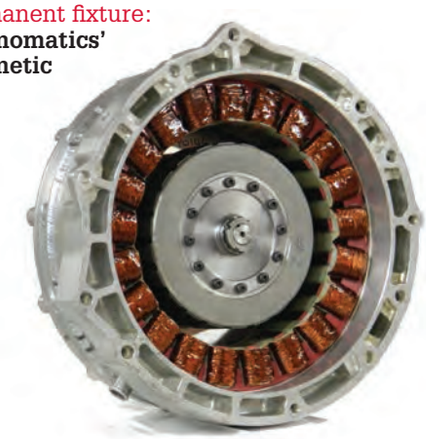
Sheffield-based magnetic gear developer Magnomatics has high hopes that, thanks to The Proving Factory, its innovative technology – already used by the oil and gas sector – could soon be embraced by the automotive industry.

The firm's core technology is a magnetic gear that uses permanent magnets to transmit torque between an input and output shaft without mechanical contact. CEO Dave Latimer likens it to an epicyclic gear but with no moving parts and says it has a number of promising applications as a power split device for the automotive sector.

The firm is working with automotive OEMs that are evaluating the technology and looking at putting it into applications.

Latimer hopes the relationship with The Proving Factory will help take the technology to the next level: "The Proving Factory ticks a box. As soon as you start talking to these guys they say 'where is it going to be made?'. We use The Proving Factory as part of our sales pitch.'

Permanent fixture: **Magnomatics' magnetic gear**



indepth

Bladon Jets' portable gen-set is to be used to supply power to mobile-phone masts in the developing world

Following an order for thousands of units from a customer in Africa, micro-gas turbine developer Bladon Jets looks set to be The Proving Factory's first success story.

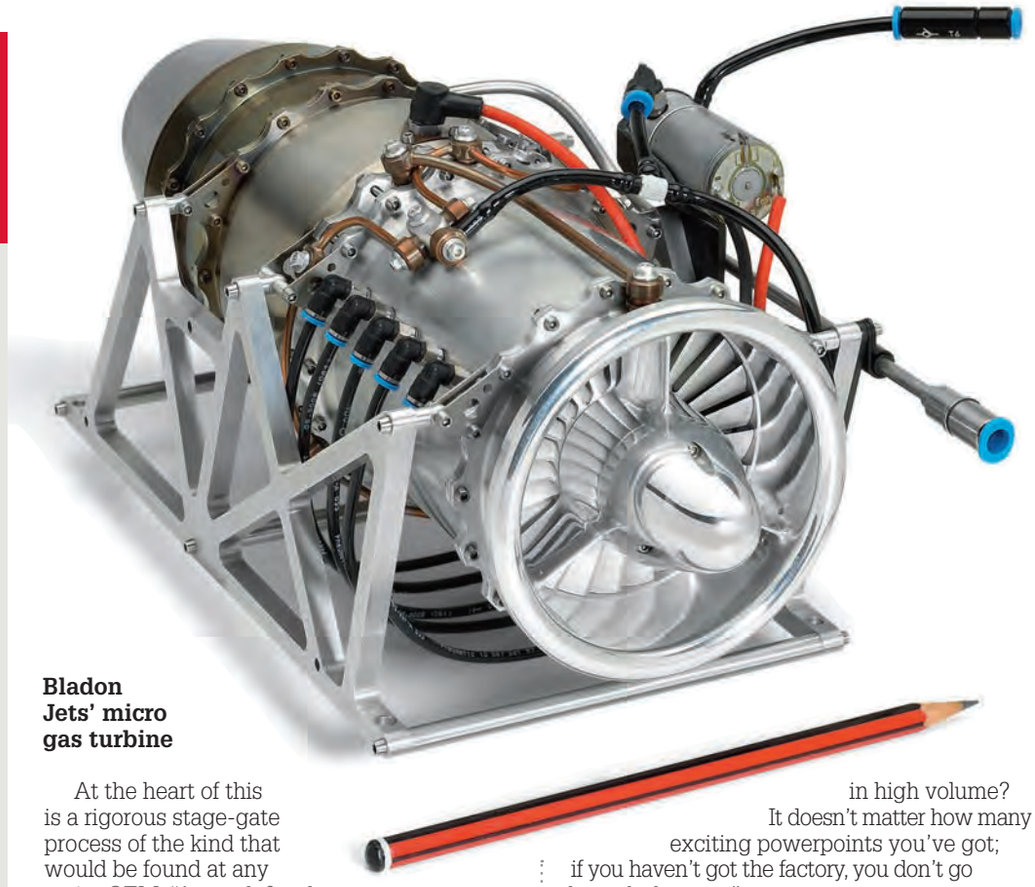
The company first grabbed headlines at the 2010 Paris motor show when its diminutive jet engines appeared as part of a hybrid powertrain on Jaguar's C-X75 concept car.

But while the company is continuing to explore automotive applications, the current order is for a portable gen-set that will be used to supply power to mobile-phone masts in the developing world.

Bladon Jets director Philip Lelliot said that the technology has a number of distinct advantages for this application, including its compactness and, thanks to its continuous burn cycle, relatively low emissions.

He added that the power units are also able to burn any type of fuel – a key advantage in the developing world where fuel can often be adulterated.

Bladon Jets is currently working with The Proving Factory on the assembly of six devices that will soon go out to field trials. Shortly after that, the company will ramp up to series production, and plans to produce 10,000 units for the customer in the first year.



Bladon Jets' micro gas turbine

Companies working with the organisation will receive help putting their technology into production and then support during the process of setting up their own production facilities.

The facility is structured to be able to take on up to 20 technologies at any one time, and to be able to manufacture a total of around 200,000 units per year.

At the heart of this is a rigorous stage-gate process of the kind that would be found at any major OEM. "At predefined moments, you review an entire set of criteria – in our case a list of 27 deliverable items – and you have to have got them to a certain stage of readiness before you can move to the next stage," said Bruges.

Dave Latimer, chief executive officer of Magnomatics (one of the companies working with The Proving Factory) confirmed that this is a critically important step for smaller companies looking to engage with large OEMs. "We're currently supplying prototypes to OEMs for evaluation, but as soon you want to go from advanced engineering projects to something that is closer to market. Effectively they have a gated process and one of the boxes they have to tick is how is this going to get manufactured in high volume?

It doesn't matter how many exciting powerpoints you've got; if you haven't got the factory, you don't go through the gate."

So far, nine technologies have gone through the development stages. As well as Magnomatics, The Proving Factory is also working with liquid-nitrogen engine pioneer Dearman Engine Company and Bladon Jets (see box), which has received a large order to supply a gen-set based on its micro gas turbine technology to a mobile-phone mast operator in Africa.

The early signs are promising. Bladon Jets has already received an order for 10,000 units, Magnomatics is confident that it will soon follow and, as this issue of *The Engineer* went to press, Bruges confirmed that the facility had been awarded a further development programme with a major automotive OEM.

For Bruges, these early signs are a vindication of a lot of hard work, and he's hugely optimistic about what the future will hold.

"We're just one of many initiatives that are going on in the UK that are really genuinely rebuilding our high-value manufacturing base. We don't need to be a high-volume manufacturer anymore, but we really do need to do high-value stuff, because we're really good at inventing things. We've been less good at getting them to market… but we now have the infrastructure in place to do that."

In the longer term, Bruges hopes the current centre will become one of three or four proving factories. "The problem exists everywhere in many different markets," he said. "We see an opportunity in several other areas: electronics, battery systems and possibly in composites or advanced materials."

Factory setting: **the £22m centre was launched last month by Vince Cable**

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Top cat

steveausten
Chief engineer and engineering director, Supacat

Education
- **1988–92** MoD technician apprenticeship in naval architecture at MoD, Bath
- **1993–99** Mechanical Engineering, University of the West of England
- **1992–94** MoD surface ship vulnerability
- **1995–97** MoD submarine in service support
- **1999–99** MoD surface ship structures standards

Career
- **1999–14** Royal National Lifeboat Institution:
- **2000–04** Senior engineer, lifeboat structures and stability, D-class lifeboat project manager
- **2004–08** Principal engineer, lifeboat structures and stability, launch and recovery system design authority, slipway winch and Shannon launch and recovery system project manager
- **2008–14** Head of engineering – responsibility for design and engineering in-service support of lifeboat fleet
- **2014** Chief engineer and engineering director, Supacat

The RNLI's former chief engineer has joined specialist vehicle manufacturer Supacat at an exciting time. Stuart Nathan reports

Supacat is among the best-known names in heavy-duty, specialist vehicles. Producing vehicles to protect soldiers on patrol in war zones and huge-wheeled and tracked trucks to plough through mud and sand in some of the most hostile terrains imaginable, the West Country-based company is a respected name in the British engineering industry.

Steve Austen, who took over as engineering director and chief engineer late last year, joined the company at a time of change. "Historically, the majority of Supacat's turnover came from the defence sector; when that was quiet, so was the company," he told *The Engineer*. "That's meant that the past couple of years have been pretty tough times." Indeed, its last full set of accounts sees 2013 turnover down 16 per cent at £13.6m, with profits down four per cent at £5m.

As a result of this, the company has been diversifying. "We're working in renewables, in marine, we continue to work strongly in defence, and we're still working with my previous employer, the Royal National Lifeboat Institution [RNLI]," Austen explained. "We are also looking at expanding into new areas, such as nuclear."

Austen first worked with Supacat on a project with the RNLI as part of its campaign to design, build and launch a new lifeboat, the Shannon class, as covered in *The Engineer*. Based on a custom-designed hull and using waterjet propulsion for the first time for the RNLI on a large boat, the Shannon class needed a new way of launching and being recovered from the water.

"One of my roles as principal engineer for launch and recovery equipment was to project-manage the design and prototyping and introduction into service for new launch equipment for the Shannon," said Austen, "and when we started the project back in 2002–03, the original project scope was to develop two systems, one produced by Supacat and one by another company to get to a point where we could do head-to-head trials with a prototype lifeboat. That was the beginning of my relationship with the company, working with its design teams on the prototyping and testing."

> **"We kept our engineering and production teams together in anticipation of this diversified work**

Wheels in motion: **Supacat's HMT (heavy military transport) Extenda**

Austen's background stands him in good stead for a company looking to move into new areas. While his apprenticeship as a naval architect formed the basis

In the same boat: **the firm developed a launch and recovery system for the RNLI's latest lifeboat**

for his work with the RNLI, his later training in general mechanical engineering gives him the skills for a company that, he said, has more in common with specialist heavy engineering than the niche vehicle sector with which it is most commonly associated. "My appointment certainly strengthens the marine side of Supacat's business, but I'd like to think that my experience and qualifications allow me to lead the team in tracked and military vehicles as well," he said.

Austen added that Supacat's versatility "comes from our ability to get machinery to work in challenging environments for a demanding customer". He continued: "If you take away the vehicle bit, that experience is going to serve us well in a variety of markets," he added.

One example of this is the company's recent work with Fred Olsen Renewables, a subsidiary of the Norwegian shipping company, for which Supacat designed and built a wave energy converter called the Bolt Lifesaver. This is a floating ring structure, which bears around its circumference generators that work via a winch whose line is tethered to the seabed. As the sea heaves and tilts the ring, the winches turn, generating current.

Bolt has now been tested at two sites around the Cornish coast, and will in the next month or so begin a new trial in the Pacific off Hawaii.

"Bolt isn't a vehicle at all, but it has a series of winches aboard, so that's our mechanical handling expertise; the steelwork to make it float has come from heavy engineering; making watertight steel boxes came from the work with the RNLI recovery system; the electrical work is a core expertise of ours – we have automotive electrical specialists and general electrical engineers," Austen said. "This ability to take skills we've gained through other projects and apply them in new ways is a core skill of ours and it's something I'm keen to make more of."

Most of Supacat's manufacturing capability is UK based, although its Australian offices in Melbourne and Sydney form manufacturing partnerships with local engineering companies to make vehicles for the Australian army special forces: the company is soon to start an 89-vehicle run. "We've also made an acquisition in the UK called Black Hill Engineering, which gives us heavy engineering capability near Exmouth, so we can make pretty large and heavy fabrications there," Austen said.

This allows Supacat to bid for work in its traditional sectors, while also using its own money to develop projects for new niches. "One example of that is SUV, which is a six-wheeled Land Rover variant designed for emergency services, and that's being used by Ambulance and Fire Services."

Supacat chose to ride out the rough economic climate without making job cuts, so it wouldn't have to try to replace lost skills when orders picked up. "We kept our engineering and production teams together in anticipation of this diversified work," Austen explained.

This is now helping with the company's production slate. "We're in the late stages of negotiation with a Scandinavian customer that we hope to bring to fruition in the next month or so, and that could lead to repeat orders from other countries; there's a smaller special ops project for the MoD as well. Plus there's an invitation to tender from the RNLI for follow-on launch recovery vehicles, so our prospective order book looks pretty healthy."

Austen said that the company's work in renewables and possible expansion into nuclear is the most exciting part of his new job. "If you look at nuclear, there's certainly a lot of scope in the decommissioning market and getting vehicles to work in that environment, but there are a lot of other areas and engineering challenges where we could bring our skills to bear, so I can't say it would always be vehicles," he said.

"Anything that allows us to develop new stuff, show what we can do and tackle these challenging environments is exciting for me."

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Body shop

Experts answer your questions on the emerging field of 3D bioprinting. Stuart Nathan reports

While 3D printing becomes more established within the manufacturing sector, one of its most exciting uses, to create replacement body parts, remains in its infancy. We put your questions to some of the leading researchers in this exciting area. Responses are by:

- **Dr Anthony Atalla (AA), director of the Wake Forest Institute of Regenerative Medicine in North Carolina, the first institution to successfully transplant a lab-grown organ into a human;**
- **Vijayan Manoharan (VM) of Harvard-MIT Health Science and Technology in Cambridge, Massachusetts; and**
- **Dr Dan Thomas (DT) of Swansea University.**

Would 3D printing technology be able to reproduce working glands such as the pancreas to assist in insulin production?

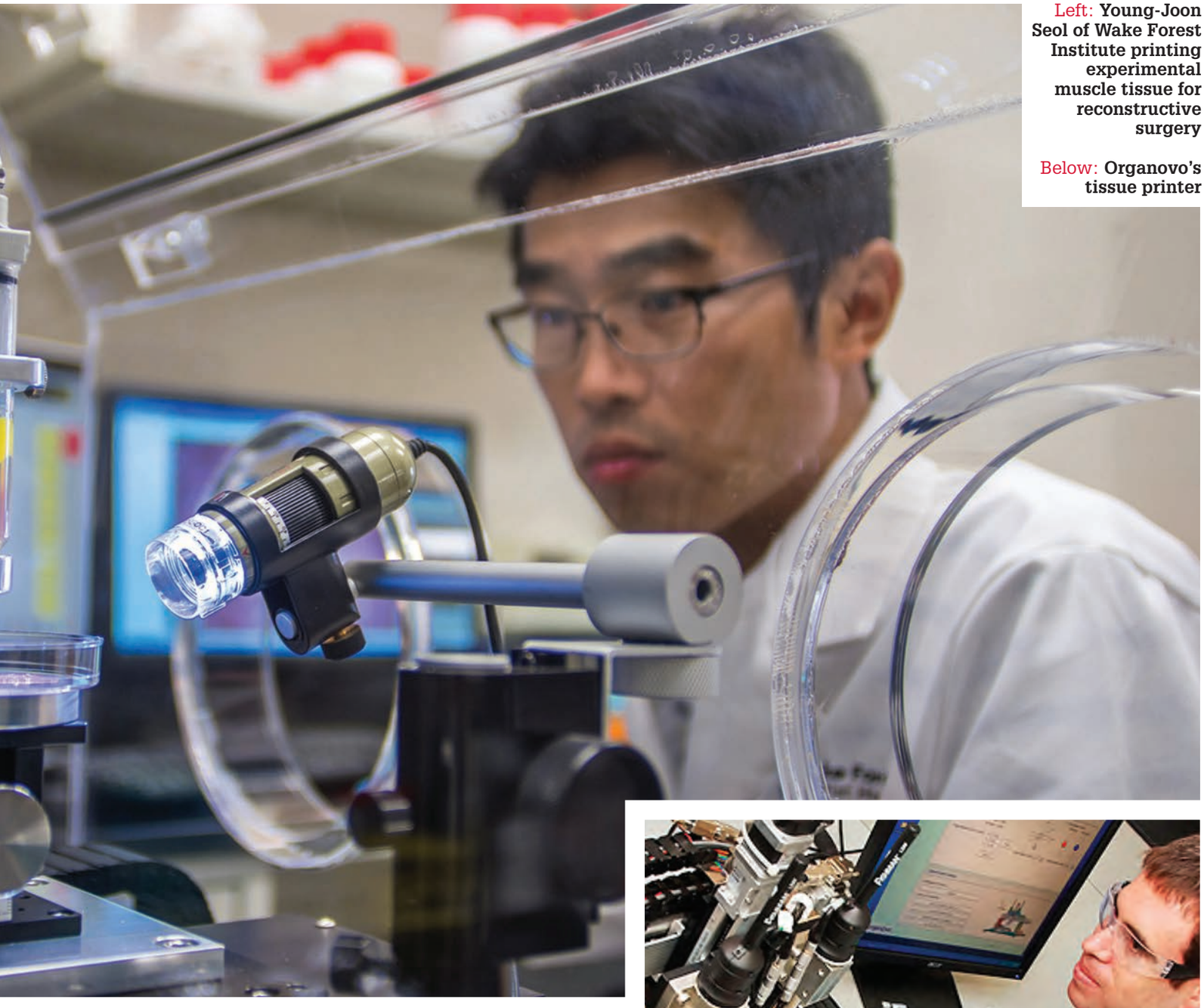
DT: With future developments and research, this is an interesting application. However, biological architectures are extremely complex to engineer, and number of the cellular mechanisms are still not fully understood. What may be the best alternative approach is in developing the capability to make small engineered tissues for acting as dynamic biotools to repair damaged glands or tissues. Macro-tissue engineering is something that is currently very interesting.

VM: This question does not have a yes/no answer. Tissue engineering is a highly inter-disciplinary field that integrates the principles of physics, chemistry and biology to engineer artificial organ and tissue systems for replacing damaged tissues in the body. Bioprinting [the term given to the technology that utilises 3D printing for tissue engineering applications] is one of the major tools in tissue engineering that has high potential to pioneer the efforts made to engineer artificial organs. Bioprinting has already made a lot of strides in tissue engineering in the recent past and it is growing at a rapid pace at the moment. In the next five to 10 years, there is a huge scope for bioprinting to reach its pinnacle by enabling complex architecture, high viability, preservation of cell functionality and high speed of fabrication. However, there are other aspects that have to be advanced along with bioprinting to reproduce working glands outside the body such as designing complex biomaterials that satisfy the needs of cells at multiple levels, finding proper and sustainable cell sources, molecular cues and so on. Hence the success of tissue engineering depends on all the tools employed in tissue engineering, and bioprinting is only one of many such major tools. So advances in bioprinting alone will not guarantee organs such as the pancreas but it will definitely push the boundaries of paths leading to such innovation.

AA: The pancreas is one of the body's solid organs, a category that also includes the liver, kidney and heart. Our experience in the 3D bioprinting of solid organs includes a long-term project to print a human kidney. And, for a project funded by the Defense Threat Reduction Agency, which is part of the US Department of Defense, we are working to print miniaturised liver and heart tissue that could be used to test drugs. So in concept, it should be possible to print pancreatic tissue. However, engineering any organ – whether by printing or another method – requires many years of scientific endeavour. The central challenge is to reproduce the complex micro-architecture of living tissue to ensure that printed tissues have biological function.

This is the kind of technology that gets misinterpreted by the press, so can you manage our expectations by telling us what is possible right now, and where the next 10 years will take us?

DT: Bioprintable tissue for transplantation is a technology that is at least 20 years away. The most likely application for bioprinting technology during the next 10 years will be that of 3D bioprinted tissue tools. This will provide improvements in pharmaceutical testing and then subsequently cancer tissue models. At the moment, the ability to control and manipulate a few hundred million cells is achievable to make simple heterogeneous tissue types. However, tissues for reconstructive surgery offer a different level of complexity. Consider that we need approximately 80 million cells for each millilitre of bioprintable material. The difficulty of harvesting, culturing and then handling this vast number of progenitor cells is very high. The ability to deposit complex bone materials into an anatomically correct geometry using 3D printing technology is currently a process that within the next five years will be harnessed.



Left: **Young-Joon Seol of Wake Forest Institute printing experimental muscle tissue for reconstructive surgery**

Below: **Organovo's tissue printer**

VM: In the next 10 years, bioprinting definitely has the potential to bring us close to the generation of artificial organs, but to bring about the complete success of tissue engineering, the advances made in bioprinting has to be accompanied by the advances of the other tools involved in tissue engineering. Having said that, there is a high possibility for an engineered tissue to make its presence in clinics in the next 10–15 years for aiding therapies.

AA: You are correct that many people may have unrealistic expectations about 3D bioprinting. The technology itself is not 'magic' – it is simply a way to scale up the current processes we use to engineer organs in the laboratory. Before any organ can be engineered – whether it's printed or built by hand – there is much groundwork that must be accomplished. Vital to the process is a thorough understanding of cell biology. Scientists must determine not only what types of cells to use, but how to expand them in the lab and how to keep them alive and viable throughout the engineering process. Do they need to be embedded in biocompatible material? If so, which biomaterial is most suitable? The bar for success is high – the structures we engineer must function like native tissue. 3D bioprinting is a relatively new field and printed tissues have not yet been implanted in humans. Within the next 10 years, we expect clinical studies to be under way for simpler tissues such as bone and muscle.

■ What sort of engineered device is able to hold, move and release lab-grown microtissues without adversely affecting the viability of the cells?

DT: There are a number of different technologies, which resulted in early progress in the field. Work by the Wake Forest Institute is really pushing the boundaries. Direct deposition is one family of technologies that is currently successful at producing simple architectures, but the resolution is not really there yet with regards to complex tissue architectures. I feel that harmonic levitation and laser curing of photo-curable scaffolds will be a key realisation of bioprinting technology. We have started a major ->

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Kidney prototype, ear and finger bone scaffolds printed at Wake Forest Institute

programme of bioprinting combined with microtissue carriers in which spheres of cells can be placed together, which is an optimum approach for producing a simple tissue in this way. Mobilisation of cells and precise deposition with harmonic energy could become the next state-of-the-art bioprinting technology. We are currently working on the first stage of this programme, which involved developing the software tools required to build complex architectures composed of multiple cell types.

VM: Viability is the major goal to achieve while successfully transforming a normal 3D printing technology into a bioprinting technology. Hence, almost all the different methodologies used for bioprinting have achieved high/reasonable viability. Examples are direct-write printing, inkjet printing, laser printing and so on. Viability concerns during bioprinting have become a thing of the past because of the advances made in the above-mentioned printing technologies. Now scientists are looking to improve factors such as the architecture produced during bioprinting, time required for bioprinting, preservation of phenotype/functionality of cells during bioprinting, the range of materials that can be employed for bioprinting and so on.

AA: With 3D bioprinting, it is the cells themselves, often combined with biomaterials, that are printed to form tissues. Research has shown that with one type of bioprinting, microextrusion, cell viability is between 40 and 86 per cent, and that rates are even higher with inkjet-based bioprinting. Of course, nozzle gauge and other factors affect these rates.

■ When can we expect to see full printed organs and what are the key steps we need to take to get there?

DT: Currently, I am not convinced that whole functional organs will ever be printed. The biggest challenge is that every cell in your body constantly communicates with the cells around it. This biochemical communication is especially intense during tissue growth phases. The reason that this is necessary is that organs are made up of hundreds of different cell types. Cell development and behaviour draws on DNA properties influenced by the signals from surrounding cells. Because cells develop from a complex spectrum of differentiation, the diversity of cell types within a single organ is vast. There are a number of key fundamentals that need to be overcome first. Improved disposition technology, direct in-situ differentiation of cells and improvements in bioreactor-based tissue maturation processes are required. Currently, reliable extracellular matrix production and the potential formation of stem cell tumours are two of the biggest hurdles that need to be overcome. Any defect in a group of cells or any defect that causes part of the tissue to die could be catastrophic if a tissue was to be transplanted. Another conceivable application of bioprinting technology is veins, although immune system rejection is a potential issue.

AA: The scientific process itself is not predictable, so it is really impossible to predict a timeframe. Certainly, simpler printed tissues, such as bone and muscle, will be implanted first. Areas of focus include developing new biocompatible materials with sufficient mechanical strength to maintain their shape and withstand external stress after implantation; improving printer resolution to duplicate the detailed architecture of organs such as the kidney; developing methods to vascularise and innervate printed engineered tissue and organs; and increasing the speed of printing.

■ What is the current state of the art in materials to support cell cultures to form scaffolds of 3D-bioprinted tissues? And what research paths are being investigated for the next generation of scaffolds?

DT: Infrared laser photo-cured hydrogel scaffolds are currently an area that is producing some very interesting results. This allows sub-100µm scaffold layers to be formed, rather than old-school biologically active materials in which 500µm were achieved. By seeding different growth factors into the scaffold, this may also provide a means to control the formation of coarse vasculature and innervation within certain areas of a specified architecture. The interesting thing is that a lot of technology and concepts from the printing and coating industry can be applied towards ultra-precision cell pattering. Methods using 3D screen printing are both ultra-high resolution and also have scalable potential.

DT: The notion that you could culture a few hundred million adult cells and deposit them together to produce a functioning tissue is not realistic. This is due to cellular signalling mechanisms that tell stem cells exactly which genes to activate so that organs and tissues can self-assemble. Progenitor cell models are one line of research. We know from various experiments, that a variety of stem cells, if given the proper signals, will spontaneously organise themselves to turn into the right kinds of adult cells needed to create functioning tissues.

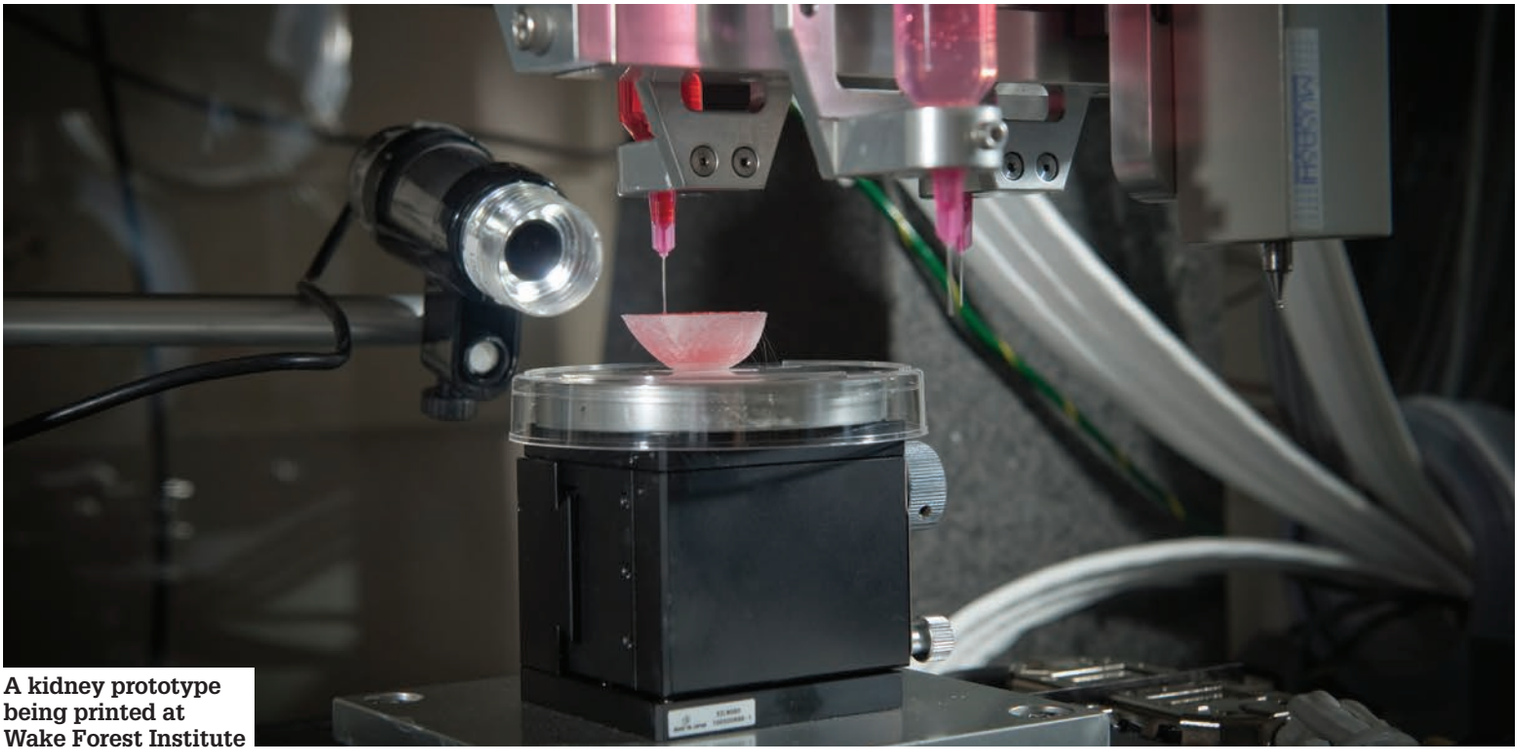
> **“ Research has shown that with one type of bioprinting, microextrusion, cell viability is between 40 and 86 per cent**

VM: The answer to the first part of the question is highly debated in the tissue engineering arena but methacrylated gelatin could easily be considered as one of the state-of-the-art materials available. This is due to many reasons:

1. It a hydrogel with regions for cell binding and remodelling, so it mimics multiple aspects of the native environment of the cells compared to many other materials.
2. It has been proven to be biocompatible in mouse models, meaning it does not produce an adverse reaction upon implantation.
3. It is cheap and easy to synthesise and fabricate.

Coming to the second part of the question, cells are inherently dynamic and materials that support and promote such dynamic behaviour of cells are highly desired. At the same time, such a material should also be susceptible to techniques such as bioprinting. So the material for the next generation of scaffold should be more complex in its ability to promote cellular behaviour and should have the ability to be manipulated by bioprinting.

AA: As scientists move away from hand-fashioning scaffolds to bioprinting them, additional biomaterials will need to be identified. ->



A kidney prototype being printed at Wake Forest Institute

The material must not only be printable, but also must be compatible with the body and support cellular attachment, proliferation and function. Also important is how quickly the material will degrade in the body. The degradation rates of the scaffold must match the cells' activity in building a 'home' from their own extracellular matrix, the molecules they secrete to provide structural and biochemical support. In addition, material selection must be based on the mechanical properties needed for a particular structure. Different structural requirements will be needed for tissue types ranging from skin to liver and bone.

■ To what extent is 3D bioprinting dependent on advances in stem cell research?

DT: This is key towards the development of bioprinting technology. There is currently a lack of understanding when it comes to the kinetic mechanism of cells. Induced pluripotent stem cell lines seem to be the most reliable starting point. This is when any cell in the body can be differentiated into an embryonic stem cell and then re-differentiated into any type of cell. This powerful discovery was a real game-changer for bioprinting research. It is this model that is proven to be an effective way towards allowing for differentiated tissues to be produced.

VM: As such, advances in 3D bioprinting do not mainly depend on stem cell research. However, for the collective success of tissue engineering, strides have to be made in stem cell research to a great extent. This is because stem cells are one of the most promising and sustainable cell sources for engineering artificial organs.

AA: Cells are a key 'ingredient' in engineered tissues, so advances in stem cell research will be vital to moving the 3D bioprinting field forward. Whether future research yields new sources of cells or information about cell signalling and tissue formation or identifies new growth factors that can enhance the engineering process, the results will play a role in tissue engineering through 3D bioprinting.

■ 3D or 2.5D. When does liquid dispensing become printing? Much work shown is 3D-compatible structures coated in a 2D layer. What are the experts' opinions on this?

DT: New processes are being developed all of the time based around this concept. In some cases, 'ghost organs' are used. This is where you start with a dead organ and remove all cells that have immune rejection functionality. What is left is an extracellular matrix that stem cells utilise when they locate themselves and self-assemble. In the short term, this mechanism for tissue engineering may yield very interesting results.

■ What kind of tissues can be printed? And does post-print manipulation or processing aid in the development of the tissue (i.e. apply something to stimulate desired growth or further development)?

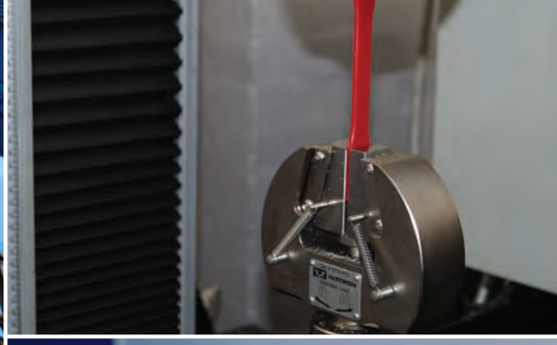
DT: Post-printing bioreactor processes are also very important as a result in which many complex biological processes – differentiation, maturation and transformation – occur. This final stage towards the formation of a final architecture is vital.

Researchers at Nottingham University are working on a number of interesting applications for producing tissues for reconstructive surgery. Sheffield University continues to make excellent progress with developing nerve repair technologies. Newcastle University continues to do excellent work into rebuilding vascularised bone tissue. Individually, these are really exciting areas of research that will yield future therapies to treat a number of debilitating conditions. Currently at Swansea, we work on tissues primarily for pharmaceutical testing. Here, MSC cells are used to make simple architecture heart tissue models. Our most complex tissue is eight 200µm layers thick, which consists of a simple multilayer structure. But there is still a long way to go before making anything more complex.

> **"For the collective success of tissue engineering, strides have to be made in stem cell research to a great extent**

■ This technology is very powerful; what is currently the most successful methodology and what future refinements need to be made? There are some really exciting companies: Organovo, Tedvideo, 3Dynamic systems and Cyfuse. Which one do you consider to be the most advanced at the moment?

DT: There are so many refinements that need to be made to the methodology. The great thing with bioprinting technology is that there are so many people doing so many different things; this scientific method cannot fail to generate results in the end. There is not just one approach to solve one problem, but many different approaches to solve a whole number of different problems. There are a number of private companies that produce excellent systems that are ultra-precise and can be used for the purpose of bioprinting. Short term, I believe that systems that are able to make porous 3D matrix will provide a natural structure in which stem cells can congregate. This will allow for cells to migrate and then gather information from surrounding tissues, potentially differentiating into precisely needed cells types.



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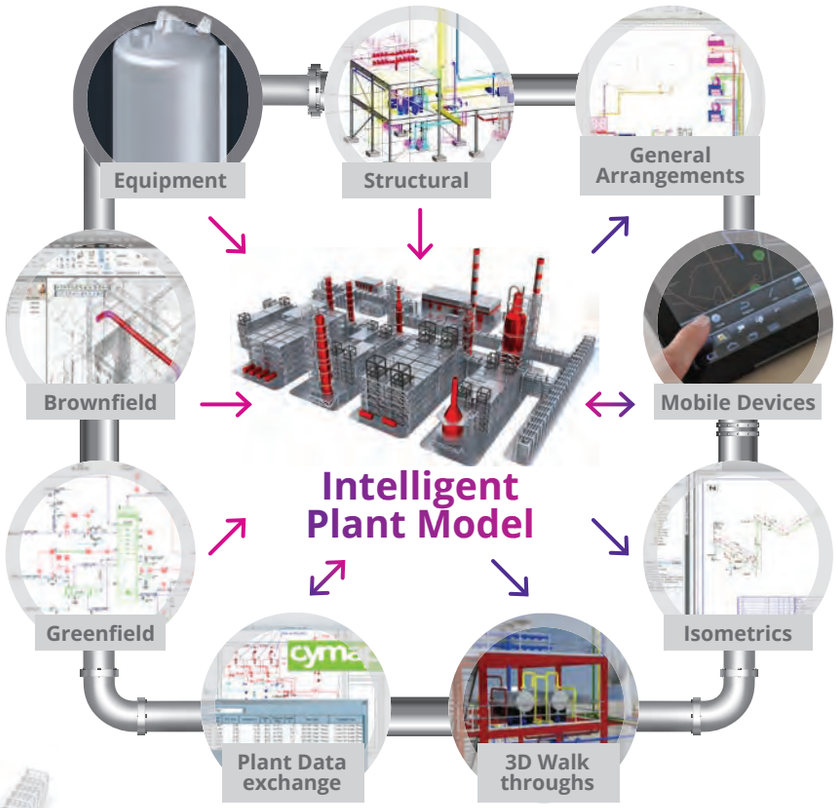

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Pump out the volume

Advanced cryopumps will help create the huge vacuum needed to operate the world's biggest fusion reactor. Michael Kenward reports

Coconuts aren't usually the first thing that spring to mind when you think about clean energy sources. But it turns out they could be an important component of attempts to make nuclear fusion a commercial reality.

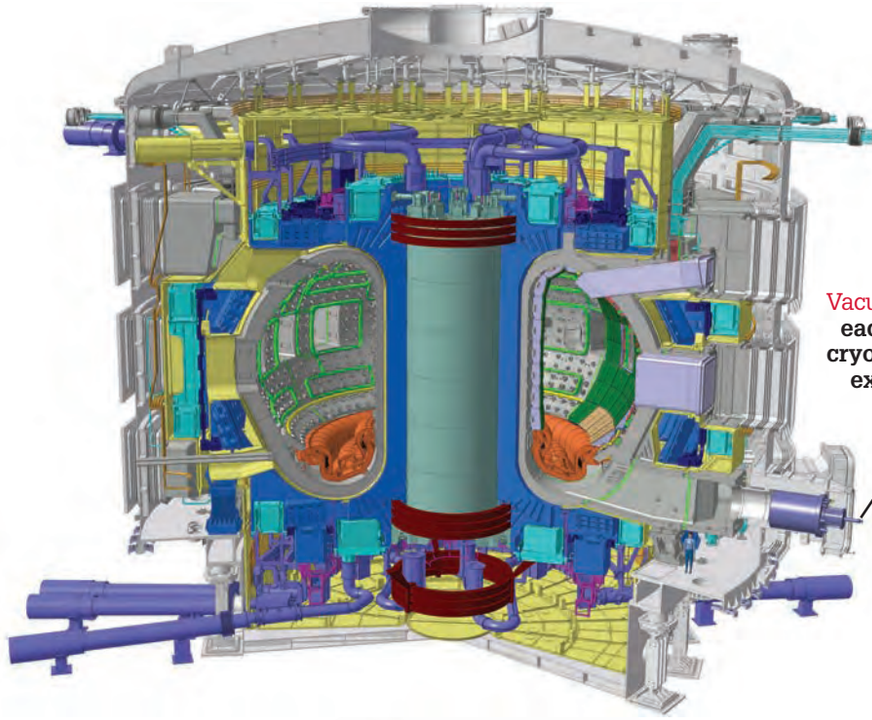
Currently under construction in southern France, Iter will be the world's largest experimental fusion reactor. It will replicate in a power station the sort of reactions that power the Sun and stars – the fusion of hydrogen isotopes into helium – in order to deliver safe, effectively limitless and environmentally clean energy on a commercial scale.

Success in controlling nuclear fusion rests on using vacuum pumps to create large volumes of nothingness: any extraneous material would get in the way of the fusion reactions. Iter's fusion reactions will happen inside a huge, 1,400m^3 toroidal vacuum chamber sat inside a cryostat – a massive 'vacuum flask'. Liquid helium will flow around this assembly, keeping the reaction chamber and cryostat at a temperature of 4.5K.

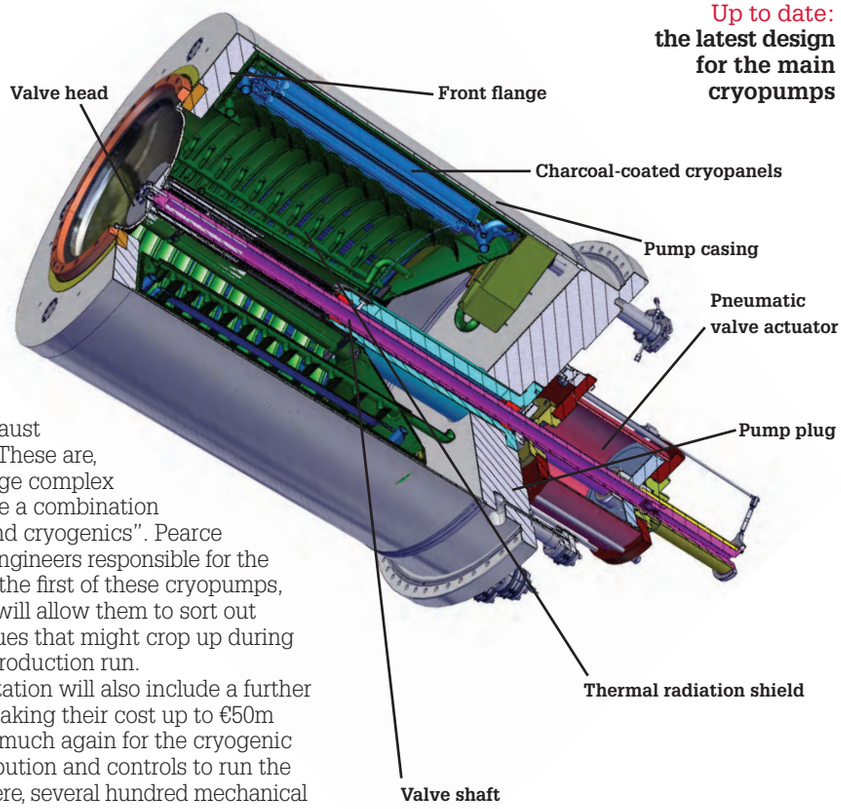
The cryostat is one of Iter's largest components, adding another 8,500m^3 to the total volume, and has to be operated at one millionth of normal atmospheric pressure. Its superconducting magnets will envelop the reaction chamber and create the electromagnetic fields that will hold in place Iter's hot plasma, the cloud of ionised fuel needed for the reaction. Together, these components will make up one of the largest vacuum systems ever built.

In order to create such a large vacuum, Iter requires very high pumping speeds and so will use cryopumps that work by trapping gases on a cold surface. The cooled surface is often partly covered with a porous material that can absorb the gases. In Iter's case, tests on many different absorbing materials showed that activated charcoal made from a particular vintage of coconuts from a plantation in Indonesia gave the best results. Iter bought up all the supplies available and, 10 years on, there is no sign of degradation in the performance. However, the project has now moved on to the 2014 vintage of coconuts and holds a large stock in the basement of Iter's headquarters.

"Activated coconut charcoal sounds a bit unusual, but is a product that is used extensively where you need high purity, high porosity and good sorption properties," explained Robert Pearce, who leads Iter's vacuum group. "The number-one market is drinking-water filters, but there are numerous other applications: Provence rosé wine is often filtered using active coconut charcoal. I even heard that munching on the coconut charcoal is a really good way to whiten your teeth [first they go black]."



Vacuum cleaner: **each of the six cryopumps will exhaust Iter's main torus chamber**



Up to date: **the latest design for the main cryopumps**

Iter's main pumping systems will include six eight-tonne pumps that exhaust the main torus. These are, said Pearce, "large complex pumps that have a combination of mechanics and cryogenics". Pearce runs a team of engineers responsible for the manufacture of the first of these cryopumps, which, he said, will allow them to sort out engineering issues that might crop up during the rest of the production run.

The power station will also include a further 12 cryopumps, taking their cost up to €50m (£36m), with as much again for the cryogenic plant and distribution and controls to run the pumps. Elsewhere, several hundred mechanical

"Activated coconut charcoal is a product that is used extensively when you need high purity and good sorption properties
Robert Pearce, Iter

pumps will maintain the vacuum in peripheral systems and diagnostic instruments. While some of the cryopumps create the vacuum, others will 'regenerate' the absorbed gases to recover tritium, one of the hydrogen isotope ingredients for fusion. If, unlike earlier fusion projects, Iter is to run continuously, the system has to be able to regenerate tritium 'online', which means completing the regeneration within 600 seconds. "That is quite a task for a pump," said Pearce.

The regeneration comes about through 'cryabsorption' of the helium and the hydrogen isotopes from the fusion reaction into the panels of activated charcoal in the pumps. The pump's surface is then heated to 100K to re-release the gases. "Then we pump it back, strangely with another cryogenic pump," said Pearce.

This new arrangement, dubbed a cryogenic viscous flow compressor, is a joint development project with the Oak Ridge National Laboratory (ORNL) in the US. February saw completion of the first of this new type of pump, with tests about to begin in Oak Ridge, Tennessee.

At this stage of the process, the cryopumps also need to remove the helium 'ash' created by the fusion reaction through use of the 'divertor', an array of 54 remotely removable cassettes that sit at the bottom of the main chamber. Described as "like a giant ashtray into which the hot ashes and impurities settle", the divertor is where the cryopumps face their toughest challenge.

Helium is a hard gas to pump, said Pearce. Effectively you have to neutralise the ionised plasma particles in the divertor and create a pressure in the bottom of the machine. "Then you have to pump that neutral gas. You are clearing out the helium, which is only about one per cent, but you are also clearing out all of the fuel. That means that the pump has to cope with a very large gas flow."

Pearce, who previously ran the vacuum group on the Joint European Torus (JET) – Iter's predecessor at Culham in the UK – described his group's current activity on Iter's pumps as turning concepts into properly engineered and manufacturable designs.

Positive reaction: **the new cryogenic viscous flow compressors are due to be tested at Oak Ridge, Tennessee**

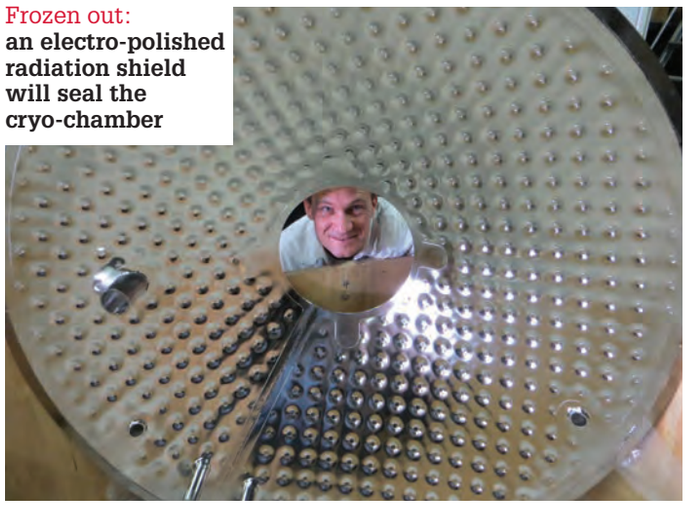
The vacuum group, with teams in Oak Ridge, France and Spain, is also looking at the engineering for fusion reactors post Iter.

"We have a concentration to get on and build Iter but we also have to do a lot of design and development work in order to have a solution that really works for the next step," said Pearce. This is a reference to DEMO, a demonstration power plant that will show the viability of producing large-scale electricity from fusion.

The new cryogenic viscous flow compressor could be a suitable candidate for future generations of reactor, said Pearce. It might eliminate what he described as the "slightly ironic" heating and cooling cycle in the current system that starts when fuel enters Iter as frozen pellets. "So the fuel gets cooled down; it gets heated up again in the plasma. Then we cool it down again and pump it. Then we heat it up again to get it out of the machine. Then we cool it down yet again to pump it. The gas goes through this cycle, which is obviously not very energy efficient."

Fortunately, he added, "we have some ideas for how we could combine a lot of this heating and cooling in one device on the machine, which would save all of these cycles". He continued: "You cool it once with your pump, which is also injecting it straight back in."

This example illustrates the challenge of Iter: turning science into real engineering. In the past, said Pearce, there have been plenty of "nice ideas". He added: "On Iter, we have actually got to turn all this into being a machine that works reliably but that is also safe from a nuclear point of view. But before you can get to any of that it has to be buildable."



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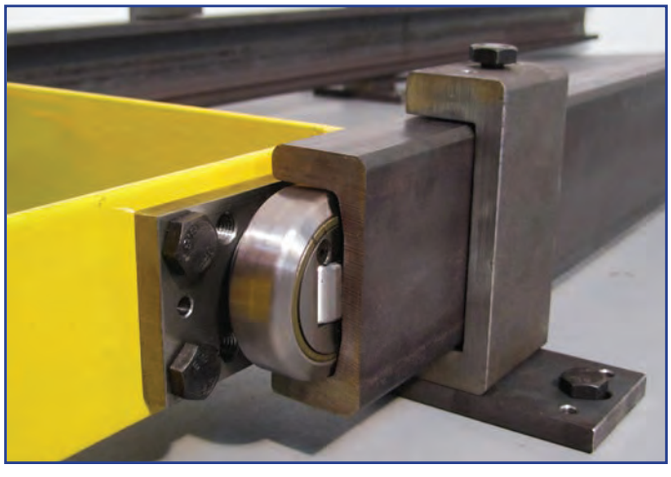

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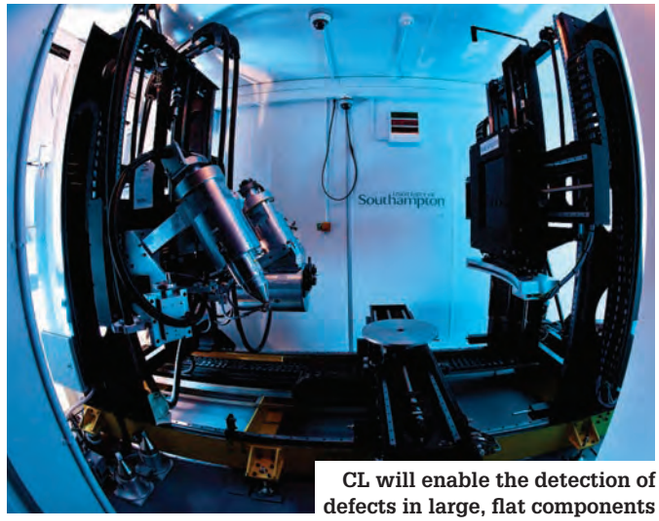
Finding flaws in composite parts

Testing could allow development of greener, safer aircraft

Innovate UK has provided funding for a project to develop imaging technology used in the design, manufacture and maintenance of current and future carbon composite aircraft.

Led by Qinetiq, the UK consortium of Southampton University and University College London (UCL) and four companies in ProjectCAN brings together experts from academia, aerospace and X-ray inspection equipment manufacture.

As part of the government's Aerospace Technology Institute, Innovate UK has provided the team with funding to develop two non-destructive testing processes for detecting flaws in composite aerospace parts.



CL will enable the detection of defects in large, flat components

According to a statement, Southampton University's µ-VIS Centre for Computed Tomography is host to one part of this three-year project. Together with Nikon Metrology UK, it aims to develop methods for scanning the insides of large, flat components using X-rays. The partners will develop the system for acquiring scan data and software to reconstruct it into a 3D volume image, allowing manipulation and visualisation using standard software.

"Conventional computed tomography [CT] techniques are widely used but are not well suited to image extended flat objects," said Dr Thomas Blumensath of SouthamptonUniversity. "We will be developing an alternative technique, which applies computed laminography [CL] techniques, to overcome the limitations of conventional CT for large, flat components. This will enhance our ability to find defects in large composite parts, such as those that are increasingly used in modern aircraft.

"This will ultimately help in production and maintenance processes and will assist in the development of more environmentally friendly aircraft and enhanced overall aircraft safety."

According to Southampton University, traditional CT requires the scanned components to be fully rotated, and will yield optimal results only when the X-ray attenuation for each angle is broadly similar. It is impossible to scan very large parts due to space restrictions; when scanning smaller flat panels, the variation of attenuation across the angles can become too large for optimal imaging. CL systems use a different motion, such as linear translation or limited-angle rotation, to scan components where CT is impossible or ill suited.

A laminography system comprises the hardware that positions the sample, source and detector to acquire 2D projection data, as well as an algorithm to reconstruct a 3D volume image from the data. ProjectCAN will develop both this hardware and software to allow laminographic imaging within the custom Nikon Metrology 225/450kV X-ray scanner already in service in the µ-VIS centre at Southampton.

productnews

Super scanner

Hexagon Metrology has launched the HP-S-X5 HD scanning sensor, a heavy-duty analogue probe that it claims will open up a wider range of scanning applications. The sensor is designed to give high and repeatable accuracy even with heavier and longer probe extensions and enables co-ordinate measuring machine (CMM) users to measure small parts as well as features deep inside a workpiece with the same probe head.

In the frame

Central Scanning is now offering 3D scanning products developed by the Artec Group. The Artec Eva – a 3D video camera – captures up to 16 frames per second, and each frame is a 3D image. Meanwhile, the Artec Spider has been developed for mass production and industrial design where higher-precision scanning is required. The Artec Spider captures up to a million points per second and is claimed to scan a dozen times faster than a laser scanner.

Keep it Handy

The latest HandyPROBE and HandySCAN3D from Measurement Solutions are portable CMMs and scanners that can be used anywhere. With built-in TRUaccuracy technology, the systems provide metrology-grade accuracy and are unaffected by vibration. The technology has been used by organisations including BAE Systems, Jaguar Land Rover, EasyJet and BMW.

Doppler detection

Pacer is now supplying a range of microwave Doppler radar motion detector units from Microwave Solutions. The units utilise the Doppler shift phenomenon to 'sense' motion. The units operate at X-Band and K-Band and can be incorporated into a range of sensors in applications such as lighting and energy management, home automation, intrusion alarms, collision avoidance, automatic door openers and traffic control.

Bright future for solar panels

Defect detection could greatly improve the efficiency of thin-film technologies

Researchers at the University of Huddersfield's EPSRC Centre for Innovative Manufacturing in Advanced Metrology have developed defect detection techniques that they claim could lead to major efficiency gains in the manufacture of flexible solar panels.

The research, carried out through the EU-backed NanoMend project, has focused on technologies suitable for the detection, cleaning and repair of micro- and nano-scale defects in thin films that are vital in products such as printed electronics and solar panels.

The team has been working with the Durham-based Centre for Process Innovation, a leading producer of printable electronics, including flexible solar panels. In these products, a thin 'barrier film' is vital to protect the electronics. But tiny defects can allow the penetration of water vapour that can degrade the barrier and reduce the efficiency of the solar panel itself.

The key technology developed by the group is a wavelength scanning interferometer, which has uses that include the detection of defects in the coating that can have a serious impact on the longevity of roll-to-roll vapour barrier coatings for flexible photovoltaic (PV) cells.

Drawing Forth

A detailed model created using mobile laser scanning technology will be used to help maintain and improve Scotland's three iconic bridges

Mobile laser scanning technology developed by Renishaw is at the heart of an effort to create a detailed digital model of Scotland's three iconic bridges over the Forth.

The £300k project – launched to celebrate Scotland's industrial heritage – covers the Firth of Forth Rail Bridge, the Forth Road Bridge and the soon-to-be-complete Queensferry Crossing. The data acquired will be used to help maintain the bridges as well as to generate animations, fly-throughs and educational materials.

In an effort to determine the best technology to use for the task, the Centre for Digital Documentation and Visualisation (CDDV), a collaboration between Historic Scotland and The Glasgow School of Art, asked Renishaw to use its mobile laser scanning technology to conduct a survey of a section of each bridge.

Laser scanners capture data by firing a laser beam from a scanner at a solid surface and using the reflected laser beam to make rapid and highly accurate distance measurements. Each of these measurements, or data points, is used to form a 'point cloud', a collection of measurements that can be used to create extremely accurate 3D models of whatever is being scanned. As the process effectively operates at the speed of light, it has huge advantages over many traditional surveying techniques.

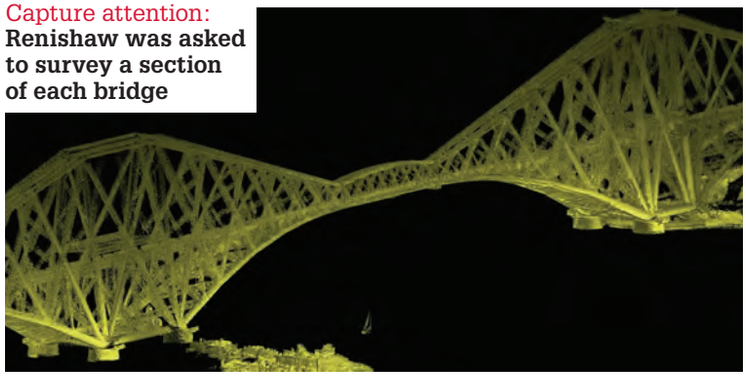
The project posed a number of challenges: the need to capture fine detail of such complex structures meant that vessel-based scanning was a necessity, yet high traffic on the riverway, and tidal patterns that limited access to the underside of the bridge to specific time windows, required careful planning.

The area is also renowned for poor global navigation satellite system (GNSS) coverage, which is essential for the laser scanner positioning and navigation, and the safety risks involved in sailing too close to the bridge were additional factors that Renishaw was able to mitigate, using its two decades of experience in 3D laser scanning.

During the project planning stage, Renishaw's spatial measurement team used tidal charts, navigation charts and studies of GNSS windows to plan the optimal time to carry out the data acquisition.

The team chose a Trimble MX2 single-head laser scanner to undertake the laser scanning, installing the system on the front of a coastguard rescue boat.

The onboard GNSS-aided inertial navigation system provided the position and orientation of the scanner at any given moment to a high degree of accuracy, and as each model is factory calibrated, installation is quick. This meant that as much of the team's time as possible could be spent gathering data.



Capture attention: **Renishaw was asked to survey a section of each bridge**

The use of a single-head unit – which captures less data in a given time period than a dual-head scanner, but is more suitable for marine applications due to its increased lateral range – meant that the boat needed to zig-zag up the river in order to ensure coverage of the full site.

Renishaw's team (which has also worked with Historic Scotland on the mapping of Kisimul Castle in the Outer Hebrides) took just one day to complete the scanning work and CDDV is now planning to carry out further laser scanning of the bridges and their environment.

backstory

Laser scanners aid preservation of ancient sites

Laser scanning systems are playing an increasingly valuable role in the preservation and detection of ancient sites. Last year, archaeologists working for the Factum Foundation used laser scanning systems to create a replica of the 3,245-year-old Tomb of Tutankhamun.

Meanwhile, a team led by researchers from the University of Exeter in the UK are currently gearing up to use drone-mounted laser scanners to fly above the Amazon rainforest and peer through the canopy to look for signs of ancient civilisation.

More recently, structural engineers from the University of California used laser scanners to conduct a structural 'health assessment' of the Baptistery of St John, an 800-year-old basilica in Florence, Italy.

Using a combination of LiDAR laser scanning, ultra-high-resolution photography and thermal imaging, the team constructed a detailed 3D model of the interior, exterior and façade of the structure.

The project has revealed a far more detailed understanding of the ancient building than was previously possible – and has provided critical data that's expected to inform the long-term stewardship of Baptistery.

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Finished business

A new quality programme is intended to help manufacturers increase productivity and reduce waste. Helen Knight reports

Ensuring that the products coming off an assembly line precisely match their design brief can save companies thousands of pounds in waste every year.

But this verification process can itself account for up to 20 per cent of a product's overall cost, so streamlining procedures to ensure problems are spotted as early as possible can have a significant impact on a company's bottom line, as well as the quality of its finished products.

To this end, the National Physical Laboratory (NPL), based in Teddington, has created the Product Verification Programme, which is intended to help manufacturing companies to improve their productivity and reduce waste through better measurement technologies and processes.

This is becoming increasingly important as customers expect components to conform to ever more stringent specifications, said Philip Cooper, leader of the Product Verification Programme at NPL. "An aircraft engine manufacturer, for example, may potentially have thousands of components supplied to them from all over the world, which all need to be brought together to be assembled into a single product," he explained. "So whether the parts are manufactured to the specified dimensions is absolutely critical, and we are talking about tolerances right down to a few microns."

By verifying that parts conform to their original design dimensions, metrology can improve the entire manufacturing chain, increasing productivity, research and development efficiency and lowering costs, Cooper added. Indeed, research carried out for the European Commission suggests that an investment of €1 (73p) in metrology results in an increase of €3 in the EU's gross domestic product (GDP).

In the UK alone, around £342bn worth of products are sold each year on the basis of a measurement of their performance, while goods worth a further £280bn are weighed or measured at the business-to-business level. "For many products, it is not actually possible to sell them if the designer and manufacturer cannot quantify their performance, and in order to do that they have to be measured," said Cooper. "So for example, at NPL we have worked with a thermometer manufacturer that wanted to develop a new way of measuring


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“Manufacturers often believe they have everything under control, and may even feel they know their weaknesses
Ken Dean, Brafe Engineering

temperature, and they had to be confident that the measurement they were claiming was accurate; it had to be verified.”

Research has shown that around three quarters of all errors have their routes in the early stages of production. But of these, around 80 per cent are not picked up until much later – either during manufacturing or after the product’s sale – making it far more costly to put right the error.

So for example, many manufacturers are equipped with co-ordinate measuring machines, devices that use a probe attached to a moving axis to inspect the size and shape of products coming off the assembly line. But there is no point in investing thousands of pounds installing such a machine at the end of the production line, if your manufacturing process is not consistent in the first place, according to Tim Jones, operations manager of the Product Verification Programme at NPL.

“You don’t want to rest everything onto your co-ordinate measuring machine at the end of the process, because by that point you have already put a lot of value into your products,” he explained. “You might already be shipping parts, and you are creating a bottleneck that will not go down well with customers obviously, and can lead to financial penalties.”

Instead, companies should also consider installing technologies to monitor the performance of their manufacturing equipment, said Jones. “You need to know that your milling machine or lathe is consistently producing what you think it is,” he said. “To do that you need to use equipment to measure the performance of that lathe or machine, such as a ballbar system.”

photo credit: vladimir salman / Shutterstock.com

Ballbar systems, developed by Renishaw, which is based in Wotton-under-Edge in Gloucestershire, are designed to provide a rapid check of a machine’s positioning performance. “It [a ballbar system] enables you to accurately map what your machining capability is,” explained Jones.

Companies can obtain grants for product verification support from NPL through the government-backed Manufacturing Advisory Service (MAS). One UK business saved up to £500,000 by taking the team’s advice to analyse its turbine blades with a thermal-imaging technology known as pulsed thermography. This revealed hidden problems with the blade coatings.

“We have a four-stage process that we work through with a company,” said Cooper. “We look at a company’s measurement practice, right the way through from quotation through to design drawings to the [final] inspection,” he said.

For example, the team was asked to help castings manufacturer Brafe Engineering, which is based in Woodbridge, Suffolk, after the company had identified areas of the inspection process that needed improvement.

The team suggested that the company improve the calibration of its co-ordinate measuring machines. It also recommended regular checks to ensure that the machines do not wander out of calibration, as well as increased training and inspection courses for staff.

“Manufacturers often believe they have everything under control, and may even feel they know their own areas of weakness,” said Ken Dean, quality manager at Brafe Engineering. “But bringing in experts from NPL really gives them a chance to examine their operations in detail,” he said.

Last year, NPL also began providing its product verification services to the government-funded Sharing in Growth and the Civil Nuclear Sharing in Growth programmes.

These projects, which are backed by the Regional Growth Fund, are intended to improve the capability of companies in the UK’s aerospace and civil nuclear supply chains respectively.

The organisation is providing each of the companies involved with the programmes with a Product Verification health check, as well as an improvement plan, specialist measurement knowledge and support with training.

Sheffield-based CW Fletcher and Sons, which manufactures precision parts for the aerospace and nuclear industries, took part in the health check in a bid to increase its efficiency and reduce costs.

NPL’s team recommended that the company make savings by improving its application of measurement techniques. As a result, John Walker, engineering manager at CW Fletcher, said: “We are manufacturing with a higher degree of confidence and improving efficiency to provide more for our customers for the same cost.”

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

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25th March 2015 at the National Composites Centre, Bristol

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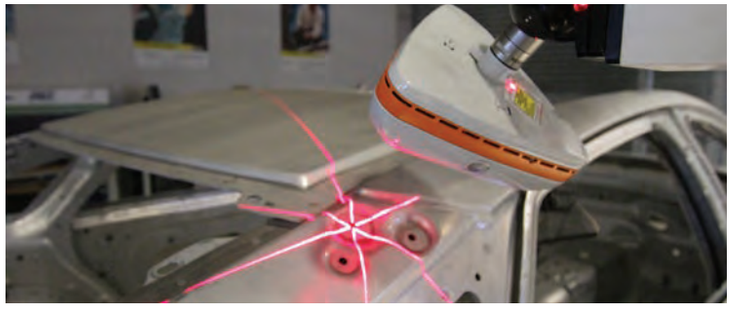
This event will feature senior speakers from the HVM Catapult, Rolls-Royce plc, the National Physical Laboratory (NPL), and the Laboratory for Integrated Metrology Applications (LIMA) of the University of Bath. It will focus on the importance of metrology, different measurement capabilities, industrial case studies, and good practice. There will also be a group discussion on metrology challenges and how you can become involved with the National Product Verification Programme. The NCC are offering a tour of their facilities, however, pre-booking by event registration one week in advance is essential. The NCC reserves the right to exclude or limit access due to operational reasons.



Who should attend?

- Engineers with responsibility for product quality
- Managers wanting to improve the capability and efficiency of their metrology operation
- Anyone interested in engaging in R&D projects in the field of measurement and product verification

Why you should attend?

- To find out more about the High Value Manufacturing Catapult and how you can benefit from working with us
- To learn about the HVM Catapult's measuring capabilities and the technologies we use
- To meet with people from the HVM Catapult centres, academic institutions and industry
- To become involved in NPL's National Product Verification Programme
- To learn about NPL training courses for industry

Can't make the 25th March in Bristol?

Further events in Sheffield and Coventry will take place later this year. Email a.attridge@warwick.ac.uk to be kept informed.

The event is held at the National Composites Centre in Bristol (near M32 J1), from 9:30 am on **Wednesday 25th March 2015**
Attendance is free, but places are limited, so confirm your attendance by Thursday 19th March
To register, visit https://ncc-catapult-metrology.eventbrite.co.uk

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Full speed ahead

The motorsport industry offers a plethora of exciting projects and challenges for engineers. Evelyn Adams reports

Across the scenic landscape surrounding the West Midlands, a burgeoning race industry has emerged attracting engineers the world over. Dubbed Motorsport Valley, this once quiet part of the country has now become known as the 'jewel in the crown of British engineering' contributing £9bn to the UK economy.

"Britain's reach is truly global where motorsport engineering and technology is concerned," said Clive Temple, programme director of Advanced Motorsport Engineering at Cranfield University. "The sector embraces a wide range of companies from the well-known teams to small but dynamic companies providing a plethora of engineering services."

The world-leading industry had an unlikely beginning in the 1950s, when after the Second World War Britain was left with more airstrips and engineers than ever before. With aerospace expertise and a fierce competitive streak, these engineers began turning their hand to car racing. Today, their legacy for innovation lives on in the 4,300 UK businesses operating in the sector.

Overall, the UK motorsport industry sustains almost 41,000 jobs, around 90 per cent of which export globally. Many of them are in Motorsport Valley, which more specifically describes an area roughly 80 miles wide stretching from the south west of Birmingham to Norwich. Larger teams, such as Mercedes and Red Bull, employ around 700 people in the area, while teams such as Force India have about 300 employees.

A recent review of the UK motorsport sector by the Motorsport Industry Association (MIA) found the sector recorded £9bn in sales during 2012 compared with £4.6bn in 2000. Spend on research and development is currently at 25 per cent of sales turnover, and opportunities for engineers in the sector are growing. Last year, eight of the 11 teams racing in Formula One (F1) were based in the UK, including McLaren, Red Bull, Lotus and Mercedes.

'But there is much more to motorsport than F1,' said Temple. 'There are all the component suppliers and manufacturers too. Interestingly, a valuable segment within motorsport is the historic side as borne out by the interest in events such as the Silverstone Classic and Goodwood meetings. And it's not just on track and on four wheels. There is off-road and two wheel, even three-wheel motorsport.'

For engineers hoping to carve out a career in the UK motorsport industry, there are a range of opportunities. From office-based jobs, designing and testing parts for cars using CAD/CAM software, to working in the supply chain, providing complex and often secretive parts to race teams who require rapid turnaround times. 'Often, the smaller the team the more responsibilities the engineers have as they have to do several jobs at one time,' aid Gemma Hatton, a course representative for Advanced Motorsport Engineering at Cranfield University.

In fact, around 35,000 people are not directly employed by racing teams, but work in smaller companies within the supply chain. According to Chris Aylett, chief executive of the Motorsport Industry Association, one of the best routes into the motorsport supply chain is through technical apprenticeship. Practical skills that can be proven are key, but so are team working, management and presentation.

And anyone working in the sector has the challenge of keeping the sport relevant. For instance, with a focus on energy-efficient technologies, engineers are facing a fresh set of challenges. "Opportunities are changing," said Temple. "Take the Mercedes-AMG high-performance powertrains activity at Brixworth. These are now powertrains, not just engines as they were once described.

"There is the integration of energy recovery systems and the Northamptonshire-based operation is linked into the heart of Mercedes in Germany – driving its research and development. Environmental considerations are a real dynamic in motorsport with disruptive

> **"Motorsport is a niche industry, and once you are in everyone knows everyone or every team is linked to another**
> Gemma Hatton

Fast track: **overall, the UK motorsport industry sustains almost 41,000 jobs**

technologies to the fore. Formula E exemplifies this and so does hybridisation of Le Mans prototypes that run in endurance racing."

As a result, there is far more scope for engineering innovation. The 24 hours of Le Mans, for example, has an entry called 'Garage 56' in which a team does not have to comply with the standard regulations and so can develop a 'concept' car using new innovative technologies. Nissan did this last year with the ZEOD, and before that the Deltawing revealed its radical energy-efficient design that looks like a cross between a fighter jet and a batmobile.

'Motorsport is a niche industry, and once you are in everyone knows everyone or every team is linked to another in some way – it really is a small world,' said Hatton. 'My main advice to anyone considering a career in the sector would be to get yourself to racetracks, always do a good job no matter what that job is, never upset anyone because word spreads quickly and always say yes to any opportunity.'

Many skills are transferable and innovation from designing and building a winning car can be used in other sectors. For instance, McLaren Applied Technologies (MAT) is using some of the lessons learned from F1 in other industries such as healthcare, as well as other sports, such as cycling, rowing and skeleton. Meanwhile, Williams has taken motorsport expertise into sectors such as public transport, helping create energy-efficient technologies.

"There are so many exciting projects and challenges for engineers that go beyond simply designing, manufacturing and engineering racing cars and bikes," said Temple. "You will need to be academically strong where maths and physics are concerned. These two subjects are key to developing an understanding of engineering and then applying your engineering expertise in a practical way. You will need to be articulate, able to present your ideas and secure 'buy-in' for your innovative ideas.

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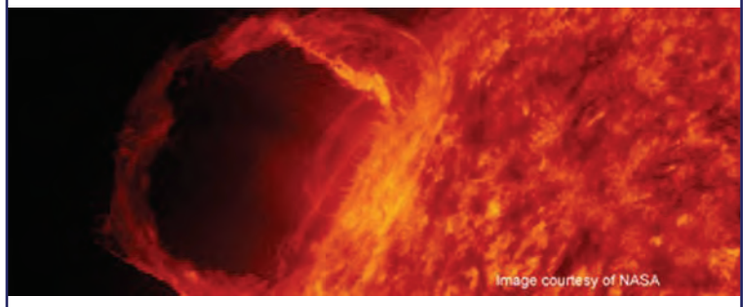

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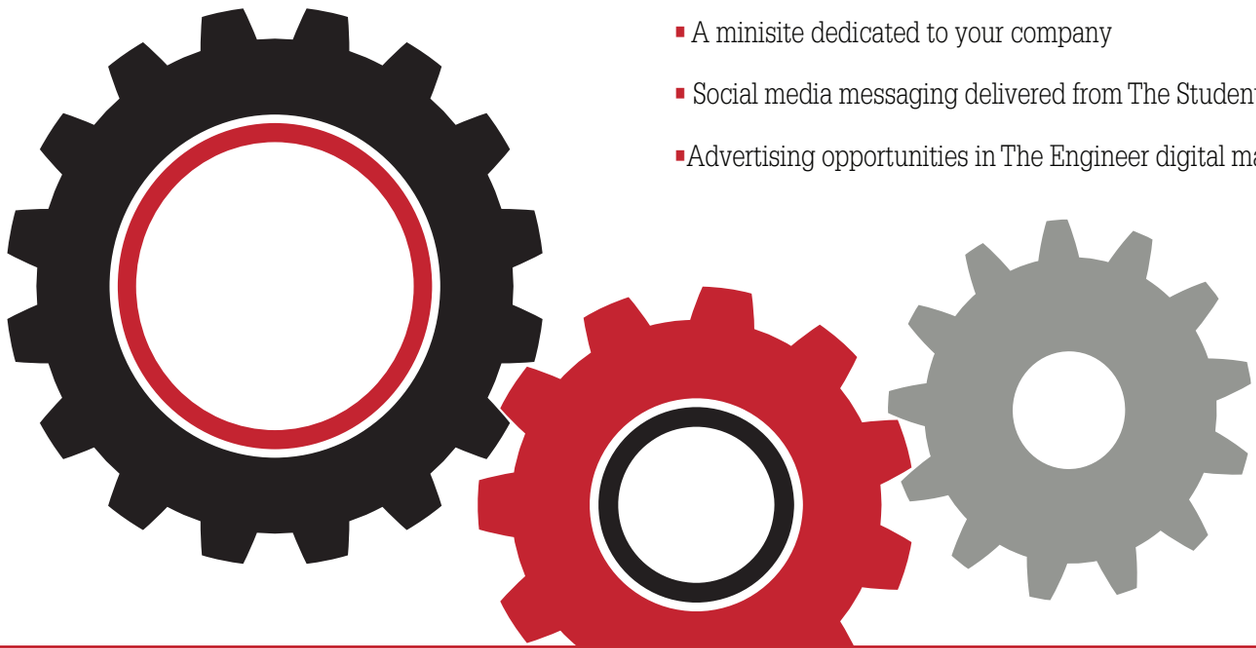

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february1906

The Engineer discussed the operation and claimed benefits of a valveless motor car

The early 20th century was awash with automotive innovations, some of which went on to dominate the industry over the following decades, while others didn't quite have the transformative impact their inventors expected.

One such curiosity is the valveless motor car – an unusual vehicle that featured a valveless, two-cylinder engine and a transmission mechanism without the usual change speed gearbox – developed by London engineer Ralph Lucas.

Explaining the operation of the engine, *The Engineer* wrote:

"When the pistons ascend, air is drawn into the crankcase through the carburettor and passage G. The petrol is, in the meantime, dropping into the chamber. The pistons then descend, compressing the air in the crankcase and forcing it though the throttle and chamber, where it becomes mixed with petrol vapour and, when the piston has uncovered the ports, is admitted into the cylinders driving before it the products of combustion of the previous explosion through the exhaust ports and replacing them with a new charge. On the next upstroke, the pistons compress the charge prior to its ignition and downward movement of the pistons."

"The car has an unusual layout, with the engine beneath the driving seat

The car itself has an unusual layout, with the engine placed beneath the driving seat and the space beneath the bonnet utilised for a cone-shaped petrol tank.

The article reports on a number of claimed advantages for the design, including greater reliability than engines with valves, silent running, high torque at low speeds and ease of manufacture. Some of these claims were put to the test by *The Engineer* in "hilly" Blackheath, and the journal was duly impressed. ***JE***

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

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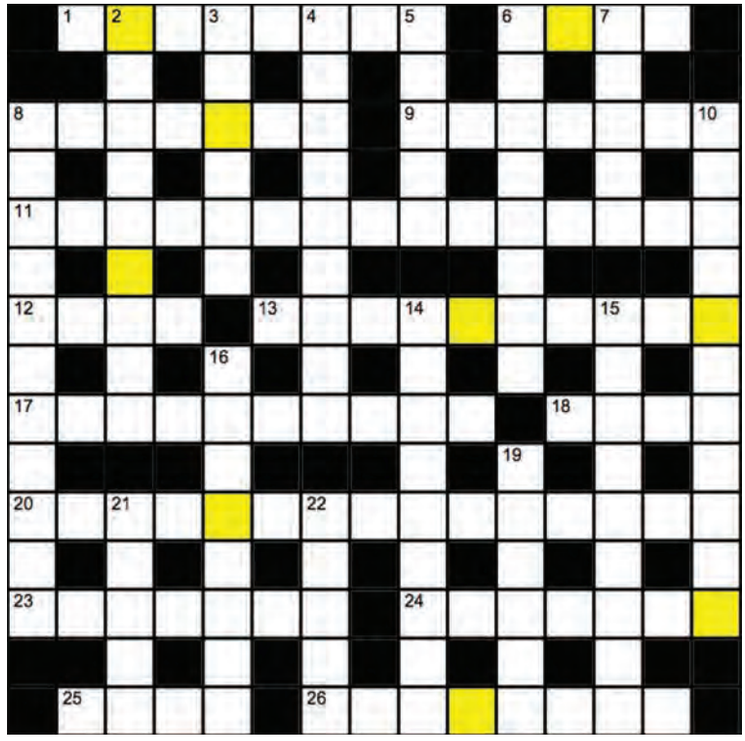

ACROSS

1 Happens again (8)
6 Framework for holding objects (4)
8 Lean in a comfortable resting position (7)
9 Sudden or abrupt strong increase (7)
11 Popular measure of temperature (10,5)
12 Having low density (4)
13 Device for automatically regulating temperature (10)
17 Work very hard (6,4)
18 Set of three similar things (4)
20 Raised electric train track (8,7)
23 Twisting hand tool (7)
24 Obtain in pure form (7)
25 Units of energy (4)
26 Shipbuilding centre of Japan (8)

DOWN

2 Not having a common centre (9)
3 Unstable situation of extreme danger (6)
4 Brought to light (9)
5 Mechanical vibrations transmitted by an elastic medium (5)
6 Electrical device that slows the flow of electrical current (8)
7 Approximately (5)
8 Compilations of the known facts regarding something (6,5)
10 Solution that conducts electricity (11)
14 Providing personal satisfaction (9)
15 Reappearance of an earlier characteristic (9)
16 People who have given long service (3,5)
19 Turns on an axis (6)
21 Strictly correct (5)
22 Protective garment (5)

origineering Anthony Poulton-Smith explores the origins of everyday engineering terms

The Oxford English Dictionary defines 'gasket' as 'a ring shaped to seal the junction of metal surfaces'. Obvious enough, but who named this item and, more importantly, why?

It may come as a surprise to learn that the word 'gasket' has been in use for at least twice as long as that vital part with which we are all so familiar. Hence the original gaskets would never be recognised by modern engineers for they were not the same thing. However, they may be familiar to yachtsmen and sailors.

This came to English from the French. Those who recall their French lessons will know 'garçon' meant 'boy', but our teachers would never have mentioned the feminine version of the word, where 'garcette' described a 'little girl'. Before long, the term was recognised in nautical circles as a 'thin rope'.

Soon afterwards, the English pronunciation as 'gar-skit' came into use, and just as the garcette had united furled sail and spar, so the gasket provided a connection between metal parts in modern engines.

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