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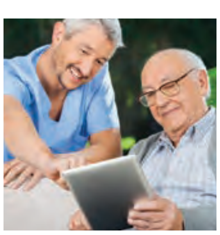
Building Bloodhound

A legend in the making »18



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Picking up pace

One of the pleasures of writing for *The Engineer* is that – if you hang around for long enough – you get to follow some pretty astonishing projects from inception to completion. It's hard to think of a better example than Bloodhound SSC, the subject of this issue's cover story (page 18) and a project whose launch we covered more than seven years ago.

Over the years, we've looked at Bloodhound from a number of different angles: we've celebrated the way that it's been used to inspire and educate the next generation of engineers (it's hard to think of a better example of engineering engagement); we've quizzed its developers on the finer details of the underpinning technology; and we've spoken to many of the members of the UK supply chain who have played a role in making it happen.

In this issue's cover story – almost certainly our last in-depth report before the vehicle heads off to South Africa for a crack at the world land speed record later this summer – we report from Bloodhound's HQ near Bristol on the vehicle's final assembly process.

From the production of the distinctive tailfin, described by one project engineer as the "hardest-working tailfin in history" to the final tests of its hybrid-rocket system, it's fascinating to see it coming together. And although there's no suggestion that the project's timelines have slipped (it's on target to be complete by 25 July), it's surprising how much still needs to be done. Perhaps the seemingly ever-present show car, an empty shell that has a number of significant cosmetic differences to the real thing, has done too good a job of convincing us that the iconic vehicle is finished and ready to go.

> **"Over the years, we've looked at Bloodhound from a number of angles**

Elsewhere in this issue, we turn to arguably weightier issues, from the impact of low oil prices on the renewables sector (page 12) to the technical challenges behind the proposed Swansea Bay Tidal Lagoon scheme (page 32).

We also look at an issue that's dominating the run-up to next month's general election: the state of the NHS (page 25). And we examine whether technology could play a role in alleviating some of the unprecedented pressures it faces.

Jon Excell Editor
jon.excell@centaur.co.uk

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theENGINEER **Centaur Media Plc,** 79 Wells Street, London, W1T 3QN

Direct dial 020 7970 followed by extension listed **Advertising fax** 020 7970 4190 **Editor** Jon Excell (4437) jon.excell@centaur.co.uk **Features editor** Stuart Nathan (4125) stuart.nathan@centaur.co.uk **News editor** Jason Ford (4442) jason.ford@centaur.co.uk **Special projects editor** Stephen Harris (4893) stephen.harris@centaur.co.uk **Senior art editor** Phil Gibson (4135) philip.gibson@centaur.co.uk **Recruitment advertisement manager** Mauro Marenghi (4187) mauro.marenghi@centaur.co.uk **Senior sales executive** Dean Wylie (4160) dean.wylie@centaur.co.uk **Senior sales executive** Ricky Rana (4426) **Sales executive** Jason Padam (4677) **Sales executive** Harry Clark (4811) **Commercial director** Sonal Dalgliesh (4487) sonal.dalgliesh@centaur.co.uk **Business development manager** Peter York (4942) **Production** Andrea Harper, Wendy Goodbun (4807) te.production@centaur.co.uk **Publisher** Simon Lodge (4849) simon.lodge@centaur.co.uk **Subscriptions & Customer Services** tecirc@centaur.co.uk

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MATERIALS

Light-bulb moment for unique material

Graphene set to be commercialised at National Graphene Institute

BY JASON FORD

The global race to commercialise graphene has moved forward with the opening of the National Graphene Institute and the imminent launch of a light bulb containing the material.

The £61m National Graphene Institute (NGI) at Manchester University was opened on 20 March 2015, with the LED bulb set to launch later in the year.

The LED bulb – which is claimed to cut energy use, last longer than similar products and cost less to make – is set to enter a market estimated by Statista to be worth €64bn (£47bn) between 2011 and 2020.

Graphene, a two-dimensional material consisting of a single layer of carbon atoms arranged in a honeycomb structure, is the thinnest and one of the strongest known materials that is also feted for its conductivity and heat resistance. The material was first isolated at Manchester University by Andre Geim and Kostya Novoselov in 2004, earning them the Nobel Prize for Physics in 2010.

"Compared with a leading LED, based on an equivalent lumen, this [bulb] will use less energy," said Prof Colin Bailey, deputy president and deputy vice-chancellor of Manchester University, adding that issues around commercial confidentiality remain in play prior to the bulb's commercial launch.

He did, however, say that the new bulbs use more sustainable components and that fewer steps are required to manufacture them compared with LEDs already on the market. The use of graphene also puts the bulb at an advantage, as it will outperform those elements in traditional LEDs that eventually degrade.

Graphene Lighting, a spin-out based on a strategic partnership with NGI at Manchester University, will produce the light bulb and other graphene products.

"We've got the all the prototypes done, we're checking the robustness of our supply chain [and] we've got investment," said Bailey. "We're going through the closing stages of certification and the first run of light bulbs will hit the market pretty soon."

Bailey said another product close to market is a passive RFID antenna likely to be commercialised by early 2016, with numerous other projects "moving through the innovation chains", including membranes for water purification, protective coatings for steel or masonry, batteries and applications in drug delivery.

"We have prototypes for composites and composite devices and again we're looking to see how we can drive that to market for aerospace components," he said. "In aerospace, you're talking 20 years plus to get those to market, but for non-critical components we're looking to get there quicker."

Key to these developments is NGI, which will see academic and commercial partners working together on graphene applications of the future. It is funded by £38m from EPSRC and £23m from the European Regional Development Fund and will develop applications to displace existing products based on cost and quality.

"Here in Manchester, we have the knowledge base that allows us to take things right through the innovation chain," said Bailey. "With [NGI] we can really start accelerating the use of graphene and advanced materials to market, which is good for the UK economy and for the local market, but also we're looking at how we can use graphene for the Grand Challenges, so water purification; for energy, looking even at sustainability – renewables, for example – and how we can use this new material to push the boundaries of those challenges further."

Looking forward, the development of a so-called Graphene City in Manchester will be bolstered in 2017 with the opening of the Graphene Engineering Innovation Centre, which will complement the NGI and initiate further industry-led development in graphene applications.

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MATERIALS

Trial separation

UK researchers are aiming to develop an 'immortal membrane'

BY JULIA PIERCE

Development of the next generation of long-lasting membranes is under way, thanks to a £4.6m EPSRC research grant.

Led by Newcastle University, the five-year project will explore the potential of new materials to replace existing industrial membrane systems in four main industry sectors: energy, manufacturing, pharma and water. Also involved are industry partners including Johnson Matthey, Evonik, GSK, BP, Pervatech, Bluestone Global Tech, Anglian Water, Severn Trent Water, Thames Water and Scottish Water.

Currently, more than 15 per cent of world energy is used in separation systems, covering everything from processing sewage to creating microscopic nanoparticles. Although this could be improved, users are reluctant to try new technologies if their reliability is not proven, so there has been little innovation in the sector. Many widely used membranes are still made from traditional materials and systems that are often short lived, require regular cleaning and are costly and energy intensive.

The new EPSRC-supported virtual membrane centre SynFabFun, from membrane material synthesis to fabrication and function, will bring together experts from the universities of Newcastle, Bath, Imperial, Edinburgh and Manchester to develop and implement new membrane systems and techniques.

To prove their reliability, the researchers will subject the membranes to the equivalent of 30 years of use in a shorter timescale through the development and use of accelerated ageing tests, employing membranes at higher temperatures and in the presence of higher concentrations of poisons that they would otherwise experience.

Their aim is to develop an immortal membrane — or at least one that will outlive the lifetime of the industrial plant or equipment where it is being used. Another key aim of the project is to develop a low-energy technology.

The project will explore the potential of new materials

"The membrane separation of molecules from organic solvents would result in very significant energy savings," explained project lead Ian Metcalfe, professor of chemical engineering at Newcastle University.

"Hydrogen and/or carbon dioxide removal from a water-gas shift process in situ — over a range of temperatures depending on the nature of the membrane — could change the way we produce hydrogen," he added.

"In terms of organic membranes, we are seeking to work on systems that are already in a relaxed or equilibrium state. Such membranes cannot lose permeance as they evolve towards some equilibrium structure. For inorganic membranes we will study, for example, routes to self-healing membranes using techniques such as secondary wetting phases."

AUTOMOTIVE

Road block

Commons transport committee sounds warning on driverless cars

BY JON EXCELL

Driverless cars could improve road safety and benefit the economy, but government must draw up clear plans for how they will be regulated, a group of MPs has claimed.

The Commons transport committee says that the rise of driverless car technology represents an opportunity for the UK automotive sector, but warns that government needs to develop a clearer strategy around the introduction of disruptive automotive technologies.

The MPs call on the government to set out how it will reform legislation to deal with driverless cars and address the relatively imminent scenario of manual, autonomous and semi-autonomous vehicles using UK roads.

The report argues that in order to reassure the public, the Department for Transport needs to explain how vehicles will be certified and tested, how drivers will be trained and how driving standards will be regulated.

It suggests, for instance, that vehicle ownership will carry new obligations such as ensuring that the latest software updates have been applied to a vehicle.

While acknowledging that intelligent systems could improve safety (human error accounts for more than 90 per cent of road accidents) the committee says that legislators need to rapidly get to grips with the issue of liability, and formulate guidance on who is responsible if a driverless car is involved in an accident.

While the recommendations of the report have been widely welcomed by industry, there is scepticism in some quarters over whether driverless vehicles will ever be accepted by the public. Writing in his blog, Edmund King, president of the AA, said that "what works for the boffins may be baffling for the motorists". He added: "What may be a quantum leap in auto sophistication may be a leap of faith too far for the average driver."

inbrief

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Civic duties

Honda's manufacturing facility in Swindon is to become a global production hub for the next-generation Civic following an investment of £200m. The Civic five-door will be produced at Honda of the UK Manufacturing (HUM) for the European and global markets. The new investment is being used for advanced production technologies.

Air of success

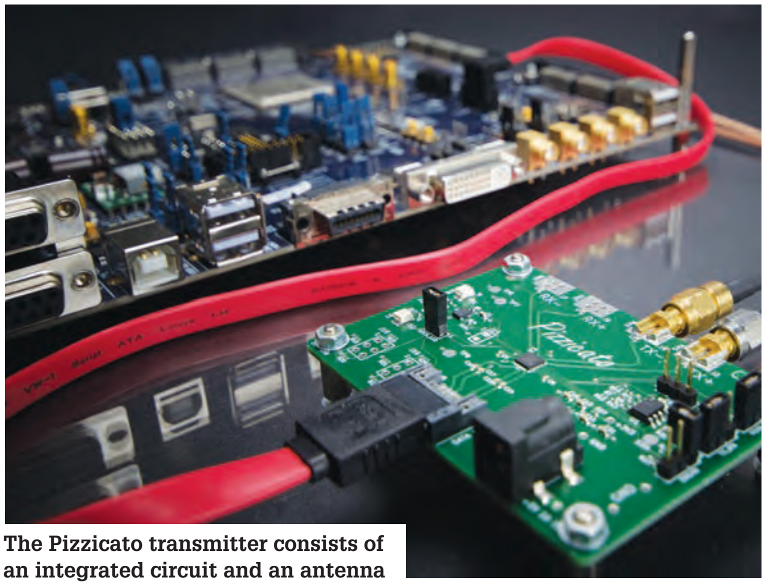
Researchers from Lincoln University have completed a three-year investigation into stratospheric passenger airships. Academics from the School of Engineering have been members of a research team that believes airships may be the 'green' answer to the future growth of aviation. The Multibody Advanced Airship for Transport project aims to position airships as the solution for future air transportation that is efficient, cheap and environmentally friendly.

Capital idea

The London Taxi Company's Chinese owner has announced a £250m investment to develop and build vehicles at the company's historic base. A new R&D and assembly facility to design and build the next generation of more eco-friendly London taxis is expected to generate around 1,000 jobs at its base near Coventry.

Leading light

A gravity-powered lamp with applications in the developing world has won the £150,000 Shell Springboard award. GravityLight was conceived by designer Martin Riddiford and developed by Deciwatt. The device consists of a 12kg bag threaded through an electricity-generating device. The bag is attached to the device, which descends to the ground. As it does so, gears convert kinetic energy into electricity, which powers an LED lamp.



The Pizzicato transmitter consists of an integrated circuit and an antenna

COMMUNICATIONS

Signal feat for mobile communications

Cambridge Consultants has revealed the world's first all-digital radio transmitter

BY JULIA PIERCE

The world's first fully digital radio transmitter has been developed by Cambridge Consultants, paving the way for 5G high-speed broadband for mobile devices.

Unlike software-defined radio (SDR), the breakthrough — named Pizzicato — is not a mixture of analogue and digital components but is completely digital, which can enable new ways of using the radio spectrum intelligently.

When transmitting data, only low-frequency signals of 1GHz or lower propagate well over distance or through walls, so they are in great demand.

Expanding to make use of frequencies of 10GHz and beyond will require techniques such as meshing and beamforming to compensate for the frequencies' poor range. However, the analogue parts of radios are becoming an increasing bottleneck in allowing this.

"Crowding 50 analogue radios together on one chip, switching their operational parameters every few microseconds and expecting them to work at 60GHz is an analogue designer's nightmare," said Monty Barlow, director of wireless technology at Cambridge Consultants. "With Pizzicato, we have created a glimpse of future disruptive technology — a radio built purely from computing power."

The Pizzicato digital radio transmitter consists of an integrated circuit outputting a single stream of bits and an antenna — with no conventional radio parts or digital-to-analogue converter. Patented algorithms perform the necessary ultra-fast computations in real time, making it possible for standard digital technology to generate high-frequency radio signals directly.

"Our first trial of the technology has created 14 simultaneous cellular base station signals," said Barlow. "The technology is a lot more flexible than current radio technologies. Our first target areas for it are defence and also WiFi access-point technologies, as well as items such as intelligent thermostat systems — these have small radios in them, but are the expensive part of the system. We believe that in the same way that microprocessors went from being expensive to being cheap enough to be installed in many everyday items, our technology can do the same for radio systems."

Its design means that a Pizzicato-based radio would, as with microprocessors, directly benefit from Moore's Law — shrinking in cost, size and power consumption with each new generation of silicon fabrication in order to provide many tiny, high-performance radios in the next generation of phones.

MATERIALS

Scratch the surface

Researchers have developed self-cleaning paint designed to withstand hard knocks

BY JULIA PIERCE

A new damage-resistant paint that can be used to create robust, self-cleaning surfaces has been developed by a team led by researchers at University College London.

Self-cleaning surfaces are repellent to water but may stop working when they are damaged or exposed to oil.

The new paint, which is made using coated titanium dioxide nanoparticles, is resistant to everyday wear and tear and can be applied to clothes, paper, glass and steel.

When combined with adhesives, it maintains its hydrophobic and self-cleaning properties after being wiped or scratched.

In tests, the paint also survived being scuffed with sandpaper for more than 40 cycles.

The research team hopes that this will make the paint suitable for applications such as car bodies, where frequent scratching can occur, although it could also be used to create art using the water droplets' patterns, or for easy-clean surfaces in hospitals.

"The surface is highly textured — on a very small scale — but has a waxy, low-water-affinity surface on top," explained Prof Claire Carmalt, professor of inorganic chemistry at UCL.

"The water forms spherical shapes when it hits this, and when it rolls off it takes any dirt with it," she added. "We used two sizes of nanoparticles to make the texture. However, most surfaces such as this are mechanically weak. To counter this, we used a spray adhesive, which allowed the material to be used on large surfaces."

The discovery involved researchers from UCL, Imperial College London and Dalian University of Technology (China). Different coating methods were utilised to create the water-repellent surfaces, depending on the material.

An artist's spray-gun was utilised to coat glass and steel, dip-coating for cotton wool and a syringe to apply the paint onto paper.

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AEROSPACE

Top-flight technology

'Record-breaking' motor could make large electric aircraft a reality, claims Siemens

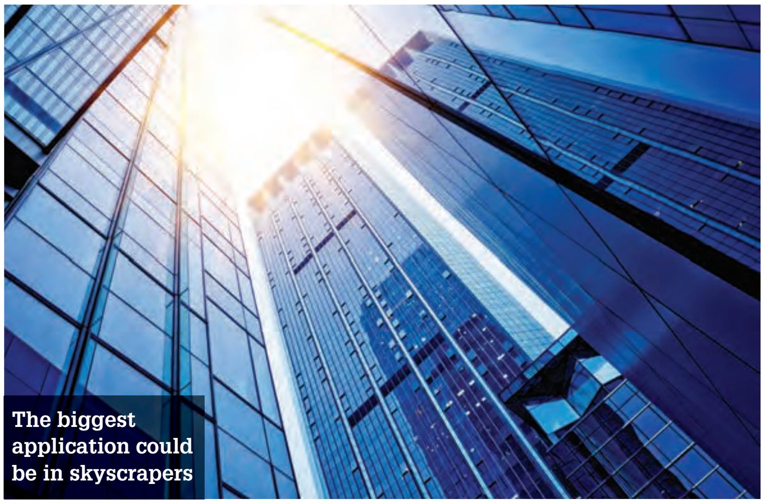
A new type of electric motor designed specifically for use in aircraft could help make electric-powered passenger flight a reality, its developer has claimed.

Developed at Siemens in Germany, the 50kg motor delivers a continuous output of about 260kW, which is five times more than comparable drive systems.

The team has claimed that the electric motor's power-to-weight ratio of 5kW per kilogram could enable larger aircraft with take-off weights of up to two tons to make use of electric drives.

Electric motors of comparable strength that are used in industrial applications typically deliver less than 1kW per kilogram, while the performance of drive systems used in electric vehicles is about 2kW per kilogram. Siemens said that it achieved the improved performance by employing advanced simulation techniques and reducing the weight of every component of the system.

Because the motor delivers its performance at rotational speeds of just 2,500 revolutions per minute, it is able to drive propellers directly without the use of a transmission. ***JE***



The biggest application could be in skyscrapers

MATERIALS

Making light work of photocatalysts

Spin-out set to develop purification products

BY JULIA PIERCE

A spin-out company from Queen's University Belfast is developing a variety of innovative products using advances in photocatalysts – ranging from antibacterial plastic films and water purifying systems to anti-pollution coatings for pavements.

The existing industry is only 20 years old, yet is already worth more than $1bn (670m) annually. SunCatalyst Laboratories, headed by research fellow Dr David Hazafy, aims to find applications for the university's breakthroughs in the field, from self-cleaning paint and fabrics to glass that never fogs up.

It is also providing an independent testing service to the growing industry, helping organisations such as Unilever to get their own photocatalyst innovations to market.

The technology works by using titanium dioxide that is prepared with nanoparticles to create a semiconductor. This is then used to harvest energy from ambient light in order to drive a useful chemical reaction, such as to destroy bacteria.

"The photocatalyst can be layered onto concrete, wood or fabric, among other things – someone is currently looking at making a self-cleaning denim," said Hazafy. "The science behind this has been under way for more than 10 years, so we have a good understanding of it. However, now we have to prove that the photocatalyst can be applied to new materials effectively as a self-cleaning agent. Its biggest application could be on skyscrapers, buildings and pavements to destroy pollutants such as nitrogen dioxide in cities, which would have a huge impact on the environment, or to combat volatile organic compounds [VOCs] in paints and lacquers. It can also be used in hospitals to make antimicrobial aprons, curtains and protective sheets."

The technology is both cheap and reliable. The spin-out team has also been combining the titanium dioxide with different substrates for some new applications.

> **"The science behind this has been under way for more than 10 years**

"Presently, around 4.5 million people in the world clean their water by placing this in a bottle and then exposing this to hours in the sun to allow the light to kill any bacteria," Hazafy explained. "We have invented a colourmatic label to show if the water has received sufficient energy to do this.

"We're also working on a plastic brush-shaped device with a high surface area that is a photocatalyst – speeding the disinfection process."

ELECTRONICS

Wireless device at your fingertips

Prototype holds promise for 3D computing

BY JULIA PIERCE

A wireless device that detects and uses the detailed 3D movements of a user's fingertips to control digital information on a computer could have a huge impact on 3D modelling and design.

The as-yet-unnamed technology, developed by Royal Academy of Engineering Enterprise fellow Dr Jack A Cohen of Warwick University, works by combining information from cameras and wireless sensors.

The technology has potential in the gaming industry as well as other niche markets such as remotely operated machinery, where it could replace or augment trackpads and mice.

Instead, people would be able to create and manipulate digital information with their hands in a free and natural way.

Cohen said: "The power we have in computers is incredible, especially on the graphics side – you can see this through recent advances in gaming graphics. However, how we interact with personal computers has barely changed since they were invented. At the moment, computers are controlled using 2D devices such as mice and track pads."

He continued: "Systems such as Leap Motion are a big step up but have limited range and gesture capabilities.

"If we work in 3D, then we can really interact with our information – for instance, when designing using CAD [computer-aided design] packages, it can be a challenge to view what you're working on.

"This system has a wide range – about the width of a desk – and in combination with head-mounted displays will allow the user a total view of their design over 360° – including with depth perception," Cohen said.

The technology could also enable people to perform complex or intricate tasks, for example sorting and processing large and disparate data.

It is currently in prototyping, and is expected to reach the market in the next few years.

Meanwhile, Cohen is seeking engineering or design companies that would be interested in using his technology or testing some early-stage prototypes.

SIMULATION

Road test

UK team set to develop driving simulator

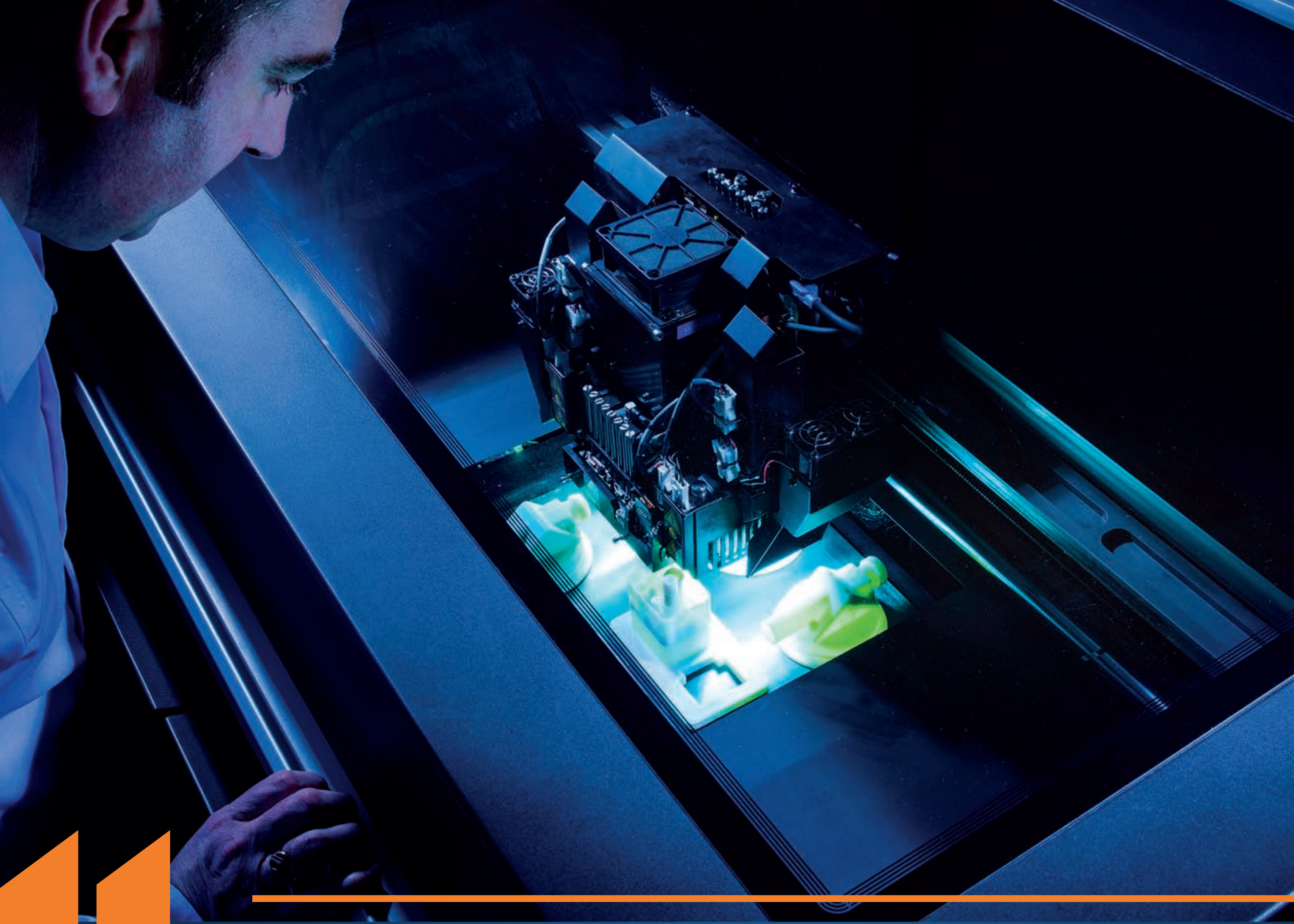
An advanced driving simulator that will enable engineers to test any make of car is to be developed by a team at WMG.

WMG – formerly Warwick Manufacturing Group – has been awarded £3.2m by EPSRC as well as £1m from industry to create what it claims will be one of the world's most adaptable and advanced driving simulators.

The simulator, available to a range of research groups, will use a LIDAR scan of 30 miles of real roads around the city of Coventry to test vehicles in the simulator.

While the simulator will use a fixed test car for many tests, it will also be configured so that any make of car can be driven into the simulator for testing.

The advanced driving simulator will be tested and piloted in WMG's International Manufacturing Centre at Warwick University before moving to its final home in the National Automotive Innovation Centre, a 33,000m^2 research facility that is about to begin construction at Warwick University. *JE*



Facing the crude truth

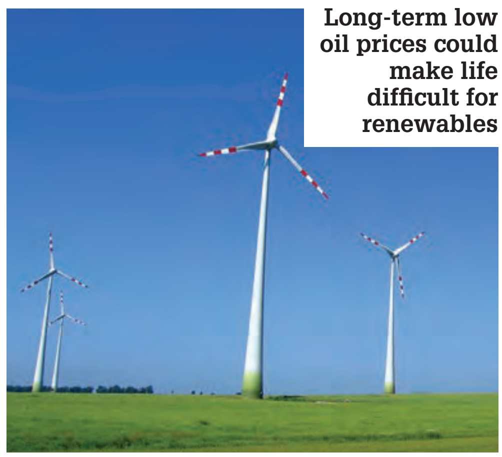
Gordon Edge, RenewableUK's director of policy, explores what the drop in oil prices means for those in the renewables sector

The dramatic collapse in the price of crude oil in the second half of 2014 has been much commented on across the media. Some of that commentary has tried to work out whether this fall is good or bad news for the renewables sector, with mainstream, non-expert opinion taking the view that as oil's competitive advantage is increased, renewables will suffer. That may or may not be the case, but the issue needs to be unpacked further beyond that simplistic analysis if players in the field are to work out how to react appropriately.

The first thing to note is that not all sectors are affected equally. Very little oil is used directly for power generation, so a fall in the price of that fuel does not have a direct effect on most renewables as they are electric technologies. Companies in the electric transportation or biomass heating business are likely to be harder hit. But to the extent that a fall in the oil price affects gas prices and thus the wholesale price of power, then it is of concern to the mainstream renewable industry. Gas prices have been falling in the UK, and this is affecting power prices.

A lot also depends on timing. If the fall in the oil price, and consequently gas prices, is short lived, up to perhaps one or two years, then there shouldn't be much impact if the prospect thereafter is a higher cost trajectory. However, if the trough were to appear to stretch out several years ahead, then it would be more difficult to sustain 'high cost' renewables in the face of 'cheap' fossil supplies. Maintaining support for policies that promote renewables will become harder.

One way that difficulty will manifest itself in the UK will be through the impact on an arcane piece of policy called the Levy Control Framework (LCF). This very boring title hides a mechanism of extreme importance to renewable power in the UK, as it dictates how much HM Treasury allows the Department of Energy and Climate Change (DECC) to take out of power bills to support the low-carbon agenda. While support given through the Renewables Obligation or Small-Scale Feed-In Tariff is immune from changes in the power price as this is paid as a fixed or near-fixed premium, that is not the case for the new



Long-term low oil prices could make life difficult for renewables

> **"Renewable advocates will have to bolster their arguments about the benefits of price stability**

Contracts for Difference (CfD). The latter is a variable premium, topping up from the market price to a fixed 'strike price'. If the market price for power goes down, then the amount needed to top up increases, and therefore the LCF is used up quicker. With a forecast of long-term reductions in the wholesale price, DECC will not be able to contract for as much renewable capacity without risking busting the budget, further increasing the 'allocation risk' that developers face – this is a measure of the difference between the amount of capacity that can bid for CfDs and the budget available to support new projects, and it already appears to be very high.

Even before the first allocation round opened, the impact of this mechanism was exposed, as DECC reduced its forecast of power prices by up to £13/MWh between July and October, massively reducing the buying power of the budget available. However, comparing the updated forecasts for 2015–16 with the current forward price for the coming year indicates that a further £10/MWh reduction may be justified.

A further shock to the renewable industry seems inevitable, although there may be a natural floor to the fall once gas prices come down to the point where coal becomes the marginal resource on the power system so long as coal prices do not fall also.

Thus we will be in for a testing time if the prospect is for an extended period of low power prices. Through this time, renewable advocates will have to bolster their arguments about the benefits of price stability from renewables, providing an insurance policy against future shocks, or renewables increasing energy independence. They will also have to keep the public's and policymakers' attention on the wider agenda of unpriced environmental externalities and subsidies in all forms, including the imperative need to mitigate climate change. A focus on this bigger picture will be needed to stick to the course of decarbonisation and high renewable contributions to the mix.

It is very important that there is such a response to this prospect of low fossil fuel prices into the future, as this is quite likely to occur in the medium to long term. While the current price crash is more to do with slowing economic growth and geopolitical manoeuvrings, if we address the need to decarbonise the global economy effectively, then the demand for fossil fuels will be on a long-term path to zero. As demand drops, so will the price – the prospect is that the last barrel of oil extracted will be sold for virtually nothing. The temptation for governments will be to put off reductions in carbon emissions to take advantage of the cheap fossil fuels and gain economic advantage, offering up a modern version of Augustine's famous prayer: "Lord make me low-carbon – but not yet." Sticking to the course will require constant reminders that the laws of physics pay no attention to the oil price, and will extract payback in the form of extreme climate impacts if they are ignored.

Gordon Edge is director of policy at RenewableUK

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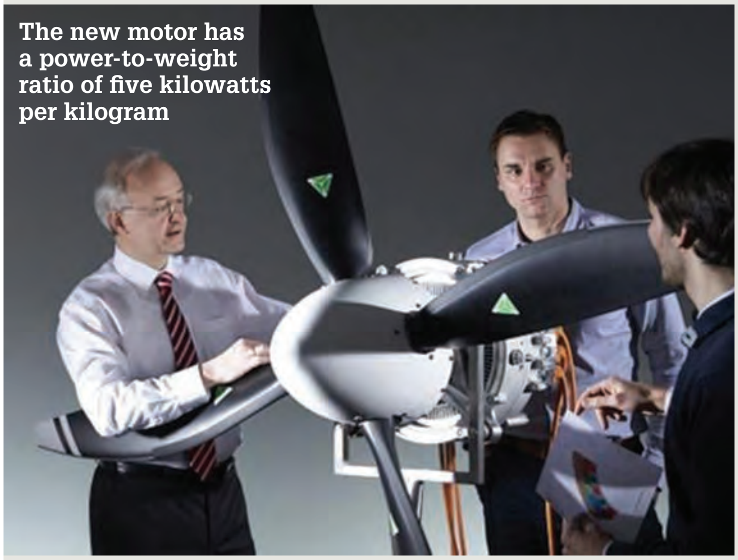
thehottopic

Is this the dawn of the electric airliner?



The new motor has a power-to-weight ratio of five kilowatts per kilogram

Our coverage of Siemens' new electric aircraft motor met with some scepticism.

This seems more suited to LTA craft with a large solar collecting area on top to assist other propulsion systems and possibly greatly extend the range or flight duration. It would need a major improvement in compact and lightweight electric accumulators before 50- to 100-seat HTA craft would have adequate range.
John K

I don't know what they are thinking, but won't the extension chord be rather long for this flying electric lawn mower? All joking aside, 5kW/kg mass is an outstanding accomplishment the team members should be saluted for. Icarus may finally get wings that won't melt in the sun.
James Stewart

Yes the motor is certainly light, but when you add the batteries to power it, you will have a different equation.
Chris Saint

Chris Saint, the purpose of using a hybrid system similar to the Chevy Volt is that you do not need a large battery pack. With a small, efficient ICE, you can generate significant power to keep the smaller battery pack charged throughout the flight. The balance of battery weight to fuel weight can be adjusted to reach optimal performance for a given distance.
Paul Scott

A hybrid system would use very few, if any, batteries. Batteries release power slowly. The prime mover (turbine, fuel cell) could do that. So kerosene remains as the main fuel. Electric storage would be in supercapacitors. They don't store so much energy but they can release it to the motor very quickly for take-off and directional change. The prime mover would run at a constant rate, optimised for fuel efficiency, so reducing size/weight, fuel costs and maintenance. Supercapacitors are the game-changer here; more than the electric motor. The motor is a response to the opportunity. Trains, trucks, trams, trolley buses, buses and cars can use this technology too.
Philip Owen

No one has addressed the class of plane this might work for. Jet engines have power to propel an aircraft very fast. I don't see this possibility with an electric or electric-hybrid power system. Private aircraft and short-range flights might justify such an approach but no one wants to be on a slow plane on a transatlantic flight.
Bill Brandon

inyouropinion

Electionviews

How should engineers engage with politicians? Our opinion piece following 100 business leaders stating their support for the Conservatives attracted lively discussion.

■ STEM industries inherently take a long view. Research, development, tooling up/construction and payback periods require long-term commitments and provide strong, long-term returns. Unfortunately, financial support, government frameworks, strategies and other issues are highly subject to political jesturing and party priorities. In my opinion, STEM government activities need to be devolved. That's not to say MPs shouldn't have government oversight and political accountability, but it would be better if this came from the Lords rather than the Commons. The five-yearly party political merry-go-round is highly detrimental to the long-term wellbeing and prosperity of STEM industries and the nation as a whole. I sincerely believe its time for a change – not necessarily party politically but certainly structurally.
Nath

■ I learnt today that the newest and fastest growth 'industry' is litigation, particularly that related to personal injury. It used to be PR-puffing share prices? Next week, how about estate agency or insurance, banking, accountancy, even the 'meja' with of course the exception of our noble journal... The range of non-wealth creating activities that the casino economy thrives upon. Count me out? Please.
Mike Blamey

■ Unfortunately, I think this misses the point – most of the CEOs of these large companies are financial bean-counters, who are remunerated by how much they 'increase shareholder value' no matter how that is achieved. They are not, in the main, at all interested in the STEM, or engineering specifically, subject, except in how it affects their company's bottom line and therefore their pay/bonuses. There are very few socially aware top business leaders. It is a dog-eat-dog world they inhabit.
Anonymous

■ I'm not sure quite what the point of this article is. Is it saying that engineering and manufacturing companies and individual 'working engineers' all have one voice? Is it clear 'what's needed' or what 'the right direction' is? Some 'working engineers' may want more pay and respect within their larger organisation so don't necessarily agree with their employers. Some may have a preference for fast gas-guzzling cars; others may want to cycle to work in a sustainable fashion. Some may be very pro defence work and others think money should be spent on the NHS. I'm not sure there really is a 'common bond' between engineers as a group, at least not enough to come up with a common set of policies to 'nudge' or lobby. How, who and where is the 'louder representation of the voices' of working engineers going to come from?
Paul Reeves

Solarpower

The discussion around renewables continued following our poll on making solar power competitive with fossil fuels

■ Solar plants in North Africa may make sense from the energy point of view but not from a political viewpoint, as we can be held to ransom for electricity just like the gas from Russia.
Dr Bob

thesecretengineer

Our blogger is annoyed by the adulation of Kanye West's wife's bottom ahead of people who actually help humanity

There have been two awards ceremonies recently. One of them got a huge amount of coverage across all parts of the media and the other one didn't. In the first instance, we have the annual bun fight in a glitzy location that is the 'Brit Awards'. I believe that lessons learnt in the notorious debacle of 'Mick Fleetwood and Sam Fox-erm-gate' mean this is no longer an utterly shambolic affair, but even so is it really worthy of televising at length? Yes, there are some rich folk and you get o see some of the current (and past) stars doing their thing, but it would appear it was all so uninspiring this year that Madonna felt compelled to hurl herself off the stage in an unscripted cry for help.

All right, I understand that the music business is something of a cash cow and that it brings joy to many people, but this wasn't about the music itself. That could be covered in any number of formats without filming the mutual back-slapping and the tedious attention-grabbing by Kanye 'my wife is famous purely for having her bottom photographed' West.

Compare this with the Semta Skills in Engineering Awards, where we can take Mark Chapman being inducted into their 'Engineering Hall of Fame' as an example for discussion (by the way, my congratulations to all who received an award at this event). It would be entirely unrealistic to expect engineering to gain a similar coverage to the bloated ego-led aberration that is the music industry, but as far as I can see the Semta Awards didn't get any national coverage outside of the specialist press. This despite the fact that engineering employs more than five million people while the whole performing-arts sector employs approximately one fifth of this.

Engineering advances humanity in a very real way and, although the importance of the arts is not to be denigrated, when (excepting the musician involved) was the last time a catchy tune saved someone's life, kept them warm or protected them from hardship? Although you could point out that a 1,000mph car wont do any of these things either, Bloodhound has always been about inspiring the next generation; the focus has always been the real legacy beyond the record. The core values that the Brits are based around are fluff and frippery; the Semta awards substance and depth.

The bottom line is that Chapman's award recognises the world-beating class of the Bloodhound project, the absolute pinnacle of brilliance for our profession, whereas the Brits recognises ephemeral popularity. The difference in the way these are covered by the press points to something broken deep within the values system of our culture.

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

■ Why should wind and solar power be subsidised at all? Both are far from being competitive with conventional generation when all factors are taken into account. For those who think that has a special merit because of reducing emissions of carbon dioxide then, clearly, nuclear power is better, cheaper and more reliable. End the subsidies and let everyone have cheaper electricity.
Bryan Leyland

■ I couldn't agree more with Bryan – let's end the subsidies to nuclear with its guaranteed strike price and government-sponsored clean-up and see how competitive and carbon friendly it is then. Let's end the tax breaks for North Sea oil – £1.3bn to save 300 jobs? All energy generation is subsidised; to believe otherwise is to not be in full possession of the facts.
Paul Arondelle

■ I do believe that there are some alternative solar thermal technologies (out of CERN) to conventional concentrators – that are possibly more efficient. I think they struggle with manufacturing issues, however. I suspect that solar thermal might have more direct usage and storage possibilities too – as well as generating electricity. The subsidies for solar cell manufacture do not seem to address the main cost issues of domestic use. It is a moot point about the cost of nuclear; there is no government push to develop affordable technologies there. Free market fundamentalists might argue about subsidies but a government that did not sort out security of supply would surely be regarded as totally incompetent and, unless the alternatives were equally so, hounded out of office. PS: I did like the idea of solar cells lasting for more than 25 years. Similar issues were said about reliability of windmills – yet the failures abound.
Julian Spence

■ Having visited Spain and Turkey in the last year, I am amazed electricity from solar panels is almost totally absent from their landscapes. Hot-water heaters are on almost every roof in southern Turkey. Why aren't their governments and the EU doing something to promote PV power in these and other Mediterranean lands?
John Briggs

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Making a lasting impression

The Big Bang Fair is an unprecedented collaboration between business, government, education and the STEM community

If you were anywhere near the NEC mid-March you may have seen the tens of thousands of schoolchildren heading into The Big Bang Fair.

David Cameron also visited the fair following the announcement of a £67m package to get more maths and science teachers – 2,500 new recruits and upskilling for 15,000 non-specialist teachers. Having a great teacher makes a lasting impression on young people and as we've been calling for an investment in science and maths teaching for a long time, it's good to finally see some progress on that front. Perhaps teacher numbers will go the same way as apprenticeship targets and become part of an electoral bidding war.

The Big Bang Fair is an unprecedented and unparalleled collaboration between business,

"The Big Bang Fair gives young people the chance to speak to leading engineers and to see for themselves the range of exciting careers their studies can lead to

government, education and the wider STEM community. We are proud of the enthusiasm for, and commitment to, the fair and what it sets out to achieve.

It is only possible thanks to our lead sponsor BAE Systems and major sponsors GSK, Rolls-Royce and Siemens, which really get into the spirit of the fair. They offer highly engaging activities at the event and their staff (including apprentices and graduates) are on site telling young visitors about engineering or science and giving them an insight into what their job is really like.

These professionals and other volunteers, young scientists and engineers released from their day jobs came to inspire the next generation. More than 200 companies and organisations are involved. If your company was part of that this year, you'll understand how important it is. If it wasn't, you should ask why not?

There's no doubt that The Big Bang Fair is a fun day out, but it's so much more. It gives young people the chance to speak to leading scientists and engineers and to see for themselves the range of exciting careers that their studies can lead to.

It's not just about the visitors and exhibitors, though. It's also about the young scientists and engineers (including, I'm proud to say, my own daughter) competing in the finals of the National Science and Engineering Competition. They not only had the opportunity to showcase their projects to the panel of celebrity judges; they were also an inspiration to the other young visitors.

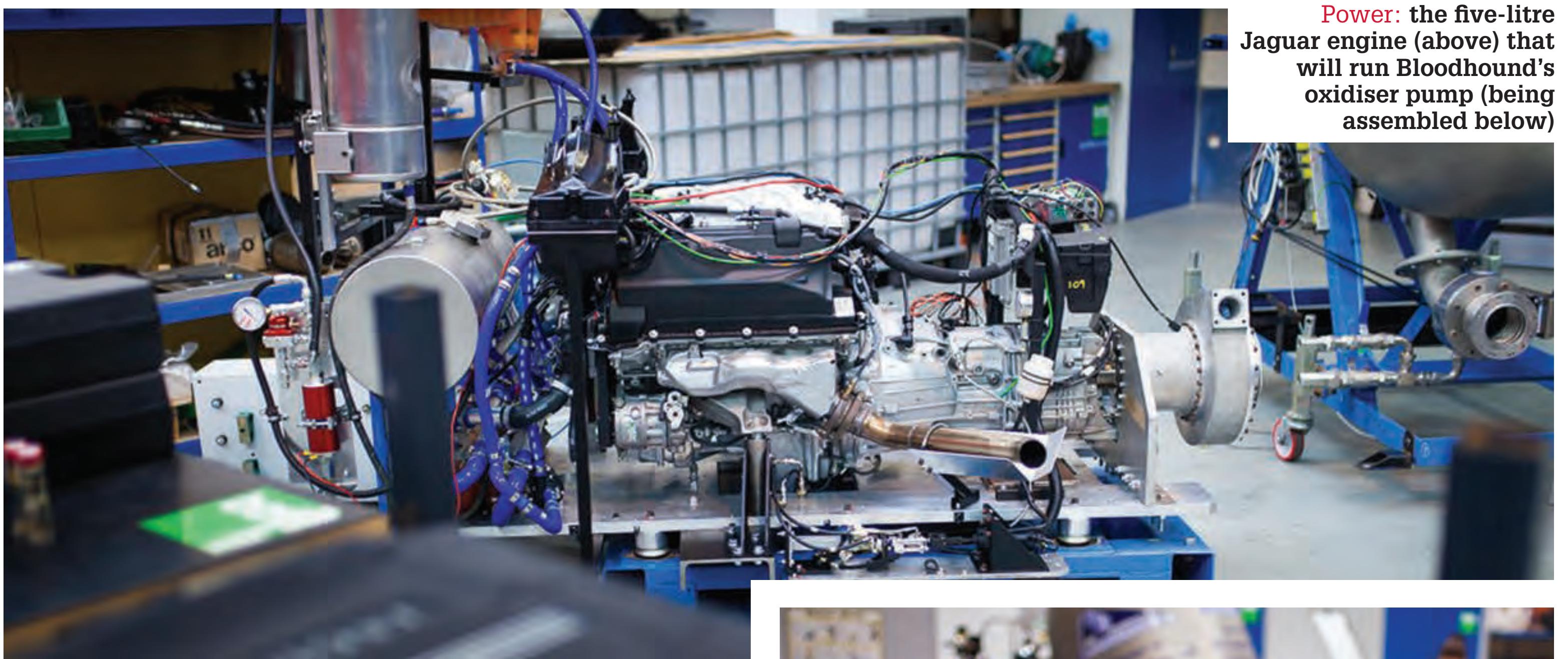
The 2015 UK Young Engineer of the Year, Colum McNally from Newry, Northern Ireland, impressed judges with his 'Agri-Hammer'. Engineers see problems and look for innovative solutions, and Colum is no exception. His invention is a hydraulic machine inspired by his experience growing up on a farm. It not only combines the two functions of log splitting and post driving but also reduces the risk of injury with its safety measures. I hear he's already had various approaches about bringing it to market. We wish him well.

The Big Bang Fair is rewarding for everyone involved. Emma Bartley summed it up well when writing about it in *The Times* recently, saying "both visitors and exhibitors make a lasting impression on each other".

Paul Jackson is chief executive of EngineeringUK

Building momentum

The construction of the Bloodhound SSC supersonic vehicle is nearing completion. Stuart Nathan reports



Power: **the five-litre Jaguar engine (above) that will run Bloodhound's oxidiser pump (being assembled below)**

Amid the clatter and buzz of power tools and the occasional clang of metal on metal, Bloodhound SSC's engineering lead for mechanical design, Mark Elvin, rubbed a hand across his scalp and considered the half-built car whose components were piled up around him. "We've been very good at being a virtual car for the past six or seven years," he said. "It's been necessary, because it's difficult to attract sponsors to something that doesn't actually exist yet, so you have to talk about it like it's real. It's a little bit strange to think that by the end of July we'll be rolling out the finished car for the first runway tests at Newquay Airport."

Indeed, each subsequent visit to the Bloodhound Technical Centre, an anonymous industrial unit on the western edge of Bristol, has revealed a more and more complete-looking car. From the boxy shape of the lower chassis to the arrival of the insectile curved form of the carbon-fibre composite monocoque that will protect driver Andy Green during the car's runs on the stony desert surface of Hakskeen Pan in South Africa's Western Cape, to the long, arched stretch of the upper chassis, the solid reality of Bloodhound is steadily making the full-scale model of the show car, familiar from its visits to industrial exhibitions and schools around the country over the past few years, look more and more like the working sketch that it is.

At *The Engineer*'s most recent visit at the end of February, Elvin was overseeing the completion of the upper chassis, the mostly metallic section running from the back of the monocoque to the rear of the car. Quite deliberately, it resembles the fuselage of a slightly old-fashioned passenger or cargo aircraft. "It's a DC3, basically," Elvin said. "The skin is titanium rather than aluminium, but that's placed over aluminium ribs. It's an aircraft structure because that's what we on the team know about." There was consideration during the design phase to use a more motorsport-derived composite structure — "but the cost and lead time were unpalatable for us", Elvin said. "You might end up with a lighter structure and it would certainly be stiffer, but the process to get there was just ridiculous."

The upper chassis sits on the steel lower chassis, which was the first component to be completed, about two years ago. "We know it's heavy, but it's going to get beaten up by the desert surface. It could be titanium, but the company we were working with was working in steel, and they did it for free, which is our favourite price."

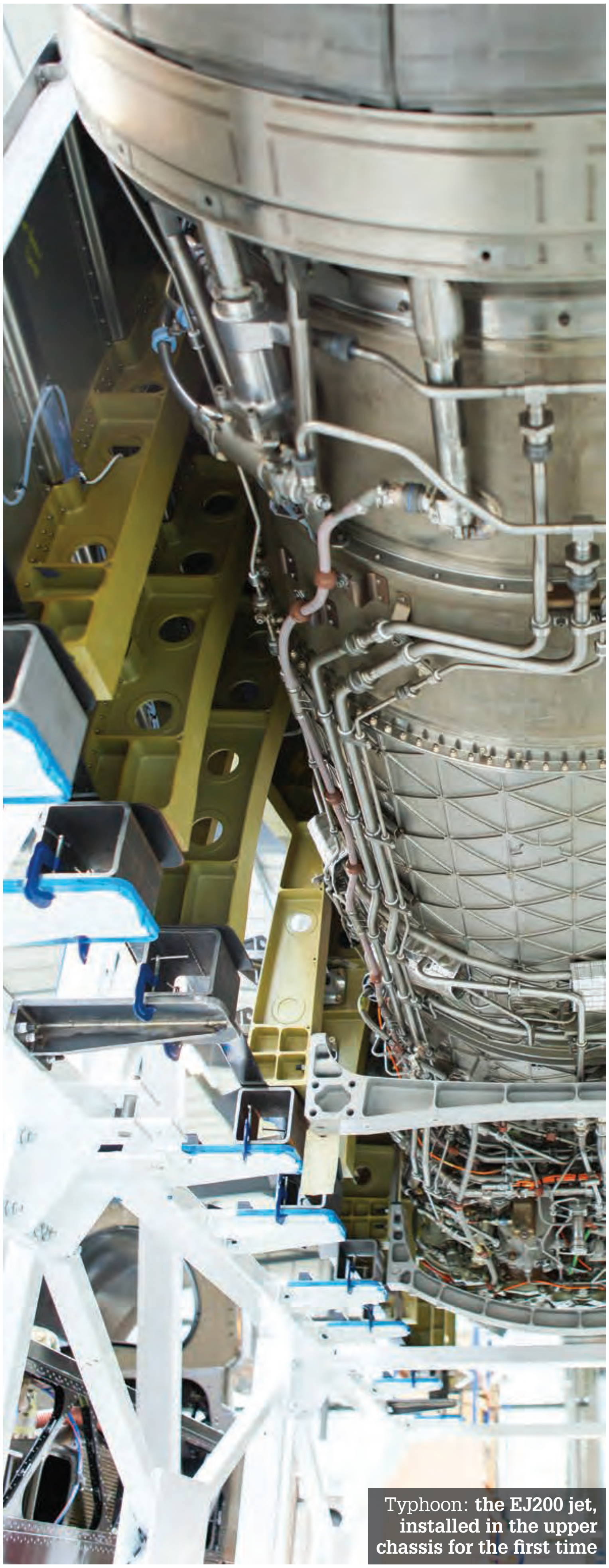
All through the project, the building of the car has been a compromise between the engineering demands, cost and the capabilities of sponsors and partners. "The entire rear of the car was a product sponsorship from the Nuclear AMRC at Sheffield," Elvin said. "They wanted to show off what their new machining equipment could do, so Smiths Group provided the material billets, the AMRC provided programming and machine time and we got three quarters of a million quid's worth of brilliantly produced component for nothing."

Things have changed now. "We've got grown-up commercial contracts because our lead times are so much shorter now — eight weeks, not eight months. So we have to pay for things properly."

> **"It's a little bit strange to think that by the end of July we'll be rolling out the finished car for the first runway tests**
> Mark Elvin, Bloodhound SSC

Everyone on the project is now aware that the clock is ticking. A big notice board by the entrance to the construction bay displays the project deadline: Bloodhound is to be finished by 25 July. "People have been here seven years now: that's a long time to be working on this," Elvin said.

Assembling the upper chassis was a multi-stage process. After the supporting ribs were produced, they were lined up on the lower chassis; then the car's jet engine — a Rolls-Royce EJ200, the world's most energy-dense turbojet and the power source for the Typhoon jet fighter — was drawn up into the space under the ribs to check clearances. "We know how much we expect the EJ will move, so we had to check we had that space before the skin went on. The titanium skin was then placed over the ribs, drilled and fixed, then bonded and autoclaved. The final step of emplacing dozens of pressure sensors under the skin was being completed during our visit, with spaghetti strands of PTFE tubing snaking from the sensors around the inner surface of the fuselage; ->



Typhoon: **the EJ200 jet, installed in the upper chassis for the first time**

they will carry the wiring from the sensors to the onboard interface block, where data will be collected during the car's runs and from where the engineering team will download to plan the speed progression.

These sensors are all over the car, placed where computational fluid dynamics (CFD) modelling has indicated that airflow is particularly crucial to Bloodhound's safe operation, especially where the flow will change direction. More often used in aircraft and motorsport, they connect to holes about a millimetre wide drilled in the monocoque, chassis and other parts of the car, such as the yet-to-be-attached winglets on the tailfin and ahead of the cockpit. These holes are somewhat smaller than those that are usually used, to avoid them being blocked by desert dust.

When the car is running, data from these sensors will be compared with CFD studies of the car at the same speed. If there is a good match, Green will be cleared for a faster subsequent run. "Discrepancies aren't necessarily bad; there could be an error in our favour," Elvin said. "But if we see greater lift or downforce than we're expecting, we'll deploy the winglets to trim the car's performance." This will not be active control: the winglets will shift to a defined angle for a defined speed. Green will not be in control of this, with the code to deploy the winglets written by the engineering team. "Andy's job is to get into the car and drive the run profile the engineering team tell him to drive," Elvin said. "He will do that with a split-second accuracy, because he's a highly trained RAF fighter pilot with a first in mathematics and he's the only person ever to have driven a supersonic car."

With the completion of the upper chassis, the focus of the engineering effort has now shifted somewhat from the main body of the car to some of its key components and subsystems. In another corner of the workshop, RAF engineers are piecing together Bloodhound's tailfin, one of its most distinctive features and a magnet for members of the projects fan club, hundreds of whom have paid £10 each to have their names inscribed on it. Somewhat larger than the fin of the show car and cruciform, rather than T-shaped, with its aerodynamic winglets set half way up its height rather than at the top, the fin is very similar to that

> **"At one point, we had four of the foremost aluminium specialists in the world sitting around one table**
> Yan Tiefenbrun, Castle Precision

of BAE Systems' Hawk jet trainer aircraft, familiar to most from its role in the Red Arrows display team.

But it will undergo very different stresses. "It's the hardest-working tailfin in history," Elvin said. "Relative to a fin on a supersonic aircraft that flies at 45,000ft, it's being pushed through treacle; the air at sea level is that much more dense." Attaching the fin to the car has also caused some concern. "It's quite important to keep the root of the fin cool. It's aluminium, so we don't want it getting above 150–160°C. But it's near the hottest part of the engine," said Elvin. "We'll have heat shielding and thermocouples and sensors in there so we can monitor the conditions. When we're running, it's less of an issue, because there's air flowing through the car, but when we stop, the case of the engine will be radiating heat. We'll plug in cool air supplies through ducts at the sides and the main intake; we should just get a momentary temperature spike between stopping and getting the cooling supplies in."

Off site, production has started on Bloodhound's desert wheels, which are forged from solid aluminium. This project is being managed by Glasgow-based Castle Precision, with the wheel blanks being forged by Otto Fuchs in Germany from billets supplied by nearby metals specialist Trimet. The wheels are made from a special grade of aluminium developed specially for Bloodhound. "At one point in the project's early stages, we had four of the foremost aluminium specialists in the world sitting around one table," said Yan Tiefenbrun, Castle's director of operations. "That's never happened before and it will probably never happen again."

The team is also adjusting to a new auxiliary power unit (APU), the engine that drives the pump that supplies high-test peroxide to oxidise the solid fuel in Bloodhound's rocket engines. During tests of the hybrid rocket system, it used a Cosworth 12-cylinder Formula One (F1) engine, but Cosworth withdrew from the project when it exited F1, so the new APU is a five-litre supercharged V8 engine supplied by Jaguar.

This has an advantage over the Cosworth, Elvin said: "It has ->

Right: **the rotor for the new oxidiser pump** Below: **Andy Green (left) oversees Mark Elvin (right) and the team working on Bloodhound's nose**

"Every run will be an experiment. A lot of the unpredictability is interaction with the shockwave and the ground
Mark Elvin, Bloodhound SSC

so much torque that we can go from 1,000rpm at start to 6,000rpm redline with no holes in the torque curve and no loss of performance. The Cosworth would stall below 30,000rpm; it's a racing engine and is optimised for that kind of performance. But this is a big, lazy road car engine, and it lets us modulate the speed of the oxidiser pump to an extent with the throttle." Again, this will be in the control of the engineering team, which will preset the engine's run profile for each run, determining how fast the oxidiser will be delivered to the rockets and therefore what thrust profile they will produce. "Andy just fires the rockets at the right moment," Elvin said.

The pump that the APU will run is also new; the previous version was not efficient enough – only 30–35 per cent, Elvin said, whereas the team needed 50–55 per cent. This involved redesigning the pump impeller. "At the intake, we have things that look like blades, Elvin explained. "They don't suck, in the sense of creating a vacuum; they slice pieces of HTP off, then they get flung out radially and that creates the pressure."

Rather than running through a conventional gearbox, to save space and weight the engine is connected to the pump via a chain-drive, derived from those used in Land Rovers and Range Rovers in the transfer box for four-wheel-drive systems. This is a simple twin-sprocket system, with the chain running between two sprockets sized to give the appropriate step-down from engine to pump.

The clutch system is also a special design, which uses hydraulic pressure to keep it closed; if Bloodhound's hydraulic systems fail, for example from a stone flying up and severing the fluid line, the clutch will disengage the engine from the pump and the rocket will stop.

Despite all the simulations and studies, the way Bloodhound will actually perform in South Africa is still a big unknown. "Every run will be a real-time experiment," Elvin said. "A lot of the unpredictability is interaction with the shockwave and the ground. We can't test it and we can't predict what the desert is going to do; we just have to run the car over it and see what it does." Bloodhound is a very different shape from its predecessor, Thrust SSC, and Hakskeen Pan is different from the Black Rock Desert where Green last broke the Land Speed Record in 1987; from simulations, the team believes that Bloodhound's shockwave will be less destructive than Thrust's, which broke up the surface ahead of the car and forced the wheels to run through relatively soft material.

The team is also not under the impression that its mission this year, to break Green's existing record, and next year, to break 1,000mph, will be a holiday. "Ambient air is about 35°C, which is going to be hard for us," Elvin said. "It'll take us a while to acclimatise. Fitness will be an issue for working in those conditions. Changing the rocket motors over will be challenging, in those temperatures, with no shade and full PPE gear; a chemical suit if you're on HTP duty, breathing equipment, fireproof gear — it's all tricky stuff. Nobody's under any illusion that it'll be pleasant. It'll be exciting and exhilarating but it won't be fun."

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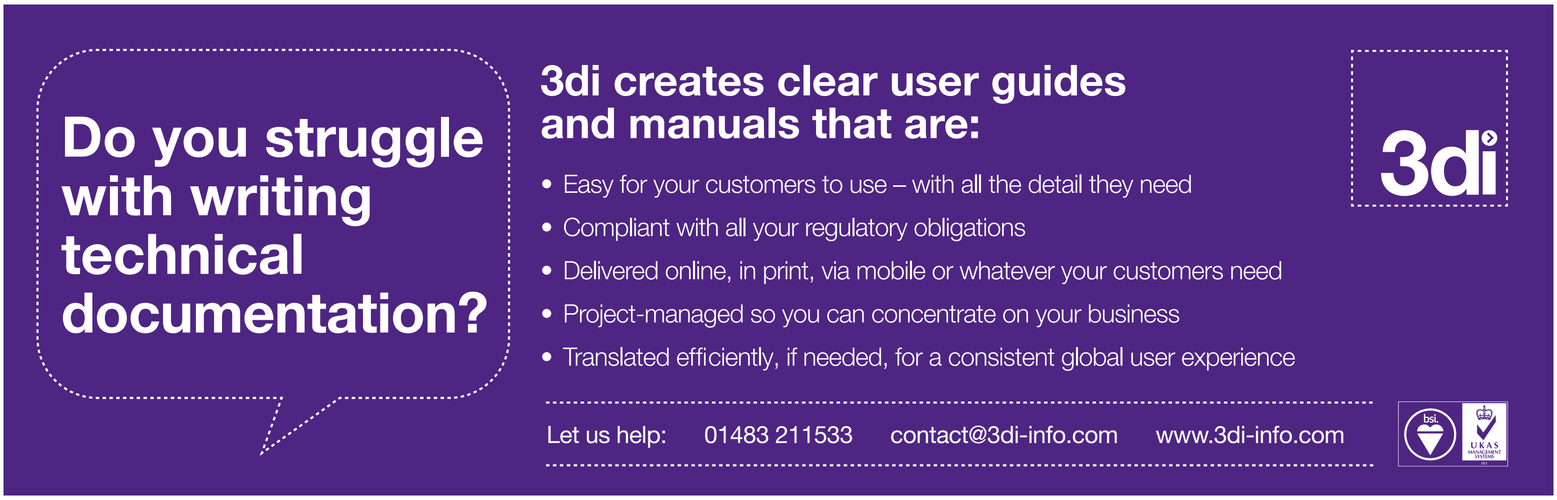
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Can technology save the NHS?

Digital devices able to remotely monitor a range of conditions could help get the health service off the critical list. Jon Excell reports

Taking tablets: **technology could reshape the way we approach healthcare**

From its crowded GP surgeries to its cash-strapped hospitals, there's little doubt that the UK's National Health Service (NHS) is going through a tough time.

And although the outcome of the forthcoming general election may provide some temporary respite for one of Britain's best-loved institutions, fundamental demographic forces are at play that mean these challenges are only likely to become more acute in the years ahead.

By 2030, there will be 50 per cent more over-65s and more than double the number of over-85s alive in England than in 2010. And this rapid growth of the number of people living into their late eighties, as well as a corresponding decrease in the number of younger people able to look after them, will create unprecedented pressures for the healthcare system in general, and its hospitals in particular.

Against this backdrop, it's difficult to be optimistic about the service's future. But could technology help fundamentally reshape the way we approach healthcare, and in the process get the NHS off the critical list?

A growing number of engineers and clinicians believe that digital healthcare could be the solution: that a host of smart sensing systems able to remotely monitor, diagnose or even treat a range of conditions could reduce the burden on hospitals and clinicians, and empower people to become more involved in their own treatment.

In a recently published report on the topic (*Patient of The Future: 2020*), Essex-based engineering consultancy Plextec argues that technological advances in the medical sector — largely underpinned by sensing technology — are poised to drive the most fundamental progression the UK health service has ever seen.

The report's author, healthcare technology expert Collette Johnson, has a keen sense of both where these pressures lie and how industry can help.

In her previous role within the NHS, Johnson helped to run Innovate UK's Small Business Research Initiative — a programme aimed at connecting public sector challenges with innovative ideas from industry — and worked closely with both technology developers and frontline clinicians.

"Getting people out of hospitals and into homes is one of the key things we need to do to help the NHS, and technology provides a remote way of dealing with patients," ->

she told *The Engineer*. "That's the key thing and that's what clinicians want."

One of the most important functions technology can perform is helping to spot complications earlier, thereby preventing the need for a hospital visit. "Where someone has an illness, you can use sensors as an early-warning diagnostic tool to make sure they don't get secondary complications," said Johnson.

Cambridgeshire company Aseptika, which has developed a range of monitoring devices aimed at helping patients to manage long-term health conditions, is already having an impact in this field.

The company has developed a sensor-based home sputum test for cystic fibrosis patients, which, according to Johnson, is able to spot the early signs of a lung infection up to 15 days before clinical symptoms become apparent. This enables GPs to prescribe antibiotics early, potentially averting the need for a lengthy hospital stay.

Another reason that many people with long-term health conditions end up in hospital is that, as a result of either forgetfulness or symptoms of depression, they stop taking their medication. And again, technology can play a role.

A good example of this is London software company uMotif, which has developed a smartphone app specifically aimed at people with Parkinson's disease, where even a couple of missed doses can lead to a profound decline in health.

The app, the first of its kind to be available on prescription from the NHS, has been designed to be used collaboratively by patients and clinicians, and works by recording data on things such as blood pressure and glucose levels, which it then uses to issue patients with reminders and help doctors to assess how well they are doing.

"It's all about getting the sensor at the frontline of the patient and catching those patients as early as possible to stop them needing that secondary care," said Johnson.

Sensing technology can also play a useful role within hospitals, where it can help to reduce some of the risks associated with a hospital stay. In one recent trial, Wigan Infirmary claims to have saved £50,000 per month through the introduction of technology that detects the early signs of bedsores and enables clinicians to start treatment before the problem worsens.

The NHS is on the brink of a digital revolution

> **"Despite 100 per cent digitisation in primary care, secondary care is yet to really enter the digital world**
> Beverley Bryant, NHS England

It's early days, and these are all relatively small-scale trials, but there's a growing feeling that such technologies, if rolled out on a wide scale, could have a major impact. And that's where the real challenge lies.

Beverley Bryant is director of strategic systems and technology for NHS England and agrees that sensing technologies have huge potential, but she says that a lot of work needs to be done on the service's underlying IT infrastructure if the technologies are to really have an impact.

"There's no point really pushing this stuff if none of it joins up with the NHS," she said. "Currently, despite 100 per cent digitisation within primary care, secondary care is yet to really enter the digital world. A lot of hospitals are still on paper and hold everything about you in filing cabinets, so there's no point putting wearables and digital devices in the hands of patients if when you press a button it goes into a black hole."

It's fair to say that the NHS doesn't have a great track record when it comes to addressing this particular problem: the abortive National Programme for IT, which cost the taxpayer £10bn, has been described as one of the biggest IT failures ever seen. So how can the organisation get it right this time round?

Bryant believes that where this initiative, and many other efforts to introduce technology, have fallen down is in their failure to properly engage clinical staff. "One of the failings [of the National Programme for IT] was that it didn't have clinical ownership," she explained. "We were trying to solve the problems of the system but hadn't really asked how can the technology help the doctor or nurse in their day-to-day job?"

A big part of Bryant's role is ensuring that these mistakes aren't repeated and that the clinical community feels that it has input into technology decisions. Initiatives introduced by Bryant to address this include a chief clinical information officers forum, set up to promote dialogue between the clinical and IT communities, and the recently launched Code for Health initiative, an effort to get clinicians ->

Clinicians need to have a say when it comes to technology

involved in coding, and ultimately developing their own useful software tools that could be used elsewhere in the health service.

Plextec's Johnson agrees that the needs of clinicians have tended to be ignored by technology developers. "We're getting a lot of technology looking for a home, but what they're not doing is going to the clinician and saying what do you need from me?" she said. "Companies need to engage with clinicians and get clinical opinion leaders on board so that they can engage with the technology. That's what's holding us back."

Johnson added that firms also need to understand the pressures that clinicians are under. One of the big barriers to technology adoption, she said, is regulation — or rather the current lack of it — for the host of technologies currently under development. "If you've got no regulation, the clinicians don't want to take the risk of taking it. No one wants to take the first jump. What if it goes wrong?"

A related issue is the increasingly litigious climate that clinicians have to work in: if a new technology records a huge amount of data on a patient, a clinician may be afraid of using that technology in case they miss something important and end up getting sued.

Johnson said that although there are now cases of companies that have worked closely with the clinical community to develop their products (uMotif and Aseptika are two good examples), companies tend to be more inclined to go down the consumer product route to market where there are quicker returns on investment.

"They see doing clinical trials as a really big expense, and it is," she said. "You have to pay NHS trusts to do a clinical trial, and you have to get lots of clinical data. It costs around £1m to get the data you need to go to market."

And despite the need for greater clinical involvement, she believes that — somewhat paradoxically — the irresistible market forces of the consumer market could be the most influential factor in terms of getting clinicians on board with new technology. "There could come a point where the clinical community turn around and say, 'oh my god, everyone's got one now'. The patients are going to push on the consultants, and are going to end up educating the medical people about how to take this forward."

Ultimately, the most successful products are likely to be those that have pursued both strategies: that have clinical buy-in but are also mindful of what's going to work best for users. "A lot of companies are doing this," said Johnson. "This is how they'll go forward because they'll get a lot of data from the consumer side that will build their profile on the medical side."

One extremely successful example of this approach is the AliveCor heart monitor, a mobile ECG device that hooks up to a smartphone app and will instantly tell the user whether their heart rhythm is normal or not. The device has been through extensive clinical trials and is available through the health service, but you can also buy it on the internet. And for an additional fee, you can even pay to have your heart data clinically assessed.

Smartphone apps can help patients become more engaged in their healthcare

Having products available both commercially and clinically could also help relieve some of the strain on the health service, believes Johnson. "People that can afford to buy it, and they will buy it. But that will release some strain from the NHS and ease the burden for people who can't afford it to have it"

There are also some big lessons to be learned from the commercial world at a more strategic level.

One of the priority areas for Bryant's team is ensuring that patients enjoy the kind of multi-channel engagement with the NHS that they're used to in the wider world: whether shopping or communicating with friends and family. And a great deal of her team's ongoing work on the NHS Choices website, and the way that patients will soon be able to use it to access detailed medical records and communicate with their GPs, has been influenced by the way we use other types of service. "It's about creating utility for citizens in a way that they're used to and building on modern transactional data processing," she said.

> **"You have to pay the NHS trusts to do a clinical trial. It costs around £1m to get the data you need to go to market**
> Collette Johnson, Plextec

But while giving patients the technology to stay in control of their own healthcare has many obvious benefits, there is, according to Johnson, a slight concern that if the technology companies do not educate their users it could be counter-productive. Unfettered access to too much data that we don't really understand could turn us all into hypochondriacs.

"The companies that will win are the ones that will educate people about the technology and help them understand what the results are," said Johnson. "If people don't understand that, they'll be knocking at the doctor's door every five minutes and that's where we have to get the balance and where clinicians will really help the market."

Ultimately, said Bryant, it is an inevitable trend. "In this internet age, people are already doing it anyway and there's no point fighting against a trend. We need to create NHS-accredited systems that have our lozenge on and that are underpinned by evidence.'

Johnson believes that all of these various drivers are creating a situation where the technology is closer to having a mainstream health impact than many think.

"We've seen fantastic outcomes come out of trials that have already been going on — small local benefits — if they can be pushed out wide scale over the next three years, we'll see some fantastic benefits," she said. "I think in the next three to five years we're going to see something really big happen, because people are taking it on now people know that they need to have it, and we've got forward-leading clinicians."

And despite all of the pressures it faces, Bryant believes that the NHS is uniquely well placed to drive nationwide change. "Because we are a national health service, we've got an opportunity to make this happen on a country-wide basis," she explained. "As long as we make sure that everything we do adds value to patients, there's no reason why we can't achieve our ambition for digital technology use in the NHS."

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

Handy man

joel gibbard
Founder and chief executive, Open Bionics

Education
- **2011** BEng in Robotics, Plymouth University

Career
- **2011** National Instruments, Newbury, Applications Engineering
- **2013** Starts Indiegogo campaign for robot hand development funding; raises £43,000
- **2014** Starts Open Bionics
- **2015** Open Bionics is named among top 50 robotics companies by *Robotics Business Review*; wins $200,000 second prize in Intel wearables competition; and is shortlisted for Nesta Inclusive Technology Prize

"Being able to share information in a way that enables people to build on previous work has made a huge difference

Joel Gibbard founded Open Bionics with the aim of producing advanced prosthetics that are both affordable and desirable. Stuart Nathan reports

Early experience of robotics led Joel Gibbard to explore ways of making advanced prosthetics available to more people by using the potential of 3D printing and off-the-shelf components. As the founder and chief executive of Open Bionics, Gibbard is now looking at ways of making prosthetics 'superhuman', to address difficulties that he thinks other developers neglect in their efforts to make their systems mimic natural limbs more closely.

Gibbard is a recent graduate, completing his degree in robotics at Plymouth University in 2011. "It was a really good course with lots of hands-on experience, covering fundamentals of control engineering, computer science and mechanical engineering," he said. "We also touched on applications such as education, industrial and prosthetics."

For his final-year project, Gibbard decided to try to develop a robotic hand. "That was my first prototype," he said. "It was well received by the department." Gibbard's motivation was the very high cost of advanced prosthetics. "They're such amazing pieces of engineering, but they cost tens of thousands of pounds, and that's just not accessible for most amputees, even in rich countries, let alone around the world."

After leaving university, Gibbard already had his hand project in mind as something he wanted to develop further, but rather than taking it to an existing robotics or prosthetics company, he took a job with National Instruments. "The other companies do awesome work, but they tend to be developing very dextrous hands for the academic or industrial work space, and the demands are different. If you're not necessarily developing a prosthetic, weight isn't really an issue and you can put mechanisms outside the hand itself. For prosthetics, it has to be light and everything has to fit into

the palm. It isn't the business model I had in mind and I didn't think my ideas would get any traction."

He now thinks this was a mistake and that working in the field he wanted to pursue would have been an advantage. "National Instruments is a great company and I learned a lot with them; I was an applications engineer doing a lot of work in customer support and education, and a lot of the presentation skills I learned came in very useful for pitching. But I'd advise other students in my position to take more time looking for a job connected with the area you want to go into."

The next step for Open Bionics was a crowdfunding campaign through the website Indiegogo, which raised more than £40,000 for development of the technology. Much of this came from people in the so-called maker community, of which Gibbard is an enthusiast. "Makers are a great community and a lot of innovation is starting to come from there," he said. "It's particularly taken off since online communities emerged, and that's shifted the culture from the old-fashioned 'men in sheds'. Being able to share information in a way that enables people to build on previous work has made a huge difference."

Again, explained Gibbard, crowdfunding was a valuable experience but not one he'd repeat. "There is a surprisingly large amount of support available, especially for university spin-outs, with incubators and grants and so on. It's very easy to get enough funding for the first six months of development and market testing. I think anyone with a half-decent idea should be able to do that. I think I went to crowdfunding too early, before looking at what else was available. But the process is so valuable in terms of talking to people who are interested and learning about your market. I thought I was racing against the clock. I had more time than I thought. University incubators are definitely the best first place to go."

The Open Bionics hand, called 'Dextrus', has been through two design interations. Gibbard has been using an off-the-shelf 3D printer to make the plastic housings – "just because it's a really good way of making low-volume products". He added: "It's not part of our business model, but at the moment it's the best tool for the job."

The initial design was a hard plastic shell, with each finger controlled by a DC motor with a spool on the output shaft that would simultaneously ravel and unravel a steel tendon, acting as both the flexor and extensor for the finger. This tendon was attached to a tensioning system to keep it taut at all times. "So each palm had five motors, spools and tensioners, and the 3D printing meant the tolerances weren't too tight. We eventually made a hand that worked, but it wasn't very reliable." It was also difficult to assemble, taking about 12 hours to put together, and rather large and heavy.

In all, it wasn't terribly suitable for Gibbard's maker customers. "About 25 per cent of people making it are makers who just want to make a cool robot hand and then the rest are makers who are also interested in prosthetics and robotic prosthetics, often making it for a specific amputee in mind, or with the intention to fit it to someone," he said. "There are a lot of these people, and similar projects to ours; if someone has a 3D printer and wants to make a robot hand. When we started we were their only option but now there are four or five to choose from." Initially, Open Bionics wanted to give its designs away as open source for people to develop and build on; now it sells its designs as well.

The second-generation Dextrus took greater advantage of the possibilities of materials. "We went back to the drawing board and started using flexible materials," said Gibbard. "The new design is printed in one piece, rather than individual housing units and finger joints, and all the joints are flexible 'living joints'."

The DC rotary motors have been replaced with DC linear actuators, which contain all their own gearing and mechanics, and only operate to close the fingers; the flexible joints spring them back into the open position when the motor is switched off. "We save lots of room, lots of weight and money, and the hand is mechanically compliant in all directions," he explained. "It makes an intuitive design for human interaction. We can also vary the stiffness at each joint to change the speed the fingers close to grasp nicely."

Once the team finds the best stiffness combination for the finger joints to grip, this will become a standard construction for the hand, although size and the fitting socket would always be customised. "To begin with, we'll only work with people who have a forearm, and are only missing a hand. As we progress, we'll work our way up the arm, introducing more mechanics for the wrist as necessary."

Control of the hand uses muscle impulses, picked up on electrically on the surface of the skin using a system with off-the-shelf circuit boards and sensors. For most amputees who have lost only a hand, the remaining forearm muscles can be used; for one recent project for actor Grace Mandeville, who was born without a forearm, Gibbard's team rigged up a system that used muscles in her back, which Grace adapted to very quickly, Gibbard said. The 3D printing technique allowed Open Bionics to make a custom socket to fit Grace's arm, which was set with crystals to provide her with a showpiece prosthetic for a red-carpet occasion. This demonstrates one of Gibbard's goals: to make a prosthetic into a desirable item.

"I want kids to be proud of their prosthetics, and other children should be jealous

"I want kids to be proud of their prosthetics, and other children should be jealous," he said. "For example, even very advanced prosthetics have a lot of trouble with computer mouses, so I want to build a laser into the hand and a Bluetooth connection so the hand itself is a mouse. That would make it much easier for amputees to use a computer.

"By the same token, you could put a small speaker in the thumb and a microphone in the little finger and use Bluetooth to connect it to a mobile phone. You generally don't realise that amputees using a mobile phone only have their prosthetic hand free, and no matter how good it is, it's not as good as their real hand. The 'hand phone' would be an improvement."

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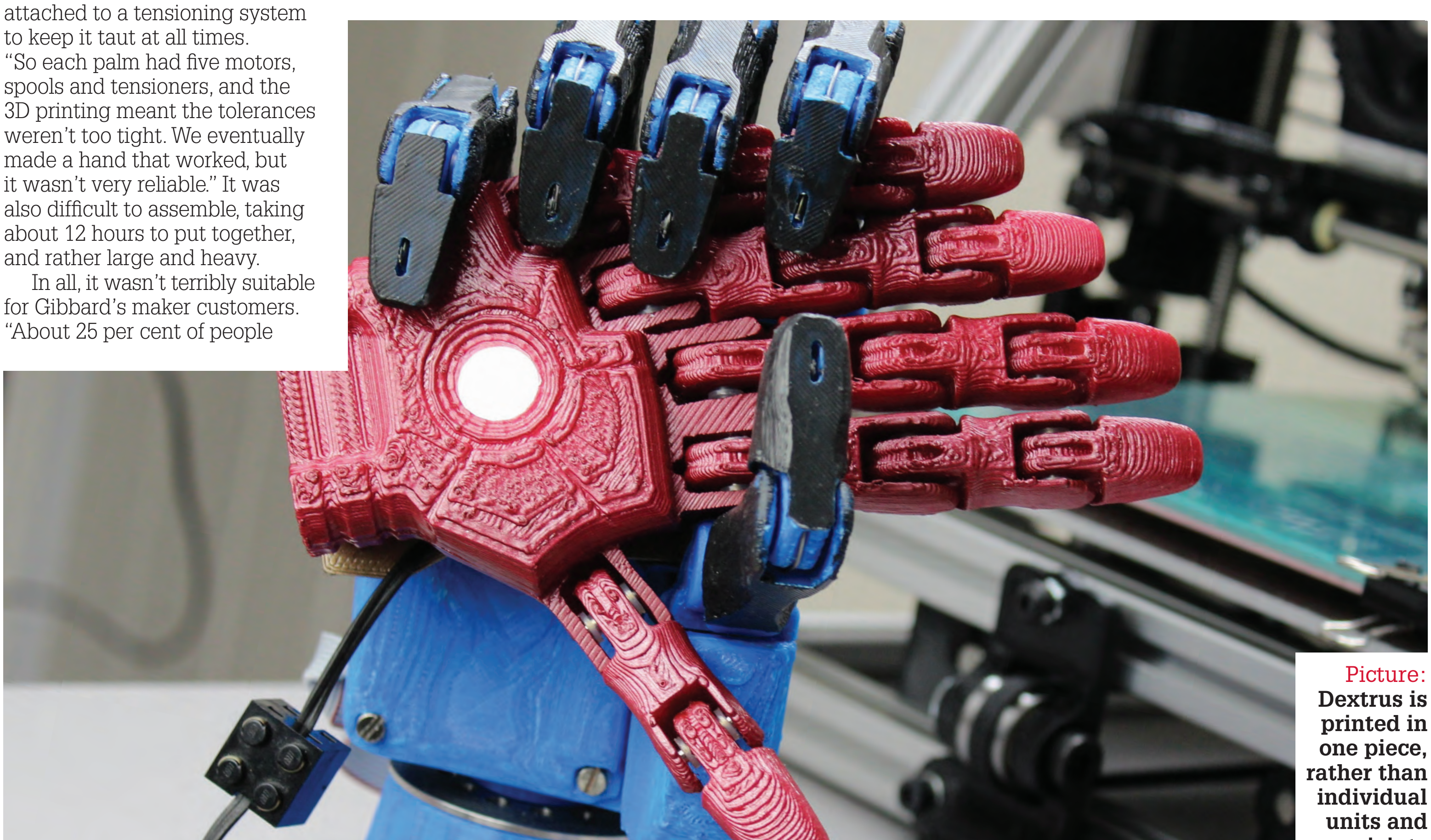


Picture: **Dextrus is printed in one piece, rather than individual units and joints**

The tide is high

Ton Fijen answers your questions on the development of tidal lagoon schemes in Britain. Stuart Nathan reports

In recent years, much of the development of tidal energy has focused on turbines that sit directly in the tidal flow in regions where the tides are strong and fast. But this was not the first way in which tides were used for energy in Britain. On the coast of East Anglia, in Orkney and in the Hebrides are the remains of tidal mills, where lagoons were created to trap the tidal water as it came in and then used the outflow to grind grain; some of these date back to the Vikings and even before. Now, this technique is under investigation again, as part of an ambitious project to generate tidal energy in Swansea, Somerset and Cumbria. We asked readers of *The Engineer* for their questions about these schemes, and Ton Fijen (TF), technical director of Swansea Tidal Energy, the company developing these concepts, answered them.

What types of engineers are involved in this type of project? As a civil engineering student, I'm curious to know if I would be able to get involved with projects such as this in the future.

TF: A project such as the Swansea Bay Tidal Lagoon covers all the engineering disciplines: electrical, mechanical, coastal, marine, civil, structural and geotechnical. We'll need between 30 and 40 people to monitor the construction process and progress.

At the moment, we are actively recruiting engineers to assist with the design development work for other tidal lagoon projects, both experienced and young engineers.

Have you considered placing wind turbines on the lagoon walls as the infrastructure is in place for the power distribution?

Lagoon wall: **the Rance Tidal Power Station in Brittany shows how the Swansea scheme might look**
Below: **Ton Fijen**

TF: That may seem to be an obvious thing to do, but we quickly recognised that tidal lagoons present a unique range of non-energy opportunities to bring people closer to the power generation sector. That has been a central design feature while establishing a viable and scalable blueprint for the tidal lagoon industry.

■ **The best measure of the effectiveness of an energy source, apart from cost of energy, which is dependent on many peripheral factors, is capacity factor (CF), i.e. the proportion of time on average that the source is running at its design rating. For the best offshore wind energy sites, this can be 35–40 per cent, and for the best tidal stream sites even more. Tidal head systems, which includes lagoons, tend to have very low capacity factors – typically 10 per cent or so. I would be interested to know if anyone can quote higher CFs for tidal lagoon energy. If not, should we invest instead in offshore wind and tidal stream energy?**

TF: CFs are a measure of energy output as a percentage of maximum possible output and for existing renewables provide an effective measure of intermittency of the power source, i.e. they are a measure of the available natural resource rather than a measure of the efficiency of the power plant. For wind and solar projects, the CF remains unchanged regardless of the number of generating units (number of wind turbines, for example).

For tidal lagoons, CF is more complicated as there is not an underlying linear relationship with the number of generating units and as the resource is finite, i.e. dependent on the size of the basin and the tidal range. By adding more turbines, you can reduce the CF but increase the efficiency of the lagoon and improve the economic viability. Furthermore, the optimisation of the generating and sluicing units within the lagoon relies upon the fact there is full predictability of the tides and therefore energy production – factors that other renewables are unable to replicate, notwithstanding higher raw unadjusted CFs.

We consider that for these reasons, it is not possible to directly compare CFs for other forms of generation with those of tidal lagoons in a meaningful way, as it would not be providing a like-for-like comparison.

In terms of the efficiency, Tidal Lagoon Swansea Bay will be extracting close to 60 per cent of the available potential energy, or energy resource, which is termed the Emax. This will make it by far the most efficient tidal plant in the world.

■ **Has a dual lagoon system been considered for any of the sites? In addition to storing the energy until peak demand, it would also allow 'pumping' at low tide, as well as at high tide as per a single lagoon. But of course the extra lagoon adds cost to build.**

TF: That could be an option for larger lagoons but is largely dependent on the energy market and the value associated with generating continual power. In our case, we are focused on maximising the energy yield of each lagoon; by creating a multi-basin scheme it would dramatically increase costs while reducing overall energy yield.

However, if we have a portfolio of lagoons, geographically separated with a reasonable phase shift in tides, we could have a centralised, intelligent, forecasting, trading and dispatch system that could produce continual generation as a balanced portfolio and in effect create a virtual multi-basin scheme. Similar systems are already used on large run-of-river hydropower cascades such as on the Rhone and the Rhine, where multiple hydro schemes are operated as a single system. With a portfolio of lagoons, this could be achieved by slightly adjusting the pumping, generating and dispatch times of each lagoon to create continual 24-hour generation from the system as a whole.

■ **Capacity, cost of grid connection and distribution would probably make lagoons more attractive than tidal stream, along with ease of maintenance. There must be some big advantages in lagoons, even if power generated will only support community. However, why has the interest shifted from tidal stream?**

TF: I'm not sure that interest has shifted from tidal stream and I believe that the UK should invest in a diverse range of low-carbon technologies.

Tidal lagoons bring another option to the table. With the concept proved through the Swansea Bay project, tidal lagoons can be built at a larger scale, providing a significant percentage of electricity generation at an economically attractive rate. ->

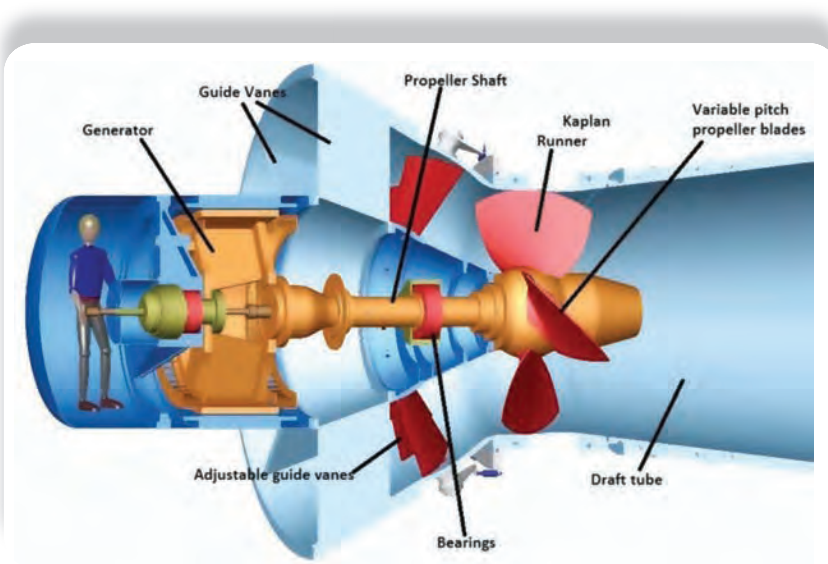
Barrage: **the Rance lagoon demonstrates the scale of tidal projects**
Below: **the turbines the Swansea team plans to use**

> **“The Swansea Bay Tidal Lagoon provides a scalable blueprint, not just to prove the effectiveness of tidal head generation using bidirectional turbines but also to prove the efficiency of our designs, methodologies and practices**

■ **Would it be sensible for the government to contribute to funding the installation of a small-scale prototype single- or twin-turbine incoming/outgoing tide system first?**
TF: The Swansea Bay Tidal Lagoon provides a scalable blueprint, not just to prove the effectiveness of tidal head generation using bidirectional turbines but also to prove the efficiency of our designs, methodologies and construction practices. The project has also mobilised funders and a British supply chain that can scale as the sector scales. The UK can establish a whole new industry on the back of the Swansea Bay project.

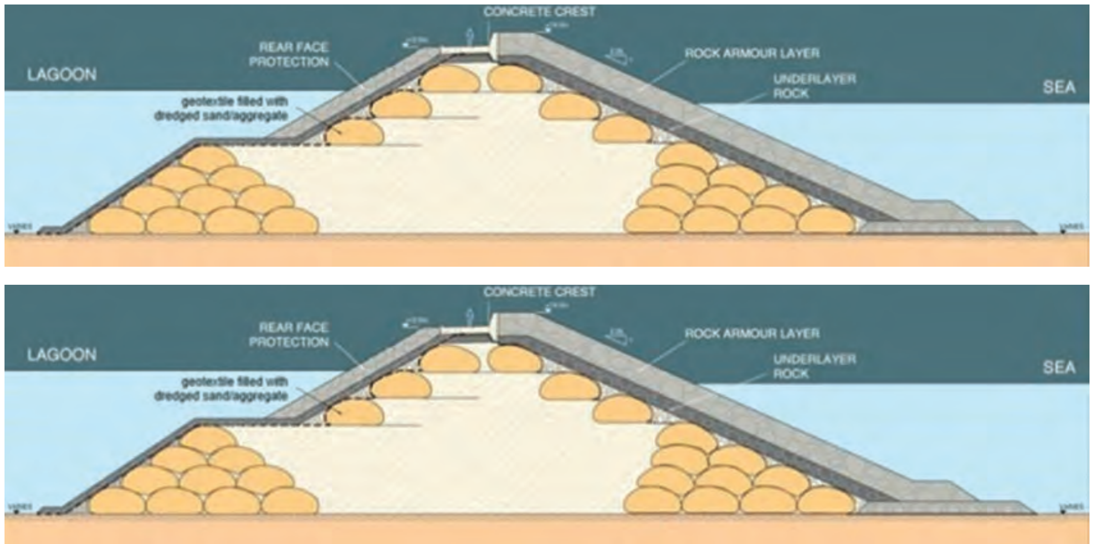
■ **How can you prevent tidal lagoon schemes from changing the inter-tidal regions that are key habitats for many threatened wildlife species?**
TF: The bidirectional turbines designed specifically for Swansea Bay have very high efficiencies and, together with the ability for pumping, will ensure that the tidal water level variability inside the lagoon is almost identical to the natural variability. This will help to ensure that the effect on inter-tidal habitat will be minimal.

We will address up front the more complex issues arising with lagoon developments in environmentally sensitive areas. Indeed, we are under way with a comprehensive programme of baseline surveys and modelling to assess potential effects associated with construction, operation and decommission. Turbines and project design will be iterated to minimise impact.



■ **How can the turbine blades be kept free from barnacles and other marine growth that could reduce their efficiency?**
TF: This is a good question. We do expect some marine fouling but due to the four-quadrant operation of the turbines (bidirectional turbines and pumping) the standstill periods when bio-fouling tends to occur are relatively short and so effect on efficiency should be minimal. However, we have factored in regular cleaning downtime into our operations and maintenance strategy and improved the design of access into the ->

Q&A: tidal energy



Massive: **two versions of the construction of the lagoon wall**

> **"Silt build-up is an issue that has been subject to detailed and investigation as part of our EIA work**

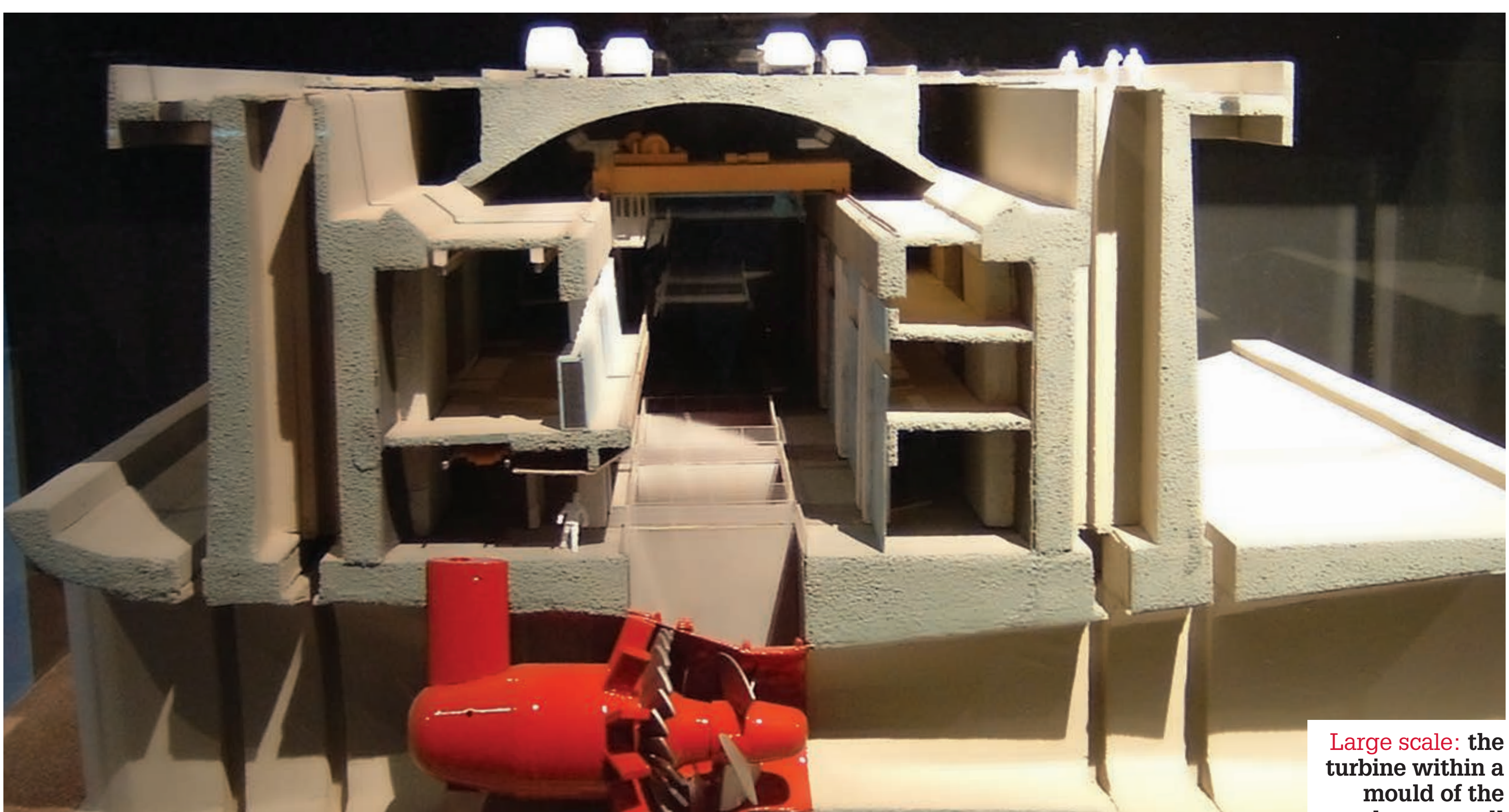
dewatered turbines to allow for larger equipment to be used in cleaning.

■ Tidal power can provide baseload, but it would be many times more valuable as dispatchable electricity from stored hydro energy. Before-generator energy storage is by far the cheapest option, calculated on a whole-system basis. What's the panel's opinion on this?

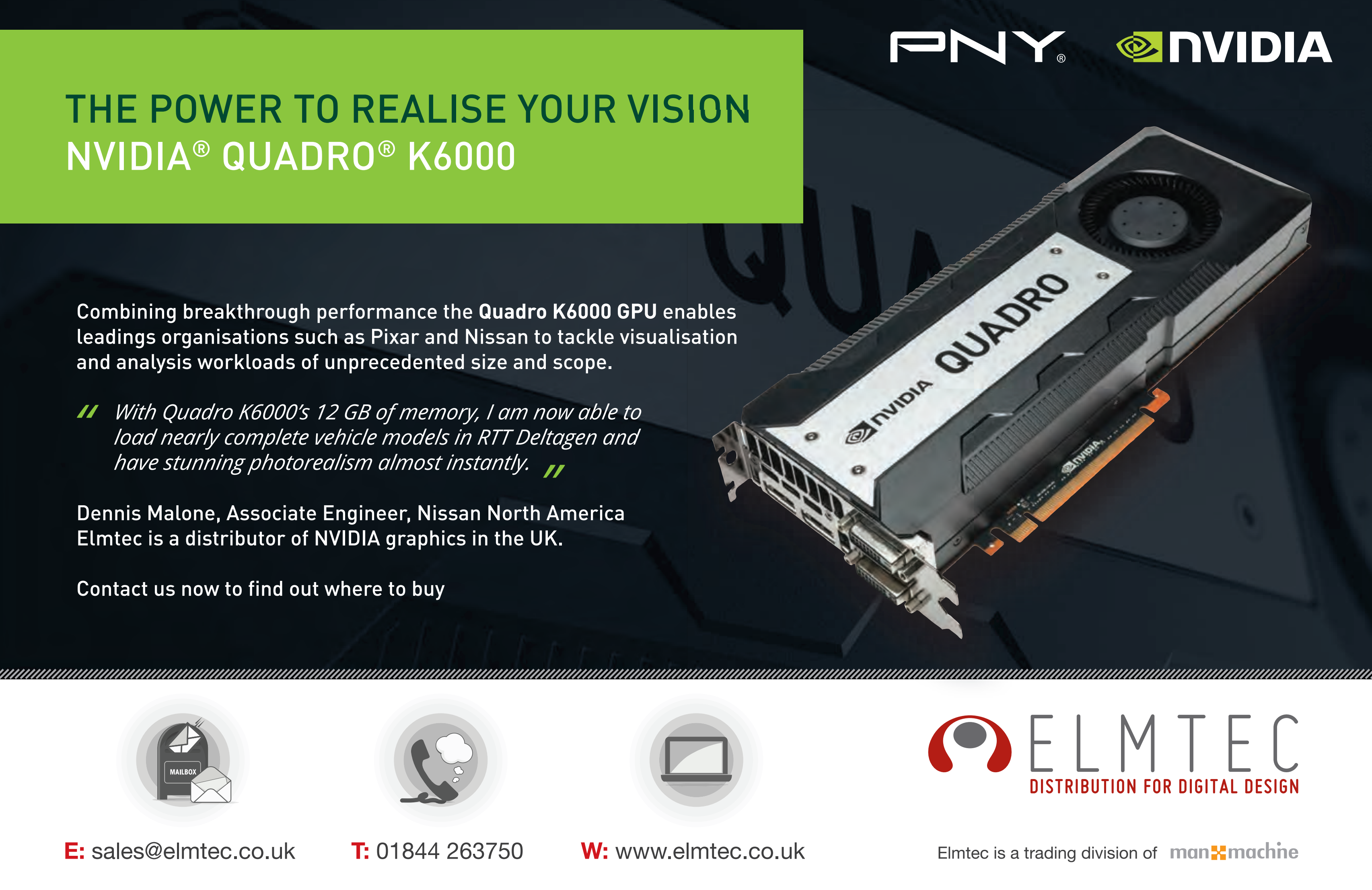
TF: Conventional pump storage schemes are very effective, and there will always be a need for such projects. By pumping, tidal lagoons can, in effect, be storing hydro energy and the dispatch time can be manipulated slightly. However, we still have to operate around the tides and therefore we cannot operate as a true pumped storage scheme — although if we were to operate a portfolio of lagoons (as described previously) it does present a greater opportunity for energy storage.

■ Is silt build-up a problem with the proposed installations, and if so how could it be overcome?

TF: Silt build-up is an issue that has been subject to detailed and thorough investigation as part of our environmental impact assessment (EIA) work and engineering studies. It should be noted that unlike previously proposed tidal range schemes we will be operating across four quadrants (bidirectional turbining and pumping), which means that standstill periods when sediment can settle out are kept to a minimum and will be on average less than two hours. In addition, due to the residual momentum of the water within the lagoon, even during hold periods, there will always be some circulation. It is inevitable, however, that there will be sediment accretion, but designs have sought to minimise its impact and over the longer term it will be managed with maintenance dredging to maintain the water depths and tidal exchange volumes.



Large scale: **the turbine within a mould of the lagoon wall**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Boat designers off to a flying start

As teams grapple with new rules for the 2017 America's Cup, Ben Ainslie Racing is using software to get ahead. Evelyn Adams reports

Race against time: **BAR is using Siemens software to design the catamaran**

There is no second place. In the America's Cup, all that matters is crossing the finish line first in a high-speed chase that sees huge catamarans 'fly' above the water at speeds of 55mph.

In 2017, the Ben Ainslie Racing (BAR) team hopes to compete against defending champions Oracle Team USA off the coast of Bermuda. Its aim is to bring the cup back to UK waters for the first time since 1851.

Engineering design is as crucial as sailing skill. In anticipation of this, BAR has recruited heavyweights in the design world. In April, for instance, ex-McLaren chief executive Martin Whitmarsh will be joining the group's dedicated team of engineers. The team will also partner with four-time world champion Red Bull designer Adrian Newey.

Right now, BAR is in the midst of a two-and-a-half-year timetable to design the best catamaran for the race. On the day *The Engineer* spoke to the team, they had just received news that the 2017 America's Cup is planning to implement a series of major rule changes to reduce team operational costs. The main change is to race in a smaller boat than the previously announced AC62 catamarans. This means going back to the drawing board to come up with the most optimal design.

To do this, BAR has teamed up with Siemens to use its NX and Teamcenter software.

NX is used for computer-aided design (CAD), while Teamcenter helps with product lifecycle management (PLM). Together, they run through tens of thousands of individual components and several hundred thousand lines of computer code.

"The most valuable factor of the software is that its tool set is very diverse," said Simon Schofield, a designer at BAR. "NX is used for automated and scripted processes for the batch creation of geometry, which is then used in the research and development process. The full ->

"The 2017 America's Cup is planning to implement a series of rule changes to reduce team operational costs; the main change is to race in a smaller boat

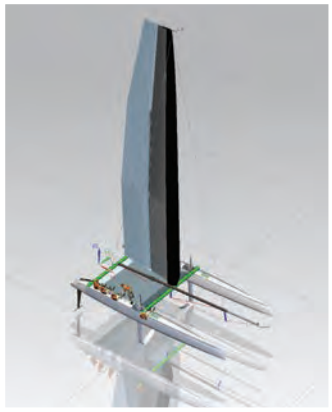
boat model is captured in both 3D and 2D and the drawing and model management is achieved using Teamcenter, with NX integration.

"BAR also uses its simulation capabilities for stress analysis including stick-model simulations, basic solid FEA [finite element analysis] and composite FEA," said Schofield. He added that with NX, BAR can generate hull shapes far more rapidly than previously possible. Whereas processing geometry used to take hours, it now takes about 20 seconds.

This is particularly valuable in light of the new rules. While most of the America's Cup teams have been working on 62ft (19m) catamaran designs, the latest drafted rule changes may mean they will be sailing 45ft catamarans.

It's a big change, designed to give smaller teams a chance of competing with better-funded competitors. In the last race, the sails on the AC72s were 13 storeys high and built like aircraft wings. These allowed the twin hulls of the catamarans to hydrofoil over the water. Geometries are complex and speeds are up to 55mph; even slight changes to its shape can have a huge impact.

As part of the rules, teams are not allowed to launch their boats until 150 days before the first event of the 2017 America's Cup qualifiers. That means most of the design, analysis and performance testing has to be completed on smaller-scale models, as well as in a virtual environment with computational fluid dynamics (CFD) and FEA helping with most of the design.



Sporting challenge: **Sir Ben Ainslie is unfazed by the task ahead**

"The one thing we cannot buy is time, and NX enables us to make the best use of available time," said Schofield. "The scripting capabilities of NX allow us to automate geometry creation, giving us the ability overnight to produce thousands of geometrical variations, which can then be utilised as part of the optimisation process.'

While the team may never use some of the shapes they design, exploring all the possibilities means they know they are not missing a trick. Before the final design, BAR also uses simulators and a test boat to get sailors thinking about the best positions to place controls. Engineers then mock up these designs in 3D using NX.

"We can also work with other specialist applications such as sail design software and use IGES files to bring accurate data into NX with ease," said Schofield.

"In addition, the ability to make late design changes to a component and see all the amendments filter through the assembly is going to be extremely useful in the future, when we have to scale up designs.'

Combining FEA with data captured from sensors on the test boats allows designers to get a better idea of safety implications and performance.

The software also helps the team comply with strict regulations, such as submitting documents to the Rules Committee to show the exact materials and manufacturing techniques used. While this can be done manually, Teamcenter can do this for BAR automatically.

"The America's Cup is a competition where you cannot afford to have an unreliable boat," said Andy Claughton, technical director of BAR. "The most important challenge for us is to build the sailors a fast boat in which they have confidence. If they don't have confidence, they won't be able to go for a manoeuvre that could win the race.

"This is why we have invested so heavily in the software and technical support. All the time we're trying to build a commonality of knowledge about the art of the possible between the sailing team and the design team. That's why the capture of the information in 3D is so important: we want to have the 3D CAD model as the living embodiment of the design as it is right now."

Olympic medallist Sir Ben Ainslie – who put the team together – is unfazed by the long road ahead. "It's a sporting challenge," he said. "It's a technical challenge and it's about bringing a large group of people together designing, building and then racing the fastest boat possible."

productnews

SSA announces simulation events

Strategic Simulation & Analysis (SSA), the leading SIMULIA (Abaqus) partner and simulation consultancy, has announced a series of events looking at non-linear simulation in a variety of industries. Different types of enterprises have different problems and drivers, and therefore simulation needs to be tailored to these needs, and the specific engineering being carried out. Webinars and live events on simulation in oil and gas, life sciences and other industries are being held through the second quarter of 2015.

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

Positive reinforcement

The art of weaving by loom could hold the key to producing stronger and more complex carbon-fibre structures. Helen Knight reports

What does a textile loom invented more than 200 years ago have to do with 21st-century aircraft engines and high-performance cars?

It turns out the centuries-old art of weaving by loom may hold the key to producing much stronger and more complex carbon-fibre composite structures.

Composites are traditionally produced by placing layers of material on top of one another and infusing them with resin.

However, this means that there is nothing holding the layers of material together, other than the resin itself. As a result, composites can start to come apart when a load is applied to them, in a process known as delamination, said Dr Jody Turner, a research engineer at Sheffield University's Advanced Manufacturing Research Centre (AMRC) with Boeing. "It can result in a problem called inter-laminar shear stress, which is where the plies start to separate," she said.

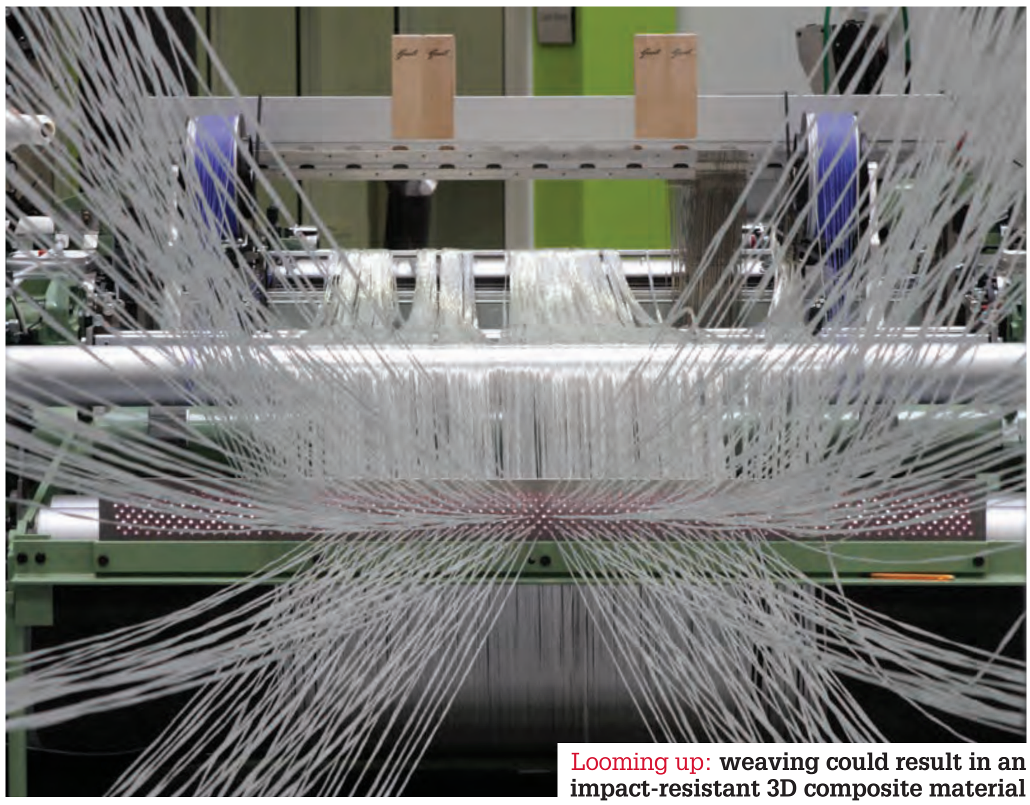
By using a loom to weave the material, engineers can introduce a reinforcing fibre running through the thickness of the fabric, to connect the layers together. This results in a 3D composite material that is better able to cope with impacts, or loads such as bending, without delaminating.

Research by Ulster University and spinout 3D weaving company Axis Composites has found that the materials exhibit fracture toughness up to 20 times higher than conventional epoxy laminates.

Distinctive properties can also be woven into different areas of a single composite structure, said Dr Edward Archer, a lecturer in the Engineering Research Institute at Ulster University and technical director of Axis Composites. This means the properties of the material can be altered at different points to best react to the loads acting upon it, he added.

So, for example, the stresses acting upon a material at curves in a structure will be in a different direction to those on flat sections. But by adding more reinforcing fibres in the direction of these stresses, it can counteract the load, he said.

What's more, 3D weaving also allows you to produce more geometrically complex composite structures, said Andrew Long, professor of the mechanics of materials at Nottingham University, and director of the EPSRC-funded Centre for Innovative Manufacturing in Composites (CIMComp).



Looming up: **weaving could result in an impact-resistant 3D composite material**

"So, for example, you could weave a flat piece of material on the loom, with the layers all connected together, but then somewhere your material might split into two layers that sit on top of each other," he said.

This can be done by ensuring the reinforcing fibres do not reach all the way through the thickness of the material, he said. "Then when you take it off the loom you can open it up to produce something like a T shape or an I beam – very important structural elements that are regularly used for stiffening in aircraft wings," he said.

Although relatively new to the composites industry, the weaving process – in which a weft thread is inserted through a warp thread at a 90° angle within a loom – has remained relatively unchanged for hundreds of years.

"With a 3D weaving machine, it is just a matter of controlling how you lift the warp yarns, and how many weft yarns you insert before you move the fabric along," said Long. "So you can insert a number of weft yarns, one on top of another, and control the warp yarns so that some of them form through-thickness reinforcement fibres."

While some companies are developing their own looms, many use conventional Jacquard machines, which are widely employed in the textile industry to weave multilayered patterns, such as brocade bedspreads. Invented in 1801 by Joseph Marie Jacquard, when punched cards were used to guide their operation, the looms are now controlled by electronics.

"You have a lot of design freedom, in terms of the pattern you can make your yarns follow within your woven structure," said Long. "You can vary the patterns of your through-thickness reinforcing fibres in lots of different ways."

Much of the interest in 3D weaving to date has come from the aerospace industry. The landing gear on Boeing's 787 Dreamliner, manufactured by Messier-Bugatti-Dowty, is equipped with fibre-reinforced composite braces manufactured using a 3D weaving process.

A traditional laminated composite would not be able to withstand bird impact or runway debris, or cope with the complex axial and ->

shear loads that landing gear face during the course of a flight, according to Albany International, based in Rochester, New Hampshire, which wove the braces for Messier.

Albany is also weaving 3D composite fan blades for the LEAP turbofan aero-engine, which is being built by CFM International, a joint venture between Snecma and GE. The 3D composite structures, or preforms, are woven on a Jacquard-type loom, and then cut to the desired shape using waterjets. They are then injected with resin in a mould.

The 3D woven fan blades and casings will reduce theweight of each aircraft by around 500kg, according to a spokesperson for Snecma. The LEAP engine is due to enter service on the Airbus A320neo in 2016, and the Boeing 737MAX in 2017.

The technology is also beginning to find its way into the automotive industry. Earlier this year, Albany announced a partnership with Ricardo to explore the use of its 3D composites in automotive applications. Meanwhile, Toyota is using a loom to weave a carbon-fibre front crash box for the Lexus LFA supercar. It has also developed a circular machine that can braid individual fibres together using an automated template, to produce the side rail for the car's front windscreen.

But despite this progress, engineers may still just be scratching the surface of what these looms can do, in terms of composite development, said Long. "At the moment, manufacturers tend to restrict themselves to two or three styles of 3D woven material, broadly speaking, because they don't really have any data on any other patterns on which to base design decisions," he said.

To this end, researchers at CIMComp are modelling the performance of woven composites, with the aim of being able to modify the design of the weave for different applications, to ensure the most significant weight savings, for example.

Dr Xuesen Zeng, a research fellow at Nottingham University, is using a genetic algorithm to find the most suitable weave for a given application – in this case aircraft landing gear braces – using the process of natural selection. The algorithm mutates and then breads the 'fittest' weave patterns from a random selection to find the optimal design.

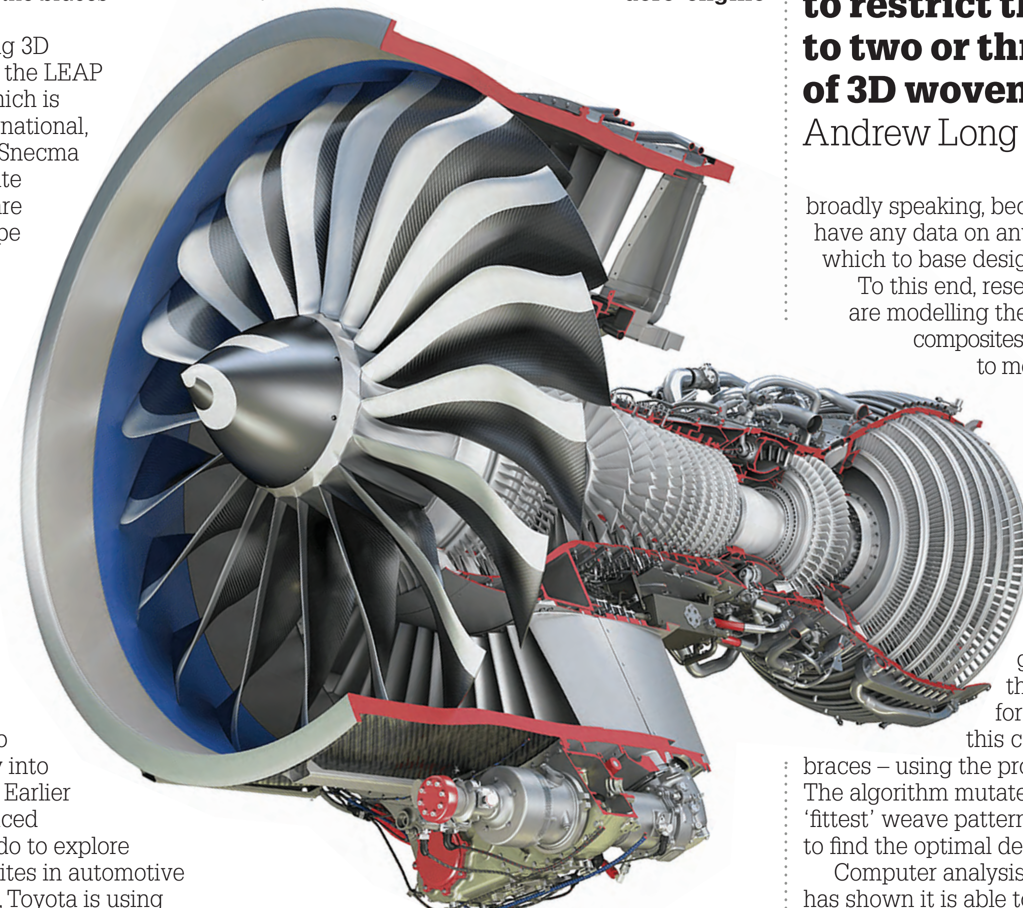
Computer analysis of his selected design has shown it is able to withstand buckling twice as well as conventional laminated composites, and 50 per cent better than a 3D material with a commercially available orthogonal weave, Zeng said.

Working with researchers at Manchester University, and with composite manufacturer Sigmatex, based in Runcorn in Cheshire, Zeng ultimately plans to produce a 3D weave of his selected design, to demonstrate that it has the improved load-bearing properties he predicts.

Meanwhile, Turner and her colleagues at the AMRC, which has recently purchased its own loom, are hoping to soon begin weaving their own material in a bid to learn more about the resin transfer moulding (RTM) process, in which resin is injected into the fibres in a closed mould.

At the moment, researchers cannot be sure exactly what happens once the resin is injected into the mould, according to Turner. "To enable you to predict where the resin will go, you've got to understand what is going on inside the mould – and at the moment we just don't," she said.

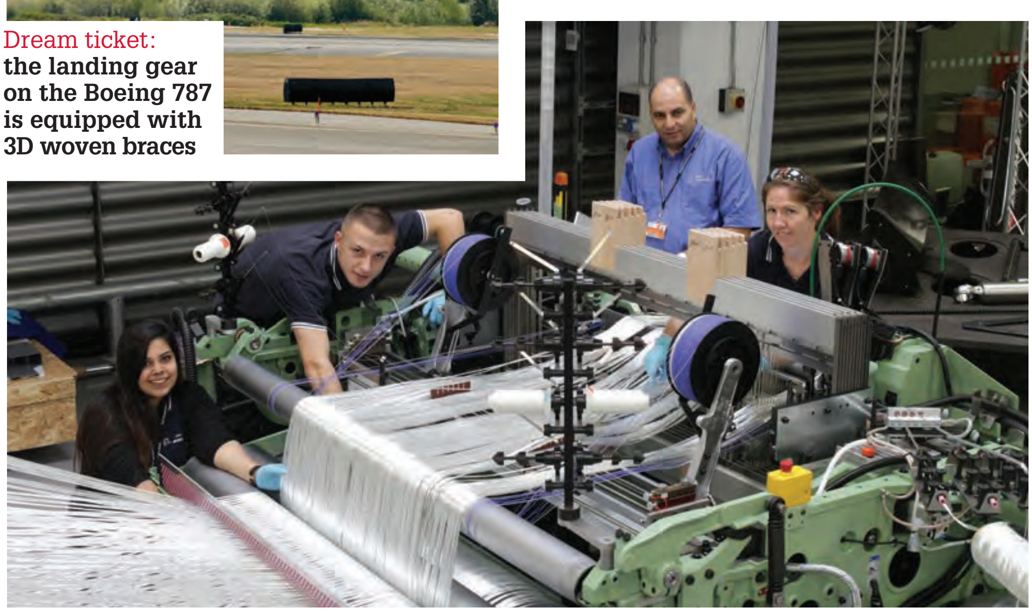
By controlling the position of the weft and warp threads during the weaving process, Turner hopes to introduce deliberate errors into the material that will allow her to determine if these then affect the resin flow through the fibres, as she expects. "In this way we can start to build up our understanding of what is happening and why," she said.



LEAP of faith: **Albany is weaving the blades for the LEAP turbofan aero-engine**

" At the moment, manufacturers tend to restrict themselves to two or three styles of 3D woven material
Andrew Long

Dream ticket: **the landing gear on the Boeing 787 is equipped with 3D woven braces**



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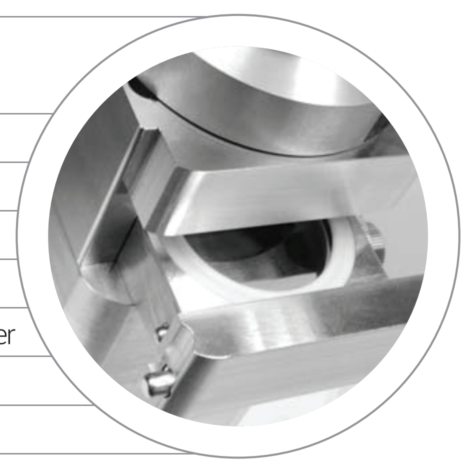
Clear Aperture	90% of central diameter
Reflection at 1064nm, 1070nm, or 1080nm	<0.2%R/surface
Damage Threshold	>15J/cm^2, 10ns



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Solid start for laser research

An ingenious British invention is at the heart of an Anglo-Czech project to improve the efficiency of a number of processes. Will Sterling reports

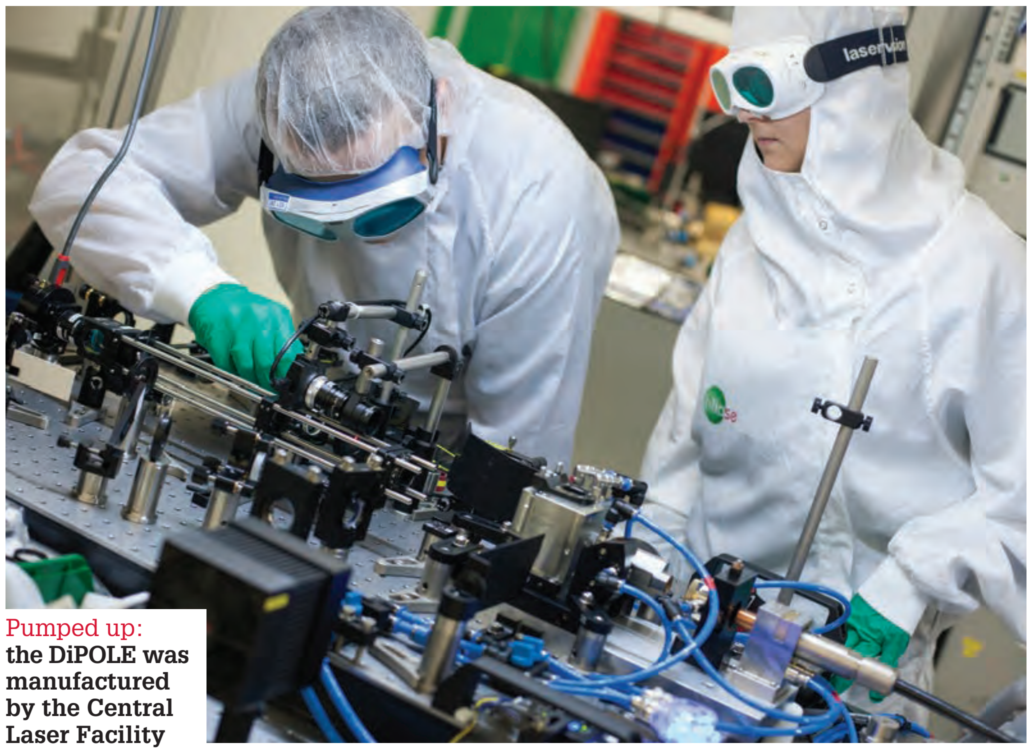
In Dolní Brežany, excited physicists are preparing to receive their new £10m super toy. The machine is a diode-pumped solid state laser (DPSSL) with special properties that they hope will justify the European Commission's €33m (£24m) investment in a new research centre, bring jobs to the region and – most importantly – provide global industries such as optics and aerospace with 'game-changing' manufacturing techniques.

The laser, to be delivered in May, will help the new facility, known as HiLASE, become one of Europe's centres of excellence for laser research in a partnership with the UK Science & Technology Facilities Council (STFC).

The HiLASE Centre will be operated by the prestigious Czech Institute of Physics and completed in mid-2014. The new machine is called DiPOLE – or Diode Pumped Optical Laser for Experiments – and was designed and manufactured by the Central Laser Facility (CLF), based at the Rutherford Appleton Laboratory in Harwell, part of the STFC. To be precise, the 100J, 10Hz laser was built by CALTA – the Centre for Advanced Laser Technology Applications, a division of CLT – and while it has pan-European suppliers the machine is all British.

Lasers have wide industrial applications, and new technology such as the diode-pumped laser brings new, exciting applications. With a lack of laser research to support industry in the Czech Republic, the four-year HiLASE project was commissioned in 2011 and should be fully operational by January 2016, according to Dr Tomas Mocek of the Institute of Physics.

"We started HiLASE to support big laser infrastructure such as ELI and also to satisfy demand from industry, locally and European," he said. The Czech component of ELI – the Extreme Light Infrastructure project – is next door. Clearly serious about its laser strategy, the Czech Republic needed some special hardware.



Pumped up: **the DiPOLE was manufactured by the Central Laser Facility**

Enter CALTA at the Rutherford Appleton Lab's Central Laser Facility and its ingenious device. There are two principle modes of operation for lasers, under which sit laser categories such as gas solid state, fibre and so on – they are continuous wave and pulsed. Pulsed operation has several types and the DPSSL at CALTA is pulsed in the picosecond and nanosecond regimes. The key to the technology is to combine high peak power with high repetition rate.

"Currently you can buy either high-peak-power lasers, i.e. a small energy in a very

->

indepth Diode-pumped solid-state (DPSS) lasers – the technology

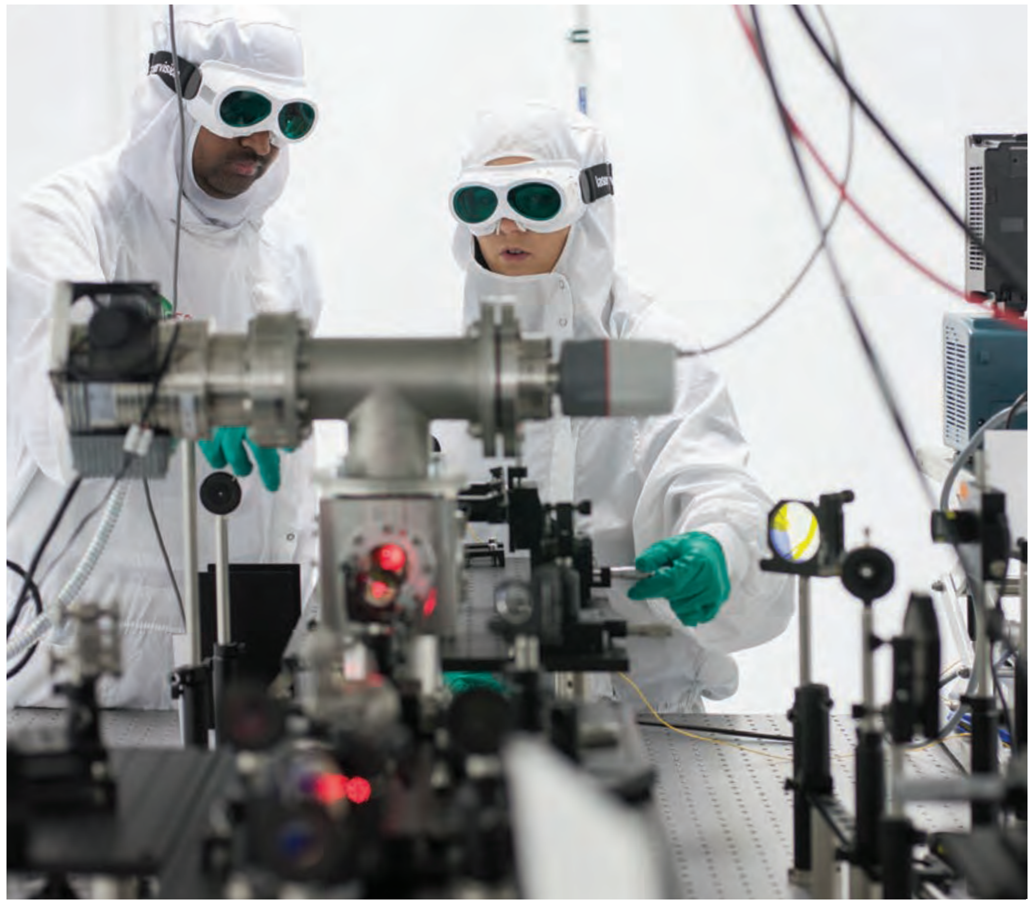
Lasers require a gain medium to amplify light, which needs to be supplied with energy in a process called pumping. Conventionally, this is pumped by flash lamps, such as those in a camera. "This is very inefficient – a flash lamp light is a broad spectrum and you absorb just a small part of that spectrum in the laser gain media," said Dr Ric Allott, business manager at the Central Laser Facility.

"[In a diode pump], you are targeting the absorption in the laser gain medium with the specific wavelength given out by the diode," he added. "The efficiency is multiple times that with flash lamp."

The DiPOLE laser built at the UK Science & Technology Facilities Council combines high average power with high peak power. By contrast, another large laser at Rutherford Appleton Laboratory, Vulcan, has high peak power but can only fire once every 20 minutes.

"The key with this laser is we can generate very high pulse energies but we can also run at 10Hz repetition, or 10 shots per second. It means a 100J laser gives us 1kW of average power – that is a huge amount of average power for a laser that is also capable of delivering 10GW of peak power," said Allott.

The high peak power is defined by the pulse length of the laser – roughly 10 nanoseconds. "So 100J delivered in 10 nanoseconds gives you 10GW of average power. That's a special situation when you have high average power with high peak power," he added.



short time, which tend to be flash lamp pumped, or a high-repetition machine," said Dr Ric Allott, business development manager at the Central Laser Facility.

"This new DiPOLE laser we have built can generate very high pulse energies and we can run it at 10Hz, or 10 shots per second, repetition." This gives users a more reliable and efficient process (see box).

Much of the laser industry is in transition from traditional flash lamp pump technology to diode pumping, according to Mocek. "This [DPSSL] is very efficient and compact, but still very expensive for companies that need a quick return on investment." This provides the need for a research centre such as HiLASE.

DiPOLE has several big commercial applications, including micro-machining, cutting, welding, removal of deposits and laser peening.

Laser shock peening (LSP) is a relatively new technology that hardens materials. Aircraft, for example, have critical parts that require treatment after a certain number of flying hours or they are subject to cracking. Shot peening – spraying the material with projectiles – is traditionally deployed. By changing the residual stress in the surface by imposing shock, you can revitalise the material surface, and this can increase the part's lifetime.

But shot peening is messy and comparatively less efficient. "With LSP, first it is easier to apply the photons than the [shot] projectiles to certain areas of an aircraft," said Mocek. "Secondly, by using LSP, the lifetime of these parts can be extended by a factor of two or three, significantly more than shot peening." Boeing, Airbus, Rolls-Royce and GE are all interested, Mocek said, but the technology is not certified yet.

"The key point is that the [new] laser increases throughput of work, because the energy per pulse is much higher and the repetition rate is much higher than existing laser techniques," said Allott. Laser peening is currently a circa \$200m (£135m) a year business with about 15 per cent growth, according to figures quoted by the STFC.

Another application is laser-induced damage threshold measurements for the optics industry. Lenses and mirrors in industry have to be resistant, and a laser-induced damage threshold test (LIPT), with an ISO standard, can be used. But the facilities that provide this are few in number. "Major manufacturers of optics need a lab to measure their optics and tell them this new layer they've developed has a defined damage threshold," said Mocek. "It's essential information for their customers so that they can improve their process."

Centre of excellence: **the HiLASE facilty supports big laser infrastructure**

The partners are excited about the potential for this technology. The CLF will look to shorten the pulse of the laser to generate radiation, which is good for imaging and non-destructive testing. "The key to this is because the pulse lengths of the source that you generate are so short, you can freeze the image on a part that is moving," said Allott. Consider testing the integrity of turbine blades while they are rotating.

CALTA is building another 100J, 10Hz DiPOLE laser for the European XFEL project at DESY in Hamburg, and there is further interest in DPSSLs from labs elsewhere.

In the last 15 years, some 12 companies have been spun out from the laser facilities at the Rutherford Appleton Laboratory. "In the future, should the demand be there, we would consider the possibility of a spin-out or JV [joint venture] company to build these [DiPOLE] lasers. We have a history of spin-out companies, the latest success being Cobalt Light Systems," said Allott. Cobalt Light Systems won the 2014 MacRobert Award and its invention is now deployed in several airports to detect the chemical composition of liquids while stored in baggage.

The future for this new technology seems bright and shows how investment in research councils can deliver real economic value.

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

Show and tell

The Engineer Conference will feature a selection of inspiring projects and will focus on some of the key issues dominating industry debate

From the Rosetta mission and the UK's new aircraft carriers to Industry 4.0 and the growth of reshoring, The Engineer Conference 2015 boasts an unmissable mix of inspiring projects and industry big-hitters.

Since its launch in 2013, The Engineer Conference has provided a platform for some of the UK's top engineers and some of its most exciting and innovative engineering projects. This year's instalment promises to be better than ever.

Running from 2–4 June at the NEC in Birmingham, the 2015 conference features three streams covering the latest thinking and the most exciting UK developments from the worlds of engineering design, manufacturing and supply-chain management.

As always, throughout the event there will be a major focus on some of the key issues that are dominating industry debate: from Industry 4.0 to the welcome, and much trumpeted, phenomenon of reshoring.

Thanks to presentations from ADS Group and the recently launched Proving Factory, there will also be plenty of useful advice to small and medium-sized enterprises (SMEs) on how to engage with OEMs, as well as first-hand accounts from small companies – such as Magna Parva – that have managed to attract interest from the UK's biggest hitters.

On the technology side, there's plenty of emphasis on the ever-popular topic of 3D printing, with Dr Chris Tuck, one of the UK's leading experts in the field, appearing alongside some fascinating real-world case studies from teams at Renishaw and BAE Systems.

We'll also be taking a look at the way new materials are affecting the design and manufacturing worlds: from the untapped potential of graphene to applications of composites and the innovations in light-weighting that are helping some of our biggest sectors lead the world.

As always, the conference will shine the spotlight on some of the UK's most challenging and inspiring projects. David Downs, the engineering director of the Aircraft Carrier Alliance (and regular blogger for *The Engineer*), will be talking about the challenges of building the UK's new Queen Elizabeth-class carriers, while Ian Costello, deputy engineering manager for Rosetta at Airbus Space & Defence, will be talking to us about the UK's role in last year's astonishing comet landing.

On display: **The Engineer Conference will cover some of the UK's biggest engineering projects**

We're also particularly looking forward to hearing from UK engineer John Lawson about how he and an international group of like-minded enthusiasts have recreated the only aircraft built by legendary car designer Ettore Bugatti.

Other presenters over the course of the three days will include: Dick Elsy, chief executive officer of the High Value Manufacturing Catapult, AMRC programme manager Dr Peter Osborne and Simon Black, senior manager of body structures at Jaguar Land Rover.

The Engineer Design and Innovation Show

The engineering conference runs alongside three exhibitions: Subcon, the Advanced Manufacturing Show – the UK's biennial showcase for machine tools, tooling and metrology equipment – and The Engineer Design and Innovation Show (TEDIS), a brand-new event focused on the specific needs of Britain's design engineers.

This new show will focus on all the tools the engineering designer needs to do his or her job and the components, materials and innovative technologies that will be incorporated into next-generation products.

The event spans the complete design process – from idea to market-ready product – and has a strong focus on the development partners who can help companies bring products to market. These include Warwick Manufacturing Group, Tharsus, Protolabs and ML Electronics.

Stephanie Williams of Warwick Manufacturing Group, the University of Warwick, said: "At the Engineer Design and Innovation Show, we will be showing businesses how we can help them bridge the technology preparedness gap – taking an idea and developing it into a project that is geared to reach market commercialisation.

"With our research expertise across a wide range of research fields, we can lower the risk of innovation. Businesses can benefit from knowledge transfer, along with access to state-of-the-art testing facilities to develop better products and services to accelerate market growth and competitiveness."

Pam Robson, head of marketing at Tharsus, added: "We work with customers to develop, manage and manufacture products that make it to the market and sell.

"Our service covers the entire process of taking a product to market and we believe that having all of this capability under one roof is faster and more efficient and has less risk than other, more traditional methods."

Grand designs for engineers

This year's PD&I conference will focus on the latest trends, technologies, materials and processes in innovation

Running from 20–21 May at America Square Conference Centre in Tower Hill, London, this year's PD+I (Product Design and Innovation) conference looks set to provide a great opportunity for industrial designers to find out about the latest trends, technologies, materials and processes.

With more than 200 delegates expected to attend, confirmed speakers include: Duncan Bradley, head of the high-performance design facility at McLaren Technology Centre; Ben Hardman, engineering manager at Speedo Aqualab; Daniel Liden, design manager at Lenovo; and Katie Raath, global creative director at Bacardi Global Brands.

Now in its fifth year, PD+I is expected to build on the success of last year's event, which featured a number of big names from the world of design, including Robert Brunner, Richard Seymour and Sir John Hegarty.

Commenting on last year's event, one delegate from the engineering world said: "As an engineer, I'm interested in the materials side. I'm liking the conference; it's a good place to get different ideas from several case studies — looking at change management, things that work and things that didn't work and how to do them differently."

Making a great show: **more than 200 delegates are expected to attend**

Looking ahead to this year's event, conference chair Chris Lefteri said: "PD+I has always had a high level of quality, with some really great speakers over the years, and I'm excited to build on this, particularly at an international level. At the end of the day, people are hungry for knowledge and want to learn, and PD+I is a great place in which to do this. There is the opportunity to hear from people who have done things well, and also to get involved in debates and of course network. I'm enjoying being involved so far and look forward to May 2015."

Lefteri is an internationally recognised authority on materials and their application in design, as well as founder and owner of Chris Lefteri Design, through which he has worked with several Fortune 100 companies and major design studios across Europe, the US and Asia.

To confirm your place at an early-bird delegate rate of £285 plus VAT for one day or £525 plus VAT for two, book before 11 April 2015 — after which prices will be £345 plus VAT for one day and £625 plus VAT for two days.

> **"Now in its fifth year, PD&I is expected to build on the success of last year's event**

Take advantage of the early prices by registering online today at http://conference.pdesigni.com or by contacting Yvonne Nartey on ynartey@crain.com.

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INTRODUCTION

The AFRC, which is one of 7 elite centres that form the High Value Manufacturing Catapult, is delighted to be hosting and managing the 13th International Cold Forming Congress. This conference is aimed at providing industry experts and stakeholders with an understanding of progress in cold forming in the last five years, and possible forward direction in the next.

The conference theme, **Achieving step changes in cold formed product weight and process flexibility for future products**, will address the following areas:

- Cost effective manufacturing of lightweight components
- Press and machine technologies for process flexibility
- Modelling and simulation to support rapid change
- Advanced materials considerations in cold forming
- Cold sheet metal related technologies
- Enabling cold forming processes to serve high demand applications
- Flexible and sustainable cold forming processes

CONTACT US

You'll find further information on the conference on the AFRC website, or if you have any questions, please contact us:

Email: **coldformingcongress@afrc.org.uk**
Web: **www.afrc.org.uk**
Tel: **+44 (0) 141 534 5200**

CONFIRMED SPEAKERS

Advanced Forming Research Centre, ACB, Boeing, BOHLER-Uddenholm UK, ESI, FICEP, Forging Technologies, GFM GmbH, Hatebur, Hadley Group Technology, HEWI G. Winker GmbH & Co. KG, Hydrasun, Korea Institute of Materials Science, Lasco, Lazpiur, Letrika, Micas Simulations Limited, Neuman Aluminium Fliesspresswerk GmbH, Repkon, Rolls-Royce plc, Schuler Pressen GmbH, Scientific Forming Technologies Corporation (SFTC), Simufact Engineering GmbH, Transvalor, UK High Value Manufacturing Catapult, University of Strathclyde, Warwick Manufacturing Group (WMG), WF Maschinenbau, Wilde Analysis and Yamanaka Eng Co Ltd.

CONFERENCE FEES

- **Early bird discount fee:** £520, when booked on or before 29th May 2015.
- **Delegate registration fee after 29th May 2015:** £600

SUPPORT THE CONFERENCE

- **Gold Sponsorship package**: £5,000
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- **Exhibitor package**: £1,400

VENUE

The University of Strathclyde's new state of the art Technology and Innovation Centre in the heart of Glasgow.

CATAPULT High Value Manufacturing

Built to succeed

This year's NECR show will provide a one-stop shop for recruiters and job seekers in engineering and construction to meet and gain advice

Just the job: **the event will showcase a range of career opportunities**

With the UK currently facing an unprecedented skills crisis, the widespread need for engineers is at an all-time high. According to the Royal Academy of Engineering, Britain will need more than a million new engineers and technicians by 2020, which will require a 100 per cent increase in the current number of annual engineering graduates and apprentices.

Engineering is a vital part of the UK economy; engineering employers have the potential to generate an additional £27bn per year from 2022. With this apparent shortage, it is clear that there has never been a better time for graduates or job seekers interested in this industry to explore their options.

Providing a helping hand, the National Engineering & Construction Recruitment (NECR) exhibition will be showcasing a range of career opportunities at the NEC in Birmingham on 24–25 April 2015. The exhibition will provide a one-stop shop for recruiters and job seekers to meet face to face and gain industry advice.

In association with *The Daily Telegraph*, the two-day event will offer an array of opportunities from renowned organisations for all engineering and construction professionals and graduates.

Industry experts will help visitors to understand the industry better and open doors to the range of careers available.

Organisations such as JCB, Interserve, Brose and BAE Systems will join other industry leaders to recruit the latest talent and offer their knowledge to those making a move up the engineering and/or construction ladder. With something to suit all preferences, the exhibitors will represent sectors including automotive, mechanical, civil, design and electrical.

John Hancock, managing director of Venture Marketing Group, which organises the event, said: "With the current news agenda highlighting the clear shortage of engineers, the NECR is one of the UK's most important events in bringing together recruiters and job seekers to discuss potential career opportunities in the engineering industry. This exhibition is the perfect occasion for those who are keen to kick-start their career in this demanding industry or the fully skilled simply seeking a career change. With everyone brought together under one roof, the networking opportunities are endless and it gives job-seeking engineers invaluable face-to-face experience with leading recruiters, something that is not always readily available."

Now in its 18th year, the event will be free to attend with hundreds of exciting job vacancies from leading global recruiters. In addition, visitors will have access to a full seminar programme, a careers advice lounge, CV and interview clinics, a networking centre for female engineers, an engineering challenge for budding engineers and a professional development hub.

Supported by the Women's Engineering Society (WES), the Women in Engineering Forum is a popular feature. Taking place on 24 April, the open forum is run by women, for women, and provides an excellent networking opportunity for women at all stages of their career. Visitors and industry representatives can share their experiences, make new contacts and discuss the options a career in the industry can offer. This year, two inspiring female engineers will be sharing their personal career experiences and give first-hand advice to those still considering their career path.

A series of free presentations from industry professionals will give an insight into a number of topical issues and advice about the recruitment process. In addition, an exclusive feature to the exhibition is the professional development hub. Here, visitors can meet with representatives and key industry institutions for advice on the benefits of institution membership.

Alongside the main exhibition, attendees can pay a visit to the CV and interview clinics. Facilitated by the experts at Talent Transitions, the interview clinic will be on hand to offer support and advice on interviewing in today's tough jobs market. At the CV clinic, The Write Stuff will be available to give one-to-one guidance on writing a winning CV.

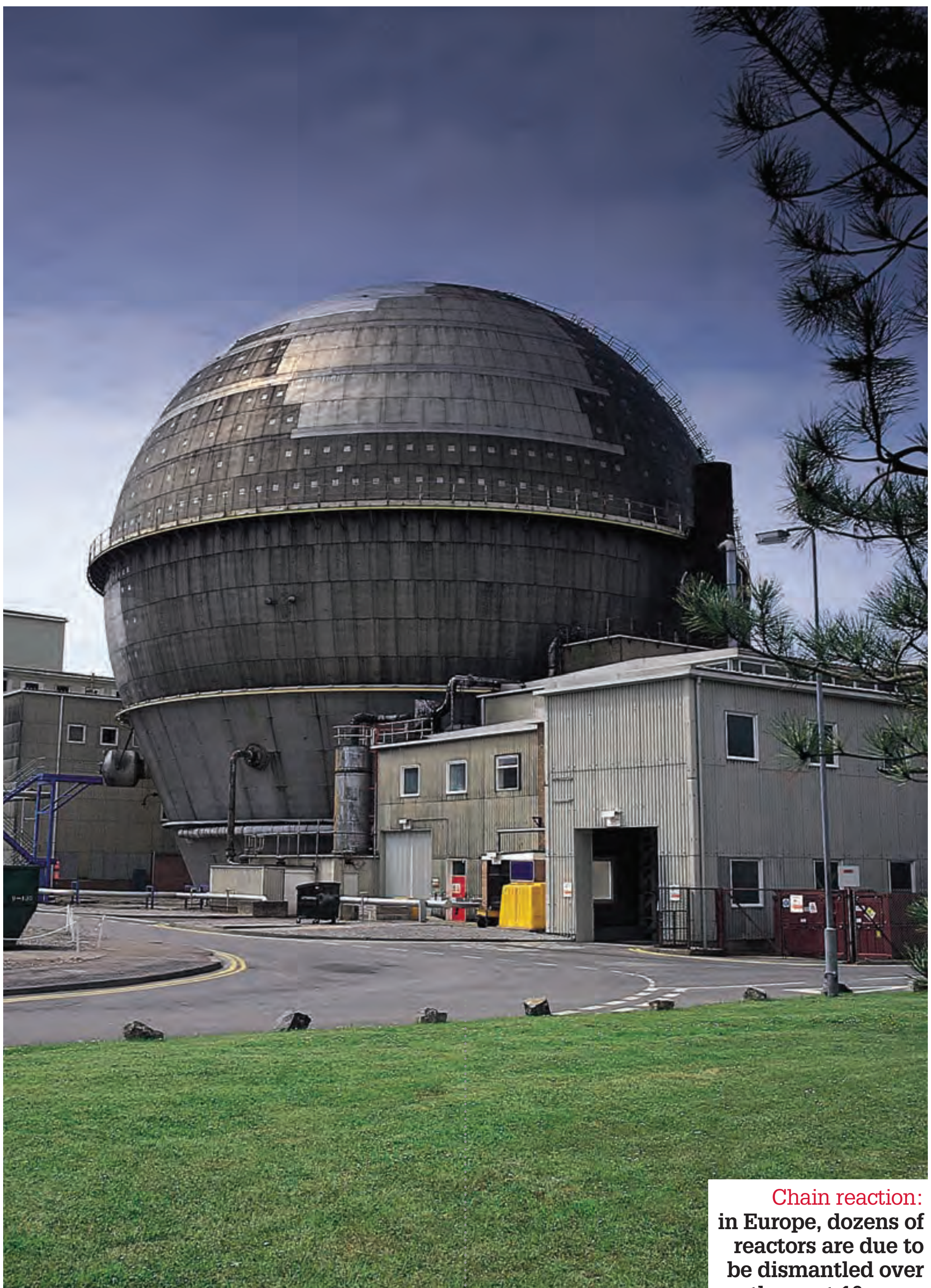
The engineering challenge will see groups of engineering students from across the UK competing for the change to win a prize of £5,003. The live task will challenge the students to design, build and test their inventions on the exhibition floor. This is a great way for graduates to get noticed by recruiters and challenge their team-working skills and technical knowledge.

With a number of exciting career prospects on offer from established industry experts, the NECR is an unmissable event for any ambitious job hunter. Hancock added: "The exhibition gives visitors the rare opportunity to gain first-hand, trustworthy advice from professionals. With hundreds of exciting jobs available, this really is a great way for anyone to get a step up onto the engineering and/or construction ladder."

A full list of recruiters, further information on features and details on parking and travel subsidies for full-time students are available at www.engineerjobs.co.uk.

Clean break for engineers

The decommissioning challenge will provide some exciting opportunities over the coming years. Helen Knight reports



Chain reaction: **in Europe, dozens of reactors are due to be dismantled over the next 10 years**

The world's nuclear reactors are showing their age. Almost 200 of the 434 nuclear reactors in operation worldwide are due to be retired by 2040, at a cost of more than \$100bn (£67bn), according to the International Energy Agency.

In Europe alone, dozens of reactors are expected to be dismantled within the next decade, with all but one of the UK's existing plants due to be closed down. A report published last year by Infiniti Research forecast that the nuclear decommissioning market in Europe would grow at a rate of 43.1 per cent between 2014 and 2018.

All of these reactors must be safely cleaned up and decommissioned, a huge global effort that was made yet more pressing by the Fukushima disaster in Japan in March 2011, after which countries such as Germany and Switzerland announced that they would be phasing out nuclear power altogether.

To add to the difficulties, only 10 reactors have been fully decommissioned so far, meaning considerable uncertainties remain about the total cost of the task ahead. In Germany, for example, there are concerns that the €36bn (£24bn) the utility companies have set aside to clean up the country's nuclear plants may not be enough, despite being the largest such sum in the world.

But of all the decommissioning projects planned or under way in Europe, none is more challenging than the task of cleaning up Sellafield.

Earlier this year, Stephen Lovegrove, permanent secretary at the Department of Energy & Climate Change, told MPs of the Public Accounts Committee that it will take 120 years to clean up and decommission Sellafield, which he described as the most complex nuclear site in Europe. It is expected to cost around £70bn to decommission all of the UK's nuclear sites, of which £53bn will be spent on Sellafield.

Sellafield has been operational since the 1940s, when it was established to produce nuclear material for the war effort, and later to meet civilian electricity demands. Some of the nuclear buildings at Sellafield that require dismantling are the oldest in Europe, while considerable amounts of hazardous waste are stored in ageing ponds and silos around the site.

More than 80 buildings have already been demolished, and some 150 decommissioning projects are under way, directly involving 2,000 employees. Engineers involved in these projects are working at the "extremes of engineering", according to Sellafield, and must find answers to complex technical problems.

Design engineers working at either Sellafield itself or at the company's facility in Risley near Warrington are pioneering new techniques to ensure the decontamination and demolition projects are completed safely.

Ian Belger, head of profession for electrical control and instrumentation (EC&I) at Sellafield, said that the company needs engineers who are excited by the challenge of working on projects of national importance. "Sellafield is doing a job on behalf of the whole of the UK," he said. "Collectively we're doing something that's vitally important." Design engineers at Sellafield or Risley could also be leading projects worth up to £250m, he added.

Extreme engineering: **150 decommissioning projects are currently under way**

Experience in the nuclear industry is not crucial, said Dave Stubbs, head of profession for mechanical design engineering at Sellafield. "We want to nurture a wide population of well-qualified, chartered engineers," he said.

The company is also looking for engineers capable of commissioning elements of its large decommissioning projects, each worth up to £300m. This work could involve anything from commissioning new encapsulation plants designed to process nuclear waste to significant new components to keep existing plants running, according to Roy Jones, head of profession for commissioning at Sellafield. "It's absolutely a chance to be part of something monumental," he said.

Sellafield is responsible for decommissioning the UK's nuclear legacy, as well as fuel recycling and the management of low-, high- and intermediate-level nuclear waste activities on behalf of the Nuclear Decommissioning Authority (NDA).

The NDA's estate now spends around £3.2bn annually on decommissioning projects. Ben Hough, team leader of the power and nuclear team at Matchtech, said engineers with specific decommissioning experience are always in demand. "There are a number of ongoing projects with the NDA that require support through natural attrition and peaks in project workloads," he said. "We are seeing a number of major projects requiring suitably qualified engineers, predominately in the north west, but also across the Magnox sites and at Dounreay, for example."

In particular, there is a high demand for EC&I engineers, safety case engineers, process and mechanical design engineers and radiological waste experts, Hough said.

This demand is likely to increase as the nuclear industry heads for a renaissance, with existing projects and new-build plants on the horizon, creating plenty of opportunities, he added.

However, this will also create a challenge for companies in the nuclear sector in attracting experienced engineers to manage and lead projects, and finding young talent to develop through their training schemes, while at the same time retaining their existing staff, Hough said. "Our recent annual Confidence Index survey of engineers in the power and nuclear sector found that two thirds of engineers say they would consider transferring to another industry in the engineering sector, with renewables and oil and gas the most popular industries."

Meanwhile a recent survey of companies and organisations involved in decommissioning by Nuclear Energy Insider found that 51.8 per cent viewed a lack of trained and experienced staff as the biggest challenge for the sector. This was closely followed by a lack of accurate cost estimations for decommissioning projects at 42.1 per cent.

As a result of these skills shortages, many companies in the nuclear industry looking to maintain their staffing levels may be hoping to target engineers from other sectors and train them internally, said Hough.

> **"Sellafield is doing a job on behalf of the whole of the UK. Collectively we're doing something that is vitally important**
> Ian Belger, Sellafield

Another area of uncertainty within the nuclear decommissioning field is the likely site of the proposed geological storage site for higher-activity radioactive waste. The government has yet to select a location for the underground site, which will be used to store extremely hazardous waste safely for millennia.

"While it would be ideal for the geological storage sites to be based near an existing nuclear area, it is not essential," said Hough. "The contract engineers in the market will move where the demands are."

Whatever the ultimate decision on the site of the storage facility, with more and more nuclear sites due to be cleaned up over the next decade, opportunities for engineers in the decommissioning sector look set to grow across the country.

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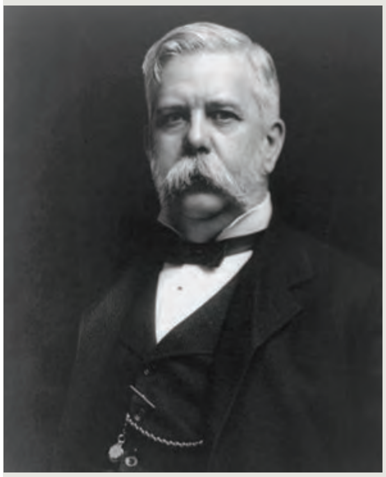
march1914

The Engineer pays homage to Westinghouse, focusing on his invention of the railway air brake

Our obituary of George Westinghouse doesn't mention the rivalry for which he's best known today.

One of the peculiarities of obituaries in archive editions of *The Engineer* is that they often don't cover what you might expect them to. We remember George Westinghouse as the father of alternating current, and for his 'war of the currents' with Thomas Edison, who was a proponent of direct current, believing it safer. It's a colourful story, taking in as it does the deliberate electrocution of an unfortunate elephant called Topsy (by Edison). But *The Engineer*'s lengthy obituary of Westinghouse doesn't mention rivalry with Edison once.



In fact, the bulk of the obituary is dedicated to one of Westinghouse's earlier inventions: the railway air brake. Westinghouse began to think about this when he was about 20, after he was delayed for two hours between his home in Schenectady, New York, and the Bessemmer Steel plant in Troy, New York, by the collision of two freight trains. "The loss of time and inconvenience arising from this accident suggested that if the drivers of the two trains had had some way of applying brakes to all the wheels the accident might never had happened," the obituary said.

While thinking of ways this might be achieved, Westinghouse read about the construction of the Mont Cenis Tunnel under the Alps. This was done using newly invented compressed-air drills, which quintupled the rate of progress the tunnellers had made using hand drills. At the time, Westinghouse had been experimenting unsuccessfully with powering his brake using steam, but he quickly switched to pneumatics, and filed a patent for his invention in 1867, when he was just 22.

" Westinghouse filed a patent for his invention in 1867, when he was just 22

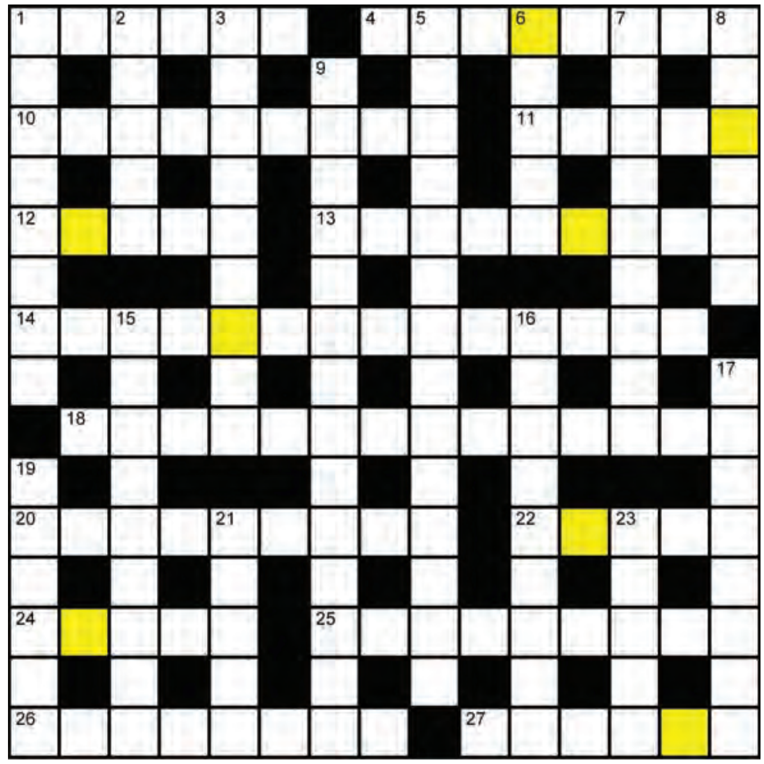
Characteristically, he then started a company to make and sell his brakes, and quickly made his first sale to the Pennsylvania and Panhandle Railroad. As it happens, in the first trial of the system, the driver used the brake to avoid hitting a horse on the track.

Things didn't go all his way, however. "One railway magnate of the time told him that anyone who proposed to stop a train by compressed air was nothing short of a fool. But Westinghouse was not a fool, and he had introduced a brake, which was, even in its then condition, vastly superior to anything that had been hitherto devised." ***SN***

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

prizecrossword

When completed rearrange the highlighted squares to spell out a natural alloy of gold and silver. The first correct answer received will win a £20 Amazon voucher. Email your answer to jon.excell@centaur.co.uk



ACROSS

1 Marked by abrupt transitions (6)
4 Large cooking vessel (8)
10 Without musical accompaniment (1,8)
11 English economist (5)
12 Muse of lyric and love poetry (5)
13 Ornamental inlaid veneers (9)
14 Contrast with equal weight or force (14)
18 Faces a difficulty head-on (5,3,6)
20 With the lower legs foremost (9)
22 Suffuse with colour (5)
24 Common black European thrush (5)
25 Income from capital investment (9)
26 Easily broken or damaged (8)
27 Causes to move forward with force (6)

DOWN

1 Mix together elements (8)
2 Industrial port city of Japan (5)
3 Glass container for drinks (3,6)
5 With a considerable degree (2,1,5,6)
6 Wales (5)
7 Concerned with actual use (9)
8 Colour knotted fabric (3-3)
9 Resistant to catching fire (5-9)
15 Adapted to various purposes (9)
16 Metal extracted from bauxite (9)
17 Forces that produce strain on a physical body (8)
19 Be able to spare (6)
21 Acid that makes up B vitamin (5)
23 Water containing salts (5)

Last issue's highlighted solution was HAEMATITE.
The winner is Robert Burns.

origineering

Anthony Poulton-Smith explores the origins of everyday engineering terms

Machine existed centuries before the Industrial Revolution. While we associate the word with metal, both the watermill and the ballista are machines, albeit wooden ones. The Greeks were using water-driven machines in the third century BC, while the weapon associated with the Romans had been used by the Greeks in the fourth century BC.

The first evidence of 'machine' in English dates from the 16th century. Coming to our shores from French, it was used to mean 'structure', even though the French sense was 'contrivance'. These, and Spanish 'maquina', Italian 'macchina' and Latin 'machine' are all traceable back to the Greek 'makhana'. The term came from 'mekhos', an existing word used in the sense 'means, expedient, contrivance'.

Yet the trail does not end 2,500 years ago. Usage can be discovered more than twice as long ago in the language known as Proto-Indo-European, which gave us 'maghana' or 'that which enables' and has its own root in 'magh': 'to have power'. This was also seen in Old English 'maeg', meaning 'I can' and is still in use today when we say 'I may'.