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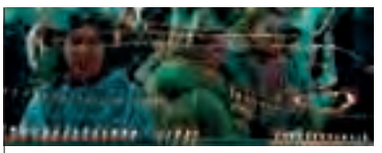

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this**issue**

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Deeply fascinating

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The incredible vessel at the heart of this effort has already ticked off its first two targets and is expected to complete the remaining dives over the course of the next few months. This will include a trip to the deepest known point of the Earth's seabed: Challenger Deep in the Pacific Ocean's Mariana Trench.

The project is bankrolled by millionaire US investor Victor Vescovo (who is also piloting the sub). But, as we report in this issue's cover story (p26), this is much more than a rich man's 'hero dive'. It has pushed out the boundaries of deep-sea engineering, and is expected to significantly advance our knowledge of the deep-sea environment, potentially even helping us understand how life evolved on our planet.

> "It has pushed out the boundaries of deep-sea engineering"

In an age when we tend to rely on robots to probe our most challenging frontiers, it's also a refreshing reminder that having a person in the loop – with all the risk and derring-do that entails – has the potential to inspire in a way that unmanned technologies simply don't.

Sticking to the inspiration theme, this issue also features an in-depth report on This is Engineering Engagement (p34), a recent event held at the Royal Academy of Engineering which brought together some of the UK's leading STEM practitioners to discuss the challenges of engaging and inspiring the next generation of engineers.

As industry often tell us, it can be difficult to know where to start with STEM. The landscape is bewilderingly fragmented, with as many as 600 different initiatives trying to do their bit with varying degrees of success, and many still relying on the somewhat old-fashioned notion that all it takes to attract kids to engineering is a few explosions.

As delegates heard, it's only by taking a more thoughtful approach to the problem that we will really begin to shift the dial. And while that may not grab the headlines, it's a challenge every bit as complex and daunting as landing a submarine on the bottom of the ocean.

Jon Excell Editor
jon.excell@centaurmedia.com

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

Direct dial 020 7970 followed by extension listed Advertising fax 020 7970 4190 **Editor** Jon Excell (4437) jon.excell@centaurmedia.com **Features editor** Stuart Nathan (4125) stuart.nathan@centaurmedia.com **Senior reporter** Andrew Wade (4893) andrew.wade@centaurmedia.com **News editor** Jason Ford (4442) jason.ford@centaurmedia.com **Commercial director** Justyn Gidley (4942) justyn.gidley@centaurmedia.com **Business development manager** Paul Tilston (4487) **Account Manager & recruitment advertising manager** Lindsay Smith (4811) **Production** Wendy Goodbun (4807) te.production@centaurmedia.com, Gillian Maher, Tim Walker, Press Association **Publisher** Simon Lodge (4849) simon.lodge@centaurmedia.com **Subscriptions & Customer Services** tecirc@centaurmedia.com

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RAIL

Project aims to get real-time damage detection on track

Monitoring system to harness energy from vibrations caused by trains HELEN KNIGHT REPORTS

Repairing the railway tracks

The UK's rail passengers make 1.7 billion train journeys a year, while 400,000 tonnes of freight are transported over the network every day. Delays and disruption to the network as a result of failures and unplanned maintenance work can have a significant impact on the economy.

Detecting damage to the track in real time, before it is able to propagate, is therefore vitally important to ensure the smooth running of the network.

To this end, researchers at the Universities of Exeter and Birmingham are working with Network Rail on an EPSRC-funded project to develop a self-powered, wide-area, track condition monitoring system for the railways.

The system, which will harvest energy from vibration caused by trains passing, will dramatically improve maintenance efficiencies, and reduce the cost of managing the UK's railway infrastructure, according to project leader Professor Meiling Zhu, chair of mechanical engineering at the University of Exeter.

"All over the world, countries have vast railway tracks, which people have to be sent out to inspect when there is a problem," said Zhu. "Alternatively, there are trains equipped with monitoring technology, but these can only spot problems when they are passing over that section of track."

Sensors embedded into the track itself would allow operators to predict faults forming anywhere on the network before they became a problem, she said.

Since the system will not need mains power or batteries for its energy supply, it will eliminate the cost of cabling and battery replacement, Zhu added.

"If you are powered by the mains, then you need to run a wire to connect with the power line, and every cable adds cost, as well as maintenance issues, so we need to get rid of this wire," she said. "On the other hand, if you introduce a battery, then that battery will have a very limited life, even though the technology has improved recently."

So instead, the researchers decided to harvest locally available energy to power the system. Since solar energy is not always available, the team chose to use piezoelectric devices that convert energy from vibrations on the track into electricity, she said.

"Vibration energy has been researched in the UK for more than 10 years now, but it hasn't yet been specifically tailored for rail track monitoring," said Zhu. "We will work with Network Rail to understand its specifications and requirements, and develop bespoke energy harvesting-powered, wireless communication sensing technology."

The system will consist of accelerometers, strain gauges, and acoustic emission sensors, which will measure track deflection, vibration and interactions between the rail and train wheels.

The embedded sensors will be wirelessly connected to an operation and management centre, equipped with automated data-processing software designed to detect signs of damage to the track.

Covering an area as vast as a national rail network with a wireless sensor network will be a significant challenge, said Zhu.

"At the moment, most people are studying short-range wireless communication sensor networks, which only cover a few hundred metres, but the railway track in many countries is thousands of kilometres long, so the network will need to be able to cover a large area," she said.

The project partners include three divisions from Network Rail: Track Renewals, based in Birmingham; Infrastructure Projects; and Telecom, both based in Milton Keynes. The project also includes Quattro and Swiss Approval. ■

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AEROSPACE

High-G training in the cockpit

New centrifuge adds realism

HELEN KNIGHT REPORTS

Military aircraft pilots will be able to "fly" a virtual fast jet while experiencing high levels of G-force, thanks to a new training centrifuge.

The £44m high-G training facility, built for the Ministry of Defence by Thales UK alongside Austrian centrifuge specialist AMST, will allow RAF and Royal Navy pilots to experience up to 9G – nine times the normal gravitational pull of the Earth.

But unlike the 1950s-built training centrifuge it replaces, the new system is also equipped with a virtual cockpit that will allow pilots to learn how to use their specialist flying equipment to cope with the stresses of high G-forces.

The system, located at RAF Cranwell in Lincolnshire, is designed to replicate flight in jets such as the Hawk, Typhoon and new F-35 Lightning aircraft.

The onset of high-G is a significant issue for combat aircraft, according to Stephen McCann, VP for avionics at Thales UK. "Previously, pilots would have just gone round and round (in the centrifuge), experiencing the G, which is not as effective as it could be from a training perspective," said McCann. "With this new device, they will experience cockpits that are very close to the real thing," he said.

The facility, which was officially opened by Air Chief Marshal Sir Stephen Hillier on 4 February, will allow pilots to carry out a range of training scenarios, including air-to-air combat and in-bound missile threats.

The 39-tonne centrifuge can accelerate up to 9G in just one second, and rotate at up to 34 times per minute. It will also be used to test new equipment, such as helmets and other safety equipment for air crew, before they are trialled in live flight.

The device features a single 7.5m arm, on the end of which is a gondola that has the power to provide dynamic G performance.

The new facility will be used by fast-jet pilots progressing through the UK Military Flying Training System and into their flying careers. Pilots will refresh their training at least every five years to keep them up to date with the techniques used to handle high G-forces in flight.

"The equipment was designed to give the RAF the highest safety capability for aircrew," said McCann.

The first trainees began using the system in December.

The RAF Centre of Aviation Medicine is using the facility to train aircrew to recognise the effects of G-force, develop awareness of it and learn the physical techniques needed to counter the effects on their bodies during combat missions. Up to 300 aircrew will receive training on the centrifuge each year. ■

The new training centrifuge

Image: Thales UK

EVENTS

Subcon opens for registration

Subcon, the UK's premier subcontract manufacturing supply chain show, has opened for registration. The event will be held 4-6 June at the NEC and will help engineering and manufacturing businesses forge new partnerships, drive down costs down, improve productivity and tackle the challenges of a tumultuous economy.

Visitors will be able to view new innovations from over 300 world-class suppliers. Confirmed exhibitors include Faro, Lucy Castings, UKF Group, Grenville Engineering, Metpro and Continental Automotive.

New for 2019 are Subcon Launchpad and Launchpad Awards. This will feature eight of the UK's hottest engineering and manufacturing start-ups, showcasing cutting-edge innovation, each of whom will receive a free stand at the show and be entered into the inaugural awards.

Subcon is co-located with The Engineer Expo and the Advanced Manufacturing Show, which will feature on-stand demonstrations of innovative new solutions. The Engineer Conference – which runs alongside all three events – will deliver insight on industry issues, with presentations from industry leaders responsible for some of the UK's most inspiring and ground-breaking engineering and manufacturing projects.

"This year, amidst challenging economic headwinds, we are dedicated to helping UK engineering and manufacturing businesses harness innovation, forge new partnerships and shape their future business strategies," said Subcon event director Gordon Kirk.

For further details and to register for this must-attend event, please visit www.subconshow.co.uk. ■

Newsinbrief

Honda plant to close

Japanese car maker Honda has confirmed plans to close its Swindon car plant in 2021. The plant, Honda's only EU-based manufacturing facility, builds around 150,000 cars per year and employs 3,500 people. Honda's Turkey factory will also close as all European market production is consolidated to Japan, where the company is based. The Unite union described the latest news as a "shattering body blow" for UK manufacturing.

Merger derailed by EU

The mobility businesses of Siemens and Alstom will no longer merge after the European Commission blocked the move. The deal would have removed a "very strong" signalling systems competitor from several mainline and urban signalling markets. Similarly, for very high-speed rolling stock, the transaction would have reduced the number of suppliers by removing one of the two largest manufacturers of this type of trains in the EEA.

Tornados return home

The RAF's fleet of Tornado fighters has returned to the UK from combat operations for the final time, with the jets due to be officially retired at the end of March. The Panavia Tornado was a pan-European collaboration between the UK, Italy and West Germany. Having first entered service with the RAF in 1979, the Tornado has enjoyed a career spanning almost 40 years.

Driverless car doubts

Almost half (48 per cent) of the nation has doubts about the roll-out of driverless cars, with a lack of trust in the technology and a fear of not having control over their own vehicle cited as the key concerns. The findings from Moneysupermarket.com found more acceptance for driverless cars among 25-34-year-olds, with 49 per cent indicating approval, compared with 18 per cent of over-55s.

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TRANSPORT

Cool tech to make electric cars lighter

Fibre-reinforced polymers could make vehicles' motors more efficient

HELEN KNIGHT REPORTS

Lighter, more efficient electric vehicles could be made possible by the development of a new cooling technology that allows motors to be built from fibre-reinforced polymer materials.

Researchers at the Fraunhofer Institute for Chemical Technology (ICT) in Pfinztal, Germany, have developed the concept, which increases the power density of the motor compared with existing designs. Although around 90 per cent of the electrical energy in a motor is converted into mechanical energy, the remainder is lost as heat from the copper windings within the stator.

To cool the motor down, this heat is typically conducted through metal housing to an outer sleeve containing cold water, according to Robert Maertens, a researcher at Fraunhofer ICT. However, since plastic does not conduct heat as well as metal, such a design would not be possible with a housing made of polymer materials, he said.

So instead, working with the Karlsruhe Institute of Technology, the researchers have replaced the round wire typically used for the windings with a rectangular flat wire that can be wound more tightly around the stator. This creates space for a cooling channel next to the windings themselves, he said.

"In this way, the heat that is generated in the windings only has to be conducted for a very short distance of less than 1mm through the polymer," said Maertens.

"For this reason we can use polymer materials because we are taking the heat away very close to where it is generated."

The resulting motor is lighter than existing devices, with a power-to-weight ratio of around 5kW/kg, compared with around 1.5kw/kg for conventional motors, he said.

> "We are taking the heat away very close to where it is generated"
>
> Robert Maertens

What's more, since a much smaller amount of material is being heated within the new design, it means that the motor has lower thermal inertia as a result, said Maertens.

"You can heat up a motor – for example, by accelerating very quickly – once or twice, but then, since this big mass of metal is now hot, on the third attempt your motor will likely have to throttle down, because it will be getting too warm," he said.

This is much less of a problem in the new design, meaning the motor has a higher continuous power output, he said. ■

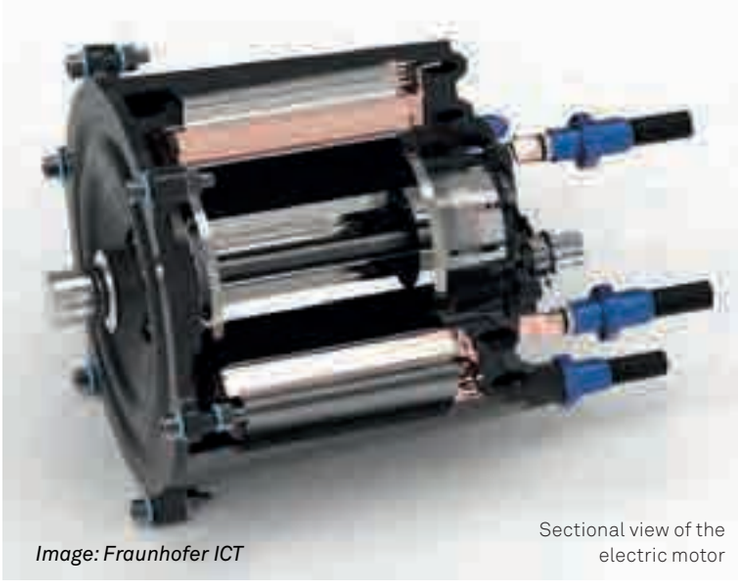

Image: Fraunhofer ICT

Sectional view of the electric motor

ENERGY

Energy-harvesting flags use wind and solar to power remote devices

Potential boost for 'deploy and forget' sensors

Researchers at Manchester University have created energy-harvesting flags that generate electricity using wind and solar power, an advance that could boost the use of remote 'deploy and forget' sensors.

The flags have been developed using flexible piezoelectric strips that generate power through movement, and flexible photovoltaic cells. As well as remote sensors, the flags can power small-scale electronics that can be used for environmental sensing.

The aim of the study is to allow cheap and sustainable solutions that can be deployed and left to generate energy with little or no need for maintenance. This strategy is the anticipated model that so-called 'smart cities' will adopt when using remote sensors.

The developed harvesters were tested in wind speeds varying from 0m/s (calm) to about 26m/s (storm/whole gale) and 1.8kLux constant light exposure, simulating a range of environmental variables. Total power outputs of up to 3-4mW were generated. JF

AEROSPACE

Solar drone to map the Earth

OS has high hopes for pseudo-satellite

JASON FORD REPORTS

Ordnance Survey (OS) is working with aeronautic engineers to develop Astigan, a solar-powered, High Altitude Pseudo-Satellite (HAPS) that will fly at 67,000ft to acquire images of Earth.

With a wingspan of 38m and weighing 149kg (including a payload of up to 25kg), the aircraft will be positioned to view any part of the Earth and collect data for 90 days at a time over wider areas compared with conventional aerial imagery capture. It will fly a pre-determined route or remain above one position.

Astigan Ltd was established in 2014 by OS and private investors to develop Britain's first commercial, sub-orbital, Earth observation HAPS.

Brian Jones, Astigan managing director, said: "By the end of 2019 we aim to be completing endurance flight testing, building up to 90 days non-stop."

OS said Astigan will have the potential to work alongside existing mapping capabilities to improve the speed, accuracy and cost involved in mapping a country. It could also provide environmental monitoring; as well as early warning, observation and communications over natural disasters; and support global land management and urbanisation challenges.

Neil Ackroyd, a co-founding director of Astigan and acting CEO of Ordnance Survey, said: "Astigan supports Ordnance Survey in enhancing its capabilities to work in partnership with other nations across the globe. By aligning this capability with our geospatial production and mapping expertise, we hope to support organisations and countries in tackling major societal challenges." ■

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Hexadrone's Tundra-M drone : 3D printed functional prototype in Windform composite materials - *Courtesy of Hexadrone*

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RAIL

Vivarail plans test for hydrogen train

Move part of push to get emission-free engines on to rail network

HELEN KNIGHT REPORTS

A hydrogen train that does not produce greenhouse gas emissions is set to be tested in the UK.

Vivarail is developing a modular hydrogen train consisting of fuel cells, tanks and two lithium ion batteries.

The test train is due to begin operating on the company's track by the end of 2019, according to Vivarail's Alice Gillman.

"We're expecting that by the end of the year, we'll be clocking up the miles and gauging its performance," said Gillman.

The train will be made up of two driving motor cars powered by the batteries, developed by German specialist Hoppecke, and two carriages housing the fuel cells and hydrogen tanks.

The Vivarail Class 230s will store the fuel cells and tanks in a robust casing beneath the floor, meaning there will be no reduction in space for passenger seating.

The train, which has a range of 650 miles, also uses regenerative braking to recover energy as it slows.

The vehicle's modular design means that trains fitted with diesel generators could ultimately be converted into hydrogen vehicles, said Gillman.

"Because of the way we have built our trains, they can all be modified, even if they start off as a diesel train," she said. "So the potential is that the trains we have sold as diesel units or diesel-battery hybrid units can at some point then be converted to run on hydrogen, which is part of our push to get emission-free trains out on to the network."

The Government is aiming to phase out diesel-only trains altogether by 2040. The Department for Transport recently announced £1.75m in funding to be shared between five projects designed to cut the carbon footprint of the UK's railways.

In October last year, Vivarail also launched a battery-powered train to carry passengers on the Bo'ness and Kinneil Railway in Scotland. The two-car unit can be split and used to develop and test next-generation train designs, with cars using different power sources charging the batteries on the driving cars.

Vivarail is now building a fleet of diesel/battery hybrids to operate the Wrexham-Bidston line for Transport for Wales, where the diesel generators will charge the batteries, rather than powering the train. ■

The hydrogen train could be tested this year

ENERGY

Drax bioenergy carbon capture pilot yields promising results

Power station could go 'negative-emissions'

Drax Power Station's bioenergy carbon capture and storage (BECCS) pilot has sequestered its first carbon dioxide, in what the company claims is a world first.

Developed in partnership with Leeds-based C-Capture, the demonstration unit will gather just one ton of CO_2 per day.

If scaled up, however, the technology could potentially be used to help decarbonise the energy sector, with Drax claiming it could become the world's first negative-emissions power station.

"Proving that this innovative carbon capture technology works is an exciting development and another important milestone in our BECCS project," said Drax Group CEO Will Gardiner. "Climate change affects us all, so this is of real significance – not just for us at Drax, but also for the UK and the rest of the world.

"The successful deployment of BECCS requires us to identify ways in which the carbon dioxide we're now capturing can be stored or used in other processes, and we're working with the government and other businesses on that." AW

AWARDS

£1m prize goes to GPS inventors

Four men 'rewrote the world's infrastructure'

JON EXCELL REPORTS

The pioneering US engineers behind the development of GPS (the first global satellite-based positioning system) have won the 2019 Queen Elizabeth Prize for Engineering.

Announcing the winners of the prestigious £1m award, Lord Browne of Madingley, chairman of the Queen Elizabeth Prize for Engineering Foundation, said the four men had "rewritten, in a major way, the infrastructure of our world".

Receiving the award, the programme director and so-called "father of GPS", Dr Bradford Parkinson, said that despite the technology's origins in the defence sector it was always envisaged that it would have a positive effect in the wider civilian world. "One of the most important things we had when the project started was a vision of world impact.

"Without that inspiration, it would have been difficult for us to weather the storms of doing something for the first time," he said, adding that, while he and his colleagues couldn't have foreseen the full impact of the technology, early applications they envisaged included car navigation systems and air traffic control.

The three other members of the team were Prof James Spilker, who designed the satellite broadcast signal, plus the first receiver to process the GPS satellite signals; Hugo Fruehauf, who as chief engineer of Rockwell Industries led the development of the miniaturised atomic clocks at the heart of the GPS satellites; and Richard Schwartz, programme manager at Rockwell, who developed the satellites. ■

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TRANSPORT

Subterranean roads solution

Carriageways built in deep channels could relieve congestion and pollution HELEN KNIGHT REPORTS

Researchers at Nottingham University have developed a concept to alleviate environmental and traffic problems associated with the greater use of vehicles, based on a network of subterranean roads.

Unlike tunnels, which can be difficult and expensive to build, particularly over large distances, the idea would be to dig channels within the ground, several metres in depth, according to Prof Saffa Riffat, chair in sustainable energy at Nottingham's faculty of engineering, who has developed the idea alongside research fellow Prof Yijun Yuan, a specialist in mining engineering and sustainable energy.

The professors have also recently unveiled proposals to build underground farms within the disused tunnels of depleted mines, as well as deep sea farms within floating containers, and deep farms within shafts dug into the sand in desert regions.

"Compared to building tunnels, it would be much easier to create a channel in the ground and put a prefabricated surface road on top, allowing you to have twice the area for vehicles to travel on," said Riffat. Deep roads would not be as heavily affected by weather conditions such as snow, ice, wind and rain, increasing safety and allowing cars to maintain a steady speed, improving their fuel efficiency.

The surface road above could be limited to lightweight, environmentally friendly forms of transportation, such as bicycles and electric vehicles, while petrol or hybrid cars could travel within the channel, said Riffat.

This could increase safety for pedestrians and cyclists, and reduce noise pollution in urban areas.

"It would also mean we could capture the pollutants from these vehicles, because you can't easily capture pollutants once they're in the atmosphere, but you can capture them from a sealed environment quite easily, using ducts," he said.

The captured carbon dioxide could then be used in intensive farming, he added.

In hotter environments, evaporative cooling could be used to maintain a steady temperature within the deep roads.

A closed water system would pump over the tunnel cover and then flow back into the road walls, which would be covered in a hydrophilic surface.

The deep road system could also include shafts designed for car parking, as well as bicycle and water storage, said Riffat. ■

Congestion could be alleviated by subterranean roads

PHYSICS

Observatories upgraded

International cash boost for facilities studying gravitational waves and black holes

The observatories that made the first detection of gravitational waves are to be upgraded thanks to funding from the UK, United States and Australia.

The upgraded facility, known as Advanced LIGO Plus (ALIGO+), will probe the origins and evolution of black holes and help scientists learn about extreme physics from the first seconds after the universe's birth.

The project will improve the two existing Laser Interferometer Gravitational wave Observatories (LIGO) in the US, and will see a new facility built in India.

The Nobel-prize winning LIGO project confirmed the existence of gravitational waves, which are ripples in space caused by massive cosmic events such as the collision of black holes or the explosion of supernovae.

In the UK, the ALIGO+ project will involve the Universities of Glasgow, Birmingham, Cardiff, Strathclyde and STFC's Rutherford Appleton Laboratory.

The UK is also supporting the construction of a third LIGO detector in India. British funding amounts to £10.7m from UK Research and Innovation. **JE**

MATERIALS

Metamaterials may make waves in optical and acoustic fields

STUART NATHAN REPORTS

Manipulating the surface structure of an engineered metamaterial allows the direction and shape of reflected waves to be tailored for optical and acoustic applications.

Metamaterials, structures which do not interact with waves in the same way as conventional matter, have been used to bend light in such a way that they can render objects invisible and manipulate sound to produce acoustic illusions.

They work because of their surfaces, which generally feature patterns with repeating structures smaller than the length of the wave with which they are designed to interact. The discovery by engineers at Aalto University, Finland, allows surfaces to be designed that will reflect waves in any direction or split the reflection so that waves travel in different directions. They can also change the shape of the wave and may have applications in optical computing and acoustic engineering.

In a paper in *Science Advances*, Ana Diaz-Rubio, of Aalto's Department of Electronics and Nano-engineering, along with collaborators from Duke University, North Carolina, explained how they designed "metasurfaces" using mathematical techniques to model the structures that would affect incident waves.

"Not only did we figure out a way to design efficient metasurfaces, we can also adapt the design for different functionalities," said Diaz-Rubio.

The team used finite element analysis tool COMSOL Multiphysics to design the metasurfaces' structure. They then translated their calculations by 3D printing acrylonitrile butadiene styrene plastic with a density of 1180kg/m³, testing the technique using acoustic waves and analysing their reflection. ■

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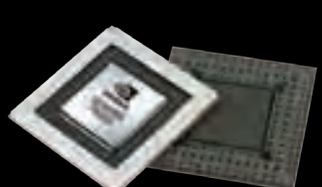

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ENERGY

Detector to track nuclear particles

WATCHMAN instrument in North Yorkshire to monitor antineutrinos at plants JASON FORD REPORTS

Europe's deepest operating mine is to host an instrument being developed to monitor nuclear plants more remotely and help reveal the origins of the universe.

Set to be built 1.1km underground at the ICL Boulby mine in North Yorkshire, the 6,500 tonne WATCHMAN detector will measure antineutrinos – harmless sub-atomic particles emanating from sources that include nuclear power stations.

The Anglo-US project was awarded £9.7m from UKRI's new Fund for International Collaboration in January and is expected to be operational from 2022.

If successful, the Advanced Instrumentation Testbed (AIT)-WATCHMAN project could lead to a scaled-up instrument designed to improve global security by tracking nuclear-weapons-grade materials.

Project partners at Lawrence Livermore National Laboratory (LLNL) in California said the depth of AIT-WATCHMAN meant that naturally occurring cosmic ray particles – which continuously bombard the Earth's surface – were reduced in rate by several orders of magnitude, removing a background that would otherwise interfere with the antineutrino signal of interest from Hartlepool nuclear power station (pictured below), some 25km away.

WATCHMAN (WATer CHerenkov Monitor of ANtineutrinos) is expected to consist of approximately 5,000 tonnes of highly purified water doped with trace amounts of gadolinium, a neutron-capture agent expected to enhance its sensitivity to antineutrinos.

Project director Dr Adam Bernstein, from LLNL, said: "The ICL Boulby site for AIT, with its proximity to an existing reactor complex, is the ideal location for our experiment. WATCHMAN and AIT give the physics and non-proliferation communities a rare opportunity to work together to harness neutrino detection for the practical purpose of non-intrusively monitoring nuclear reactors."

Created by the sun and other stars, neutrinos are among the most difficult fundamental particles to study, as they carry no electrical charge and rarely interact with ordinary matter. Studying the properties of neutrinos and antineutrinos is an important component of wider physics research into the origins of the universe.

> "The site is the ideal location for our experiment"

A scaled version of WATCHMAN would join a small number of large, high-sensitivity astrophysics research detectors to detect neutrino emissions from nearby supernovae.

Sheffield University's Dr Matthew Malek, principal investigator for the UK, said: "[AIT-WATCHMAN] enables us to learn more about the universe on so many levels, while also supporting an innovative programme of non-proliferation." ■

Image: EDF

MEDICAL

'E-skin' can power prosthetic hand

Energy-dense, wearable solar-powered device can deliver up to 2.5V

Engineers at Glasgow University have developed a flexible and wearable solar-powered supercapacitor capable of powering the motors in a prosthetic hand.

Made from a graphene–graphite polyurethane (GPU) composite, the supercapacitor harvests energy from integrated flexible photovoltaic cells. The 'e-skin' device can deliver up to 2.5V, making it significantly more powerful than similar wearable energy storage devices.

The Glasgow team developed a ratio of graphite to polyurethane that provides a relatively large, electroactive surface area where power-generating chemical reactions can take place. The result is an energy-dense supercapacitor which can be charged and discharged quickly. During lab tests, the device was cycled 15,000 times with no significant loss in performance.

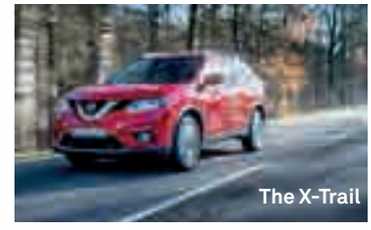
As well as powering the high-torque motors in a prosthetic hand, the supercapacitor was also capable of operating a string of 84 LEDs for more than a minute.

"There's huge potential for devices such as prosthetics… which incorporate this technology," said Ravinder Dahiya, professor of electronics and nanoengineering at Glasgow. AW

AUTOMOTIVE

Fears for jobs after Nissan's X-Trail move

Company will produce model in Japan, not Sunderland JON EXCELL REPORTS



The X-Trail

Nissan's next-generation X-Trail for the European market will be produced in Japan and not Sunderland, as announced in 2016.

While a number of factors are thought to be behind the decision, not least the slump in diesel sales, Nissan Europe chairman Gianluca de Ficchy said that the UK's impending exit from the EU was also a factor. "The uncertainty around the UK's future relationship with the EU is not helping companies like ours to plan," he said.

Nissan had previously pledged to produce the model at its Sunderland plant following assurances from the UK government, a decision hailed at the time by prime minister Theresa May as a "vote of confidence [that] shows Britain is open for business and that we remain an outward-looking, world-leading nation".

While the company claims that existing production and the almost 7,000 jobs at the plant are safe, the decision to cancel production of the X-Trail – expected to create hundreds of jobs – has caused concern.

"We remain seriously concerned that the apprenticeships and additional jobs that come with future investment will be lost," said Steve Bush, of union Unite.

Julie Elliott, the Labour MP for Sunderland Central, described the decision as "devastating news" .

Nissan's decision follows December's ratification of a free-trade deal between the EU and Japan, which has contributed to concerns that Japanese firms will reconsider their investments in the UK once it leaves the European Union. ■

pacer
A Solid State Group Company

Expansion of High Tech Facility solves Optoelectronics Manufacturing Headaches for UK OEMs

Finding expert resources for niche optoelectronic design and assembly is challenging, as there are very few companies in the UK with the right skills and experience to tackle such demanding requirements. UK-based Pacer International is well positioned to offer OEMs a cost-effective outsourcing option for projects involving photonics, optics, sensing or displays.

Further expansion of their state-of-the-art design and production engineering facility in Dorset now enables Pacer to offer even better engineering services. With a proven track record in providing the quality and reliability needed for military, medical and scientific applications, Pacer's team can address the design and pre-production of modules, assemblies or complete systems.

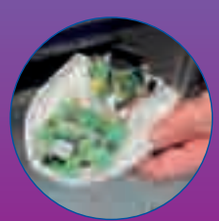
Pacer's team benefits from over 40 years of die attach and wire bond experience, and the new addition of this technology at the company's Weymouth site greatly enhances their manufacturing capability. The skills and experience of Pacer staff add real value to projects – working closely with customers, Pacer's engineers frequently advise on product and manufacturing enhancements which result in better yields, higher performance, increased reliability – and in many cases, reduced project costs.

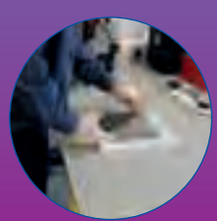
Extensive expertise in production engineering and Design For Manufacture (DFM) enables the smooth transfer of products from research and development prototypes into real life production. The multi-disciplinary team in Weymouth offers electronic, optical and mechanical design capability, and can address a wide variety of projects – from assembly and test of a simple optical switch, the alignment of boresight optics over long distances, touchscreen calibration or display alignment, through to full design and production of complex analysers and illuminators.

The recent expansion of Pacer's ISO14644-1 class 7 cleanroom enables the manufacture of complex optoelectronic assemblies involving extremely precise alignment of optical components and lenses to very tight tolerances. Pacer has developed a world-wide network of strategic manufacturing partners, offering high quality, competitive manufacturing solutions with ISO 9001-2000, QS9000, ISO/TS16949 and ISO 13485 approval.

Capability and Equipment

- ISO14644-1 class 7 70m^2 cleanroom
- Precision optical assembly - active and passive alignment
- Automated wire bond and die attach
- Subassembly and module design and production
- Box build – complete fully tested products, injection moulding facility, direct shipments
- Hi-rel device screening, characterisation and burn-in
- Custom display and touchscreen assemblies
- Technical and commercial project management





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Industry X.0: Ready your business for the digital reinvention of industry

Ben Salama, UKI Industry X.0 Lead, Accenture Managing Director and Yen-Sze Soon, UKI Industry X.0 Delivery Lead, Accenture Managing Director

Almost every day, it seems a new technology emerges with the potential to disrupt the way businesses design, manufacture, distribute and market their goods. From the Internet of Things to AI-enabled automation, 3D printing to augmented reality, the innovations keep coming thick and fast. And industrial businesses are trying to adapt to this changing landscape as best they can by investing in testing, assessing, and rolling out new technologies to ensure they remain competitive.

But how effective are these investments? Are companies getting everything they hoped for? Are they able to balance investments in growth with those in efficiency? It seems not. In a recent Accenture survey of business executives, only 13 per cent said their companies are getting both cost saving efficiencies and new growth from their investments in digital technologies.

Better coordinating investments

Why is this happening? We believe the answer lies in the way companies invest in technology. By and large, businesses have invested in a piecemeal way. As a result, the benefits of a given technology are only flowing to one part of the organisation. So, for example, a B2B manufacturer may well have invested in robotic applications to automate its production lines, but still be carrying out marketing and sales in a traditional "analogue" way. It's like coming off a motorway: as soon as you hit that analogue slip road your supply chain inevitably slows.

If digital technologies are to live up to their promise of higher efficiency and new growth, what's needed is coordination and combination: a wide variety of customer-oriented, seamlessly connected technologies that enable an end-to-end digital supply chain from design to post-market. This is something different to "Industry 4.0" or the "Fourth Industrial Revolution": Accenture calls it "Industry X.0" and it's a framework for ensuring a business can rapidly absorb all future technological disruption, and benefit from change as soon as possible.

Building a diverse future workforce

Industry X.0 goes deeper than just manufacturing; it spans all core business operations, from product and service design to engineering, and production. Advances in these operations through the application of intelligent technology are interfacing with human ingenuity and creating a new kind of industrial workforce altogether – one that promises previously unobtainable sources of growth, value and innovation. In fact, Accenture estimates that the new era of human-machine collaboration could boost business revenues by as much as 38 per cent over the next five years.

Up to now, machines and applications have often existed in parallel to the human workforce – present but isolated in their automated efficiency. AI changes all that. By enabling systems that can sense, communicate, interpret, and learn, AI shifts the question beyond "automation" to one of elevating the entire workforce – human and machine alike – to new heights of performance.

Traditional jobs will change. Machines remove people's physical limitations, and heavy industrial work that has, until now, been more suited to strong, able-bodied individuals can now be carried out by robots managed by people of any physical ability.

Take one example: auto manufacturers using robots in their factories to do the most labour-intensive work, freeing up people on the production line to do tasks where human intelligence and creativity can make a big difference (vehicle inspections, for example).

This is the new reality. Almost three in four business leaders say they plan to use AI to automate tasks to a large extent over the next three years. More interestingly, virtually all (97 per cent) say they plan to use the technology to enhance their workforce capabilities. Just consider some of the ways this will reimagine our understanding of what "work" is and how we do it.

As with all previous industrial revolutions, new jobs will be created. And opportunities will arise for them to be done by anyone – before they're claimed by any particular type of person (and stereotyped as such).

Oil companies will use AI to guide their technicians as they pinpoint new deposits. Pharmaceutical companies will be able to accelerate phenotypic screening in drug discovery. Aerospace engineers will use generative design to mimic nature's evolutionary approach to find optimal design configurations. And logistics businesses will transform the role of their drivers, promoting them to "in-cab systems managers" who perform high-level analysis as the truck controls basic functions like braking and acceleration.

And that's just a taste of what's to come. It's all part of pivoting a diverse workforce towards the activities that create new kinds of value for the business. This pivot needs to be considered and deliberate, emphasising mindset as much as operating model, and upskilling employees in the capabilities needed for long-term competitive advantage.

The intelligent Industry X.0 enterprise is already here

A perfect example of an Industry X.0 business is Schneider Electric, an energy multinational headquartered in France. Schneider Electric has combined digital and IoT technology with B2C thinking around the customer experience to create a 'Digital Factory' in which it can build, test and deploy new applications with ease. Through this innovation framework, Schneider has been able to rapidly develop and launch new customer service offerings and has created new value for its customers and itself by building new services around existing products. For example, a new risk management service for customer equipment providing predictive maintenance and personalised support services. Collecting and analysing huge volumes of data via an IoT platform the company can predict equipment failures and alert customers to take appropriate action well in advance. Based on this intelligence, Schneider's equipment can adapt to its environment at speed, reducing overall downtime and improving asset utilisation for its customers.

Get ready for change

So how do you prepare yourself to become an Industry X.0 business? There are six imperatives for businesses to focus on as they adapt and thrive in the digital revolution:

1 **Transform the core**. Industry X.0 companies build core engineering and production systems around digital technology, synchronising infrastructure and applications to unlock previously unseen cost efficiencies.

2 **Focus on experiences and outcomes**. Industry X.0 companies use their newfound investment capacity to develop hyper-personalised experiences for customers.

3 **Innovate new business models**. Industry X.0 companies ideate and create new business models to drive new revenue streams offering differentiated value for their customers.

4 **Build a digital-ready diverse workforce**. Industry X.0 companies source, train and retain talent from all backgrounds with digital-ready skills and use intelligent technologies to elevate the performance of both people and machines.

5 **Re-architect new ecosystems**. Industry X.0 companies create a robust ecosystem of suppliers, distributors, start-ups, and customers that allows them to rapidly scale new business models across the digital value chain.

6 **Pivot wisely**. Industry X.0 companies continually balance investment and resources between the core business and the new business to synchronise innovation and growth.

The end goal? A business that is smarter and more connected. One that "learns" and adapts, almost like a living organism. One that finds new sources of growth and competitive advantage. And one that creates a workforce which does not discriminate against either machines, or the people working alongside them. That's the promise of Industry X.0.

If you would like to learn more about how Industry X.0 can help a business thrive in the digital revolution, please read our report Combine and Conquer: Unlocking the Power of Digital accenture.com/combine.conquer

A united voice has the greatest impact

An ambitious new initiative, the National Engineering Policy Centre, aims to bring the profession together to help policymakers make informed decisions

Engineering not only provides the backbone of the UK's industry and economy but also benefits our everyday lives. The sector generates 23 per cent of the UK's total turnover and accounts for nearly half our exports. Engineers have insights and skills that can help address many of the country's biggest challenges, such as improving our productivity, harnessing disruptive technological change for public good, and upgrading our infrastructure, energy and transport systems.

Good decisions on grand-scale, transformative projects such as these cannot be made in isolation by government. The engineering community has a desire to help the UK thrive, and by sharing its expertise can support policymakers to make informed decisions about the future.

The challenge for policymakers

Policymakers face increasingly complex challenges, often with strong technical elements, at a time when the UK's relationship with the world is changing. They are not experts in all topics and need external advice to develop solutions to these challenges, improve productivity and drive social and economic growth.

We know that the scope and diversity of the engineering profession is one of its great strengths, but for policymakers it can be confusing to navigate. We need to make it easier for them to access the vast reservoir of knowledge that is spread across a fragmented and specialised landscape of separate engineering organisations. It is also important to recognise that a unified voice has much greater impact – coordinating our efforts across the profession makes a big difference.

Increasing engineering's impact in government

Engineers have an enormous amount to contribute by collaborating across our own profession and, crucially, with policy makers. They are problem solvers with deep knowledge of addressing complex systems issues, and it is vital that their wealth of experience is fully brought to bear on these national challenges

Working together as a profession is not a new idea, and a unified voice for engineering has real impact, as our previous collaborations have shown.

The centre will allow partners to work together on issues that affect, or should be informed by, the whole profession

The engineering profession came together to produce a unified response to Brexit and to the Industrial Strategy Green Paper. More recently, the pan-profession report, *Engineering Skills for the Future – the 2013 Perkins Review Revisited*, has been well received by government and is opening up a series of new conversations.

This is Engineering, a social media campaign delivered in partnership with the engineering profession and industry partners, has significantly increased consideration of engineering as a career among UK teenagers, as part of the Government's Year of Engineering in 2018. By aligning our efforts across the profession, we have seen measurable improvements in public perceptions of engineering.

Over the past year, we have been in discussions with other engineering organisations as to how to work together for the common good. We are hugely encouraged by their support and assistance, which has resulted in the formation of the National Engineering Policy Centre, an ambitious partnership, led by the Royal Academy of Engineering, between 38 different organisations.

National Engineering Policy Centre

This is a big step forward for engineering. The centre will allow partners to work together on issues that affect, or should be informed by, the whole profession, while respecting the distinct capabilities of each institution. It will provide evidence-based policy guidance, informed by industry, academia and practitioner insights and expertise. It will also build relationships between policymakers and engineers, growing mutual awareness and enabling policy advice to respond to the needs of both.

I strongly believe that by working together we can deliver more powerful and agile advice and expertise on the issues that matter, while providing policymakers with a streamlined route to engineering knowledge.

The centre will trial new approaches to create deeper networks between policymakers and engineers. Policymakers will have easy access to engineering expertise and see the centre as a trusted and responsive partner in informing evidence-based policy making for the public good. There are benefits for the profession, too, with a new route into government to inform and have greater influence on critical issues of social and economic importance.

Our aim is that the centre will help deliver economic growth and better social outcomes in the UK by enabling engineering expertise to be applied where it is most needed. But none of this can be done without the support of engineers, so I look forward to working together with you to realise this ambitious vision.

Prof Dame Ann Dowling is president of the Royal Academy of Engineering

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Thehottopic

Life after Honda

Readers discussed the role of Brexit in Honda's decision to leave the UK and speculated on an alternative future for its Swindon facility

Whether or not you support Brexit, to think that Honda leaving the UK has nothing to do with it seems naive – as if their departure from the UK and our departure from the single market is entirely coincidental. There are probably many other reasons why they chose to do this, but Brexit would definitely have been one of them...
Andy Davis

Honda was quoted after this press release as saying that the promise given to them by Mrs Thatcher – that the UK would be able to provide a platform from which to export to the whole of Europe when they agreed to build a site 30 years ago – has now been broken.

Turkey is not in the EU and Japan has now brokered its own FTA with the EU. We no longer have a competitive advantage over the other sites due to Brexit
Ian Wheaton

While Honda (and every other multinational in a similar position) says Brexit is not relevant, this is misleading. Brexit is part of the global economy evolution and is a factor in their decisions, even if not the sole one. We already have advantageous trade deals with one major economic bloc, which we are throwing away, and are yet to achieve similar or better with anyone else. Trade deals require a compromise by both parties, and whatever we do we will still have to sell EU-standard goods to Europe as we do now, but in due course with tariffs and extensive bureaucracy, we still have to sell our goods to the US, China, India, and the rest of the world to whatever standards they insist on, and vice-versa.
Nick Cole

In the not-too-distant future there is going to be a ready-made factory lying empty, with upwards of 3,500 people looking for work. If electric vehicles are the future, why doesn't the Government invest in reviving a British-owned car manufacturer? If we are leading the way in developing electric vehicles, then let's do it for a UK-owned brand.
Tom Mongan

This is an attractive idea and should be discussed with the staff at Honda now. They would just need the disciplined Japanese approach to manufacturing and we have all learned about ISO 9000, so it should be possible, whereas this would not have worked in the 1970s.

The UK always had the creative ability; we just needed the discipline. Hence why the three big Japanese firms have been making very good motors here.
David Childs

Without commenting on the Brexit effect, no one seems to be thinking about any business opportunities that might arise from the withdrawal of an underperforming manufacturer from Swindon. Could the assets, including the site, be purchased by a better car maker? What about Chinese car makers, or could Dyson also build his electric car or batteries there? Why not a consortium of small UK car manufacturers jointly operating the site? Or supply chain specialists? If we do end up with import tariffs on cars, then we need to assemble more of them here for the domestic market, as well as components.
Phil Sheppard

If the Government got involved in a consortium to build electric cars, from history, it would take 20 years to decide which colour to paint the factory floor.
Sandy

Two points: The EU/Japan trade deal grants 0 per cent tariff access. Effectively, Japan become 'honorary' members of the EU, at least where cars are concerned, so (from their point of view) they might as well manufacture there as here. Did the EU negotiators in 2013/ pre-referendum think or care about the consequences to the EU member (Britain) where Honda manufactures and would things be different if Honda had been based in France or Germany (more protectionist approach, retaining tariffs)?
Trevor

Thesecretengineer

Our anonymous blogger remembers the late John Haynes, whose car maintenance manuals inspired countless fledgling engineers

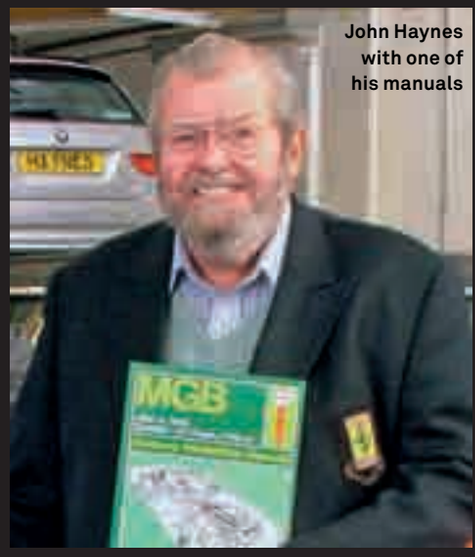
John Haynes – A Lasting Legacy

Even if you didn't know his Christian name, chances are that the mere mention of John Haynes will bring one of his maintenance manuals to mind. Such is the far-reaching influence of the man who passed away a few days ago, at the age of 80.

If, by some fluke, you remain ignorant of them, then let me tell you that they are a series of hardback books, A4 in size, with each giving a step-by-step guide to maintaining a particular car. They came about when, in the late 1950s, Mr Haynes realised that the factory manuals were only suitable for trained mechanics and therefore of little use to the growing number of people running older vehicles on a shoestring, reliant only upon their own wits and skills to keep them on the road.

I remember being aware of this extensive polychromatic self-help library while growing up, but I bought my first book (second-hand) when I got my first car – a 1300 Vauxhall Viva (also second-hand). Part of the excitement of fledgling car ownership was digging through the manual to understand how it all worked.

Although I've never reached the dizzy heights of full rebuilds, I have carried out my fair share of oil changes, suspension fixes and replacement of head gaskets. These were carried out on the drive and on the roadside, the latter having the added thrill of passing cars ruffling your hair while you were lying flat out reaching up into the nether regions of the engine bay. Such is their worth, that it is rare to find a Haynes manual, other than a brand new one, that is not covered in oily fingerprints.



John Haynes with one of his manuals

The whole culture of DIY car maintenance was, and is, engineering in one of its most accessible and enjoyable forms. Whether it is an activity undertaken through choice or (as was more often the case "back in the day") financial necessity, this is a way of understanding basic, and not so basic, principles in real terms. Apart from how an internal combustion engine works, there's also gearboxes, springs and dampers, electric circuitry, hydraulic systems, standardisation of parts and so on. In later years, the remit for the publications has expanded, with numerous volumes on, among other things, various 1980s Grand Prix cars and Second World War aircraft; but crucially they still focus very much on the technical aspects of the subject matter.

I suspect that the growing general affluence of society, coupled to the increased sophistication of cars, is eroding the traditional Haynes business model, which no doubt goes some way to explaining the need for the company to start pushing into different markets. Perhaps there will be a small redress as more folk are able to indulge their dream of owning a classic car and, as a hobby rather than a necessity, seek out the chance to cherish the increasingly rare opportunity of experiencing the satisfaction that comes with fixing something yourself. We shall see.

I think that the legacy of the Haynes manual reaches further though. Who knows how many people these indispensable tomes have given the confidence to take their first steps into the world of practical engineering? Odds are that there will be someone who can trace their career back to tackling a job armed with their trusty Haynes, but the more likely scenario is that it helped a nascent engineer to clarify what they wanted to do with their life. The joy of making something work opening their eyes to a potential future within our industry. John Haynes may not have revolutionised our profession, but through his books he did have an influence on a great many of us. Enough cause then, I would suggest, to take a moment to mark his passing. ■

Inyouropinion

The end of the A380

This is really sad news for everyone involved, especially the folks at Broughton & Filton. What an iconic aircraft. Let's hope the other products ramp up to fill the hole.
Mark Bidwell

Like Concorde, it's a sad day to hear that the A380 will be consigned to the boneyard in favour of twin-engined 'kites'. I'm sure Boeing will step in and take the gap with a Super Jumbo now the 747 will be only manufactured for freighters!

Accountants must be running the Airbus manufacturing business rather than engineers. I'd rather fly long-haul with four engines than two.
Robin Walton

UK harpoons space junk

OK, this works for the larger stuff, junk and debris. What about fragments that might break away when the harpoon is deployed? What is the plan for smaller space junk?
James Stewart

Real problem is with the 'shrapnel' – smaller debris that is impractical to collect as individual items, and more difficult to detect and avoid by spaceships. Martin's idea is a good one, or maybe even an unfoldable Kevlar sail to kill objects' speed so they fall to earth and burn up in the atmosphere
Mark Hassell

I have a much better idea, especially for catching smaller parts, which are the main concern. My idea is to use a cochlear shell-shaped satellite. It would have to be reasonably large, but the idea is to have it placed in front of any floating items and they will enter inside and follow the internal spiral shape. This will allow the item to slow down inside and will not penetrate the material of the satellite.
Martin

Instead of spending untold millions clearing space debris, someone might turn their expertise to clearing the debris that is littering our roadside verges.
Graham Taylor

Join the debate theengineer.co.uk

The marque of a modern classic

A blast from the past that's rooted in the present: Stuart Nathan talks to an automotive entrepreneur on a personal mission to combine the styles of the 1960s with the advantages of current top-of-the-line cars

From the outside, David Brown Automotive has little to mark it out from any other small engineering business on an industrial estate: it occupies a nondescript modern building in Silverstone Park, adjacent to the legendary racing circuit at the heart of Northamptonshire's so-called 'Motorsport Valley', where the shrill note of a racing engine rises and falls in gurgles and screeches as it negotiates the corners.

However, the company badge on the outside of the building, with its elongated Union Jack styling, has a certain sports car swagger. When you get inside, that swagger becomes as obvious as Sean Connery approaching a vintage Aston Martin in a sharp silver-grey suit. Lined up on the factory floor is a rank of cars that seem to come from another decade: from the front resembling a classic E-type Jaguar, blending at the rear into a subtly finned form recalling James Bond's legendary Aston Martin DB5.

There are even echoes of the English Electric Lightning fighter jet in the curve of its flanks; but these are no vintage vehicles – they are very obviously brand new. Facing these objects of automotive desire are very familiar forms: classic Austin Minis, goggle-eyed and far more diminutive than their new BMW reincarnation, also looking brand new in polished pastel, cream and brown shades with leather straps across their bonnets. Has a fragment of the Swinging Sixties materialised in this modern industrial unit?

The man behind this operation is the eponymous David Brown, a trim figure in his early sixties, comfortable in jeans, boots and leather jacket and very much looking the part of the owner of a sports-car marque.

The company's customer suite is a fitting place for a chat, overlooking the factory floor and bedecked with samples of paint finishes and swatches of leather for prospective owners of DBA vehicles to choose how they would like their new purchase to look.

Brown is the son of an engineer, also called David Brown. His roots are around the North Yorkshire market town of Knaresborough, where Brown Sr originally worked as a timber-master, felling trees and lugging them from local forestry to sawmills using a variety of tractors. While recuperating from a serious accident when a tractor overturned on top of him while he was trying to use it to pull out a particularly reluctant trunk, Brown Sr turned to engineering design to come up with a customised crane that could perform the job safely. After recovering, he started a new business designing and building heavy vehicles for agriculture, construction and quarrying. An articulated dump-truck design was particularly successful, and led to the business, DJB Engineering, eventually being acquired by Caterpillar after a long partnership.

Brown Jr then began a period of entrepreneurship in his own right. "I had a talent for starting companies," he says. "I started with the sort of companies of which I had been a customer, such as bars, restaurants and men's clothing – with a certain arrogance, I suppose, thinking that I could do it better."

Profiting from the sale of these businesses, he became, by any metric, comfortably off, and indulged in what many would see as the fairly stereotypical hobby of classic car endurance rallying. "I entered a rally in the south of France, and a friend of mine loaned me his classic Ferrari Daytona convertible to drive. It was the dream car of my young adulthood and I was so looking forward to it. But when I picked it up at Nice airport, I was instantly disappointed. The steering was heavy, the brakes by any standard poor and it was woefully underpowered. It was also very uncomfortable. Perhaps fortunately, on the second day of the rally it got stuck in second gear and I had to abandon the rally. I rented a standard modern Peugeot to follow the rest of the race, and it was comparatively a joy to drive: it had air-conditioning, it had a radio, it had power steering and the brakes worked.

"Several of the other competitors offered to lend me their classics for a day, ostensibly so I could continue with the rally experience but actually because they just wanted to spend the day driving a more pleasant car. It got me thinking, wouldn't it be great if you could combine the style of those beautiful late 1960s-early 1970s sports cars with contemporary power and all the features we take for granted?"

Thus was born the idea for the DBA Speedback, the alluring Jaguar/Aston Martin/Lightning cross sitting below in the factory. "I'm not an engineer by training," Brown says, "but

The DBA Speedback in red, white and blue

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01 The DBA Mini Remastered

02 A look inside the Mini Remastered

from knowing my family automotive business, and from building my own cars for rallying, I knew how we could make something like this at volume – admittedly never huge volumes, but enough I could make a business out of it."

Brown is under no illusions that he isn't in a luxury business. "Look, nobody needs a car like this. You have to want one, but enough people do that it's viable for me to build them."

The idea was to build a classic GT – a real gran turismo, a car designed to cover long distances in comfort. To design it, Brown called on ex-Land Rover designer Alan Mobberley, who came out of retirement to work on the project. "You might not believe it, considering the way the Speedback looks, but we didn't go into it with any particular final shape in mind. We surrounded ourselves with icons from the era, pictures of classic cars and Sophia Loren on the wall and got ourselves into the 1960s mood. We might have drunk a few bottles of wine. And that is the design that came out."

Mechanically, the Speedback is based on a Jaguar XKR chassis, 503bhp, 5-litre supercharged engine, transmission and suspension, but everything visible is custom-built. The bodywork is aluminium, made by a specialist subcontractor and formed using the old panel-shaping technique of the English wheel. Interior details are polished walnut, and the upholstery is handmade by an in-house team. "I'm very keen on keeping that craft aspect of the business alive," Brown says. "But equally, there is a place for new technology as well." Along one wall of the upholstery studio, a series of small 3D printers hum busily, turning out prototypes of interior details and accessories.

Other modern features include LED lights, performance brakes, climate control, electrically folding door mirrors, parking sensors, satnav, Bluetooth and a high-end audio system. And the price tag matches: the "standard model" costs around £600,000, while the "Silverstone" edition, consciously styled more after a fighter jet, costs a cool £750,000. Nevertheless, there are plenty of customers and the limited edition run is sold out, with buyers from around the world. For those with not-so-deep (but still pretty capacious) pockets, DBA's other model, the 'Mini Remastered' retails at a slightly more modest £99,000. Rather than being a new car like the Speedback, the Minis literally are remastered: the company buys vintage Minis, strips them back to the chassis, and rebuilds them from there. The original bodywork is lovingly replicated in aluminium, with the distinctive seams (which marked where the original panels were joined together) omitted to give a smoother profile; new suspension (solid rubber, like the old version: "we tried springs, but they just don't feel the same"), restored engine and gearbox and new interior, including dashboard, installed, with all the audio and navigation devices you would expect on a new car. The car retains the original registration, vehicle identification number, and so on, from the donor vehicle. Brown expects to build 50-100 per year.

He remains committed to his mixture of manufacturing techniques from the past and present. "What you see here is a great example of a combination of traditional skills and contemporary ways of manufacturing and measurement," he says. "We are lucky to have some great suppliers and people with real heritage skills: craftsman skills. Our suppliers go the extra mile for us: when we ordered paint for the Speedback, the samples we were sent exceeded the standard we had asked for in our brief. The brand stands for reimagining products from the past using the finest British craftsmanship and materials.

"Leave styling to one side for a minute, because styling is a product of time, but if any of the manufacturers of the 1960s had access to the things that we can use, they would have used them in exactly the same way that we are using them now. I do not want to get trapped into nostalgia for nostalgia's sake. If you look at the panel joins on the Speedback, they are superb, and the only way we can get that quality is by using digital measurement."

As we walk around the trim room after our conversation, the leather workers are using tools made from whalebone and stitching by hand while the Rolling Stones' *Paint It Black* emerges from the digital radio that sits between the busy 3D-printing machines. These machines, Brown tells me, are making a prototype for the lining for a picnic hamper to be offered to customers on their car's birthday, which will be trimmed in leather matching their upholstery – in fact, from the same hide. It seems utterly fitting. ■

Deep Impact

An ambitious effort to take a manned submarine to the bottom of the Earth's five oceans is pushing subsea technology to its limits. Jon Excell reports

It's something of a cliché. But we still know more about our closest cosmic neighbour than the depths of our own oceans.

While 12 astronauts have walked on the surface of the moon, just two manned missions have made it to the deepest known point on the Earth's seabed: Challenger Deep in the Pacific Ocean's Mariana Trench (10,916m).

And although robotic probes have been sent to almost every corner of our solar system, the murkiest depths of our own planet remain a mystery: a risky frontier of bone-crushing pressures and near-freezing temperatures where navigation is difficult and the prospect of rescue remote.

Which makes a current effort to land a manned-submersible on the deepest parts of the world's five oceans all the more exciting and impressive.

The so-called Five Deeps mission is the brainchild of thrill-seeking US financier Victor Vescovo, who is hoping to add the bottom of the world's five oceans to an explorer's CV that already includes the 'seven summits' and skiing expeditions to the North and South poles.

The project ticked off its first milestone late last year, when – aboard a hi-tech submersible developed by Florida based submarine manufacturer Triton – Vescovo became the first human to reach the Puerto Rico trench in the Southern Ocean (8,376m). Last month, he reached the southern portion of the Atlantic's South Sandwich Trench (7,433.6m) and in the coming months plans to land his vessel on the bottom of the Java Trench, thought to be the deepest point in the Indian Ocean; Molloy Deep in the Arctic Ocean; and, of course, Challenger Deep.

But the $48m (£36m) effort is much more than a rich man's vanity project. Those involved – who include some of the world's leading experts in deep sea exploration – describe it as a scientific mission without precedent, an undertaking that has driven the development of a host of advanced submarine technologies and which will shine new light on our planet's most mysterious frontier: the 6,000-11,000m Hadal Zone, a world of deep, dark trenches home to some of the hardiest and most unusual living organisms on the planet.

Clearly, achieving this requires some pretty extreme engineering, and that begins with the submarine at the heart of the project, the 11.2 tonne, titanium-hulled Triton 36000/2 (or Limiting Factor as Vescovo has named it).

Triton's chief engineer John Ramsay, who is based in the firm's UK engineering office in Devon, told *The Engineer* that the vessel is unlike anything he has designed before.

Whilst most of the firm's subs are able to make use of off-the-shelf components from other sectors such as oil and gas, nothing is really available for depths beyond 6,000m, he said. So the team has had to develop a host of technologies from scratch: from the pressure-compensated batteries that power the sub to its assorted manipulators, thrusters and electrical systems.

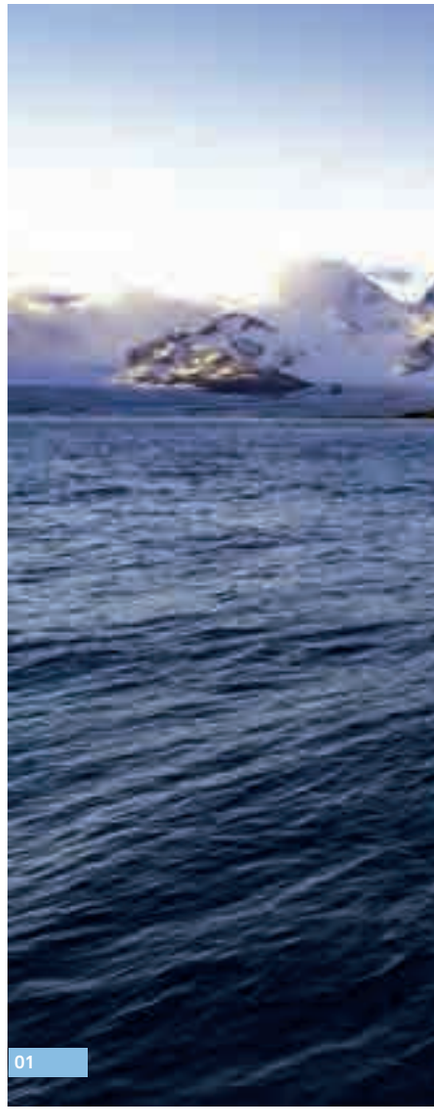
The most striking feature is its giant titanium pressure hull, a precision-engineered 90mm-thick structure, able to withstand 16,000psi and accommodate two passengers within its cosy 1.5m diameter confines.

Formed from giant forgings joined without welds and machined to within 99.933 per cent of true spherical form, the production of the hull was, said Ramsay, a major challenge.

"Normally if you make a pressure hull like this it would all be welded. But we were determined from the start that we wouldn't have any welding... because it introduces so many unknowns into the design. It means that essentially once it's welded you don't really know the strength in the weld, it causes everything to move and shift, you want it to be as close to a perfect circle as you can."

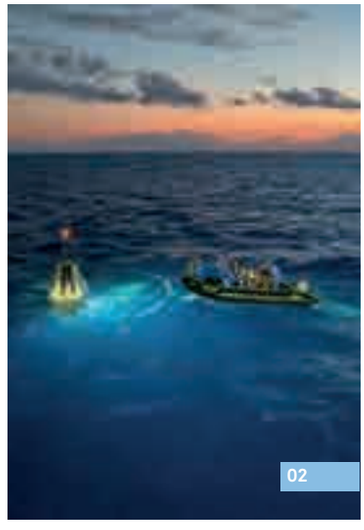
The end result is a hull that is barely affected by the enormous pressures it encounters at full depth. Ramsay estimates that it reduces in diameter by just 4mm, quite an achievement considering it has the equivalent to the weight of the US's largest aircraft carrier pushing down on it.

One of the most problematic areas of the hull was the design of the viewports, which are made from acrylic and therefore not as strong as the titanium. "The pressure on the acrylic is higher than the rated strength of the acrylic – so it's quite an unusual design," said Ramsay. "As the sub dives deeper the acrylic viewpoint gets pushed into a conical opening and moves about 7mm into the viewport seat. It's all designed to distribute the stresses evenly at the maximum diving depth."



01 The Submarine shortly before its successful visit to the South Sandwich Trench. Image: Caladan Oceanic

02 The Limiting Factor returns from its Dec 2018 trip to the Puerto Rico Trench. Image: Caladan Oceanic



Despite the enormous pressures, space constraints within the pressure vessel, coupled with the challenges of passing electrical signals through a titanium hull, mean that many of the key components – including the submarine's lithium polymer batteries – are actually stored outside and designed to operate at the ambient pressure. "Electronics where possible need to be pressure-tolerant, so they're immersed in oil that's compensated at water pressure," explained Triton's chief electrical engineer Tom Blades.

The batteries power 10 powerful electric thrusters controlled by joysticks within the vessel. These include four transverse manoeuvring thrusters, two additional thrusters for manoeuvring up close and four vertical thrusters that can be used to arrest the submarine's weight-enabled descent. "If you're descending and for any reason you want to stop for a moment, you can arrest the descent with the thrusters without having to drop all the weights," explained Ramsay.

Electrical wiring for carrying control signals and power is passed through the pressure hull via a series of specially designed penetrators, developed for the project by Aberdeen firm CRE. These use an innovative glass-to-metal seal to ensure that the pressure integrity of the hull isn't compromised.

Beyond the innovative design elements, one of the key factors that differentiates the submarine from other deep diving vessels is that it has been engineered for repeated use.

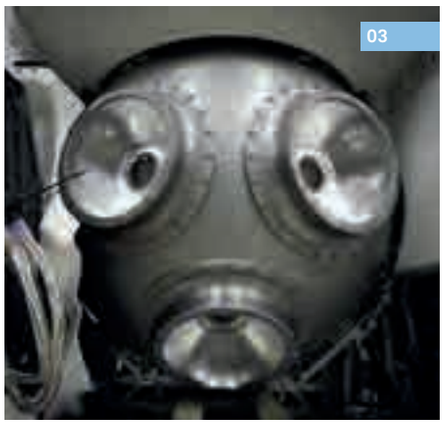
While previous efforts, such as the two successful attempts to reach the bottom of Challenger Deep (the Swiss-designed Trieste in 1960, and James Cameron's Deepsea Challenger in 2012) were one-off dives, the Triton sub has been designed to perform thousands of missions.

To achieve this, the engineering team had to work closely with the marine certification body DNV GL to get the vessel approved. "That level of scrutinisation... sets it aside from what you might call a prototype or a sub that was only going down for one specific dive," commented Ramsay.

Getting the design to this point called for a rigorous programme of testing. And in the absence of any existing facilities the team worked with Barcelona-based submarine manufacturer ICTINEU on the development of the largest high-pressure hyperbaric chamber in Western Europe. This has been used to test every single component at pressures 1.2 times greater than those experienced during actual use.

Another major aspect of the design has been the development of safety and redundancy systems to ensure that, in the event of a problem, the submarine can get back to the surface without assistance. "It's going to be on its own," said Ramsay, "There's no chance of getting rescued when you're down at 11,000 metres."

Alongside back-up batteries, thrusters and breathing equipment, one of the key innovations here is that all of the external features, including the thrusters, batteries and manipulators, are ejectable, meaning the pilot can rapidly increase the buoyancy of the sub and also disentangle it should it become snagged on something. "Every sub pilot's biggest fear is pulling a rope into the thruster," said Ramsay. "The safest and most reliable way is to just have the thrusters drop if you snag onto anything – we use these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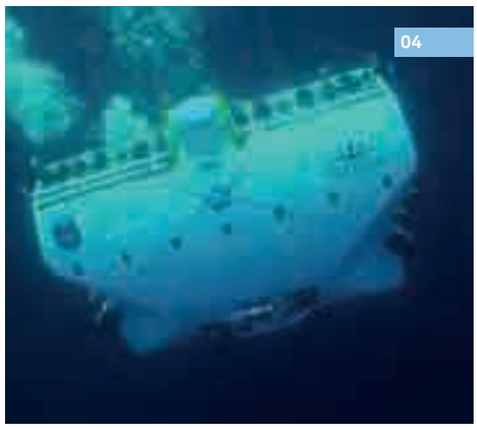
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amazing explosive bolts where you apply a current to a sheath around the bolt and after about 90 second it snaps," he explained.

While the submarine is the star of the show, it is just one element of a wider package which includes a support vessel (the DSSV Pressure Drop) and a series of advanced unmanned subsea landers. These are particularly key to the development of an innovative underwater GPS system that uses modems on the surface vessel, the landers and the sub itself to triangulate the position of the vessel and help it navigate to its target.

Triton's Tom Blades explained that while submarines operating at shallower depths typically use so-called ultra-short baseline (USBL) systems that communicate with a surface vessel using acoustic pulses, this method of navigation is not effective at greater depths.

"To get all the way down to full ocean depth you need to use much lower-frequency sound," he explained, "which gives you the problem that you can't sense direction without a much larger array." The solution has been to use acoustic modems that can transmit and receive analogue voice communications and also data.

These subsea modems have a high-precision time reference synchronised to GPS on the surface. Whenever data is sent from the subsea modems, the time of sending is encoded into that message. "You compare that to the time at which the message was received and you have time of flight which, using bathymetry data, we can calculate the speed of sound through water and get a distance," explained Blades. "We use all these distances to triangulate the sub's position."

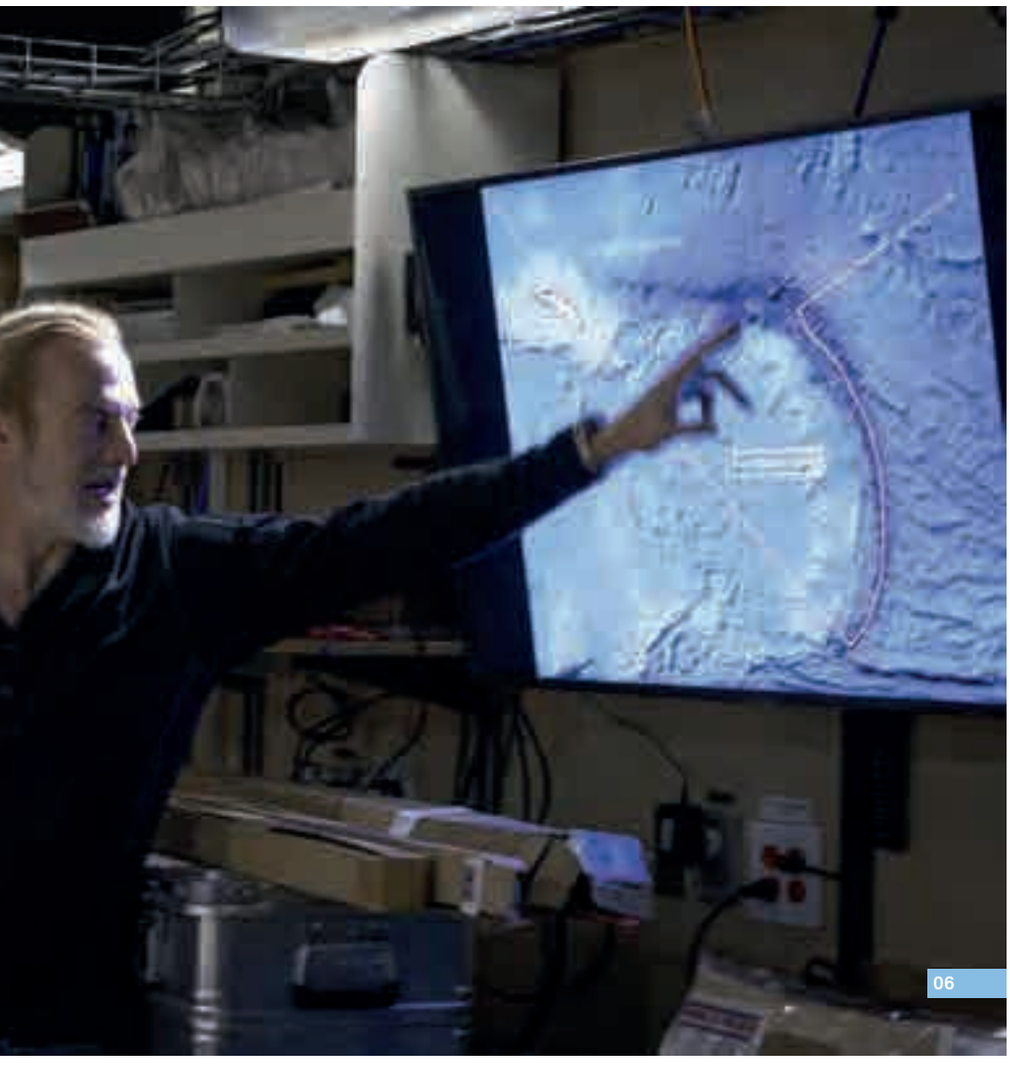
Alongside their role in the navigation system, the subsea landers are also a key component of the scientific side of the mission and are equipped with a host of sensors, baited cameras, traps and push cores that can be used in collaboration with the submarine to record, collect and return samples from the seabed.

This area of the project is being headed up by one of the world's leading experts in the deep ocean and the technology required to study it: Newcastle University's Dr Alan Jamieson.

Over the course of his career, Jamieson has carried out some of the pioneering work in Hadal Zone exploration, discovering dozens of new species of fish and crustaceans and writing one of the definitive books on the topic: *The Hadal Zone: Life in the Deepest Oceans*. He even has a species of shrimp named after him: the Princaxelia jamiesoni.

"Having someone in it grabs people's attention. Kids don't look at ROVs and go 'wow!'"

Dr Alan Jamieson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03 The Sub's precision-engineered Titanium pressure hull

04 Limiting factor during one of its test dives

05 The submarine aboard its support vessel, the DSSV Pressure Drop

06 Victor Vescovo studies data on the South Sandwich trench. Image: Caladan Oceanic

07 Early engineering work by one Triton's engineers


07

However, despite being involved in around 250 dives of 6,000m and deeper in the last 12 months (all of which relied entirely on free-falling landers) he believes the Five Deeps mission could be a game-changer.

"This Five Deeps thing is a really big jump forward because of the sub," he told *The Engineer*. "When we use baited landers we can film and sample all of the mobile animals that come to us, but there's a whole bunch of stuff that isn't attracted to bait so the sub and lander combined give us the best of both worlds.

"I think the true legacy of this is going to be the scientific and exploration side."

Of the sites being visited by Five Deeps, the Mariana Trench is the only one that Jamieson's group has been to before. And he expects that examining other trenches will lead to the discovery of a number of new species and also, as he puts it, "help join up some of the dots".

One of the big things his group is looking at is genetic connectivity. "The deep trenches are very isolated," he explained. "They're like an upside-down island.

"There's a lot of things that live at the bottom of trenches but can't get from one to another. But the tectonic plates have been moving all of the time, so we have what Darwin was talking about with his finches except on a much, much bigger scale and it's happening right now.

"You can see genetic diversions between two trenches that have been slowly moving apart for the last 50 million years." Getting similar samples from all of the five deeps sites will, said Jamieson, help the group start to develop a bigger picture about how life evolved on earth.

The mission will also, he said, dramatically improve the information we have about the seabed. "One of the first things we did when we got involved was to work with colleagues at BGS (British Geological Survey) to go through the five deeps and have a look at the bathymetry, the data, the quality of the data and when it was taken, and where people think the deepest places are. And it was amazing – every single one of them was wrong. There was one time in the Tonga trench we found a vertical wall about 1km high that isn't even on the charts!"

While much of this existing data was acquired using pretty primitive equipment, the echo-sounder aboard the Five Deeps support vessel is, he said, the most advanced instrument of its kind in the world, and will significantly advance our knowledge of what lies beneath. There is even the intriguing possibility that it could identify hitherto undiscovered depths.

Despite Five Deeps' undeniable scientific promise, in the age of the remotely operated vehicle there is – Jamieson concluded – something a bit old-fashioned about the notion of a manned research submarine. "They're a thing of the past because they're so unbelievably expensive. To operate them you need a whole different level of support vessel and an army of technicians to keep them going."

But, as with space exploration, there is something undeniably exciting about having a human in the loop. And Five Deeps' package of technologies, which goes on sale for the princely sum of $45m once Vescovo's mission is complete – could offer someone with deep enough pockets an opportunity to build on this excitement. "Having someone in it grabs people's attention," mused Jamieson. "Kids don't look at ROVs and go 'wow!'" ■

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Conservation transformation

How drones, AI and citizen science are helping to protect endangered wildlife

Andrew Wade reports

It is no small irony that as humanity destroys more and more of the natural world, it concurrently increases its ability to both study and protect it. We are living through the largest period of extinction since the dinosaurs disappeared 65 million years ago, with multiple species wiped from the Earth each day at a rate estimated to be 1,000-10,000 times faster than normal. Technology has, of course, played a fundamental role in this anthropogenic disaster. Now, researchers are hoping to harness technology to protect what we have left.

At a recent conference hosted by the Born Free Foundation and the British International Education Association (BIEA), conservationists outlined how technology is being applied both for ecological study and protection. Using a combination of drones, citizen science and artificial intelligence, the front lines in the conservation battle are being redrawn.

"We're currently experiencing a big problem with extinction in the world," Dr Josh Veitch-Michaelis told the conference. "There are five species that will go extinct today. There are less than half as many animals in the world as there were 30 years ago. And the World Economic Forum has ranked this as a top 10 threat to humanity."

> "Drones have had a massive explosion in use in conservation"
>
> Dr Josh Veitch-Michaelis

Veitch-Michaelis is a member of the Astro-Ecology group at Liverpool John Moores University, a multidisciplinary team using astronomy and machine learning techniques to better understand animal populations and their health.

Finding and counting animals is key to this, but mainstream methods haven't changed much since the heyday of Jane Goodall and Dian Fossey, with individuals trekking across swathes of land, pen and paper in hand. More recently, however, the discipline has been given a tech upgrade. "We fly drones with thermal imaging cameras," said Veitch-Michaelis. "Over the last 10 years, drones have had a massive explosion in use in conservation, the reason being that drones are reasonably cheap, you can cover much more area than with a ground-based survey, and we can put the kind of instruments we want on to them."

Veitch-Michaelis and his crew predominantly use multirotor drones, equipped with GPS, stabilised cameras on gimbals and autonomous flight capabilities. As many animals have evolved to camouflage themselves, thermal cameras have become an important tool, capable of penetrating jungle canopies and thick savannah grasses. The technology has even been employed by the John Moores team as a method for detecting poachers, who are adept at blending into the environments they operate in.

"The problem is that a lot of other stuff looks like poachers," said Veitch-Michaelis. "In places like South Africa, where it gets quite warm, the sun heats objects on the ground like rocks or tree trunks, and they look the same as the bright blobs that could be mistaken for humans."

Similar problems can occur when it comes to counting fauna. Animal waste is the same temperature as the animal itself, and this can easily lead to miscounting. Refining software to correctly label thermal images is the current major challenge.

"What we want is something... where we can take an image, put it on to computer, and have the computer label the image for us, which saves us going through thousands of images by hand," said Veitch-Michaelis.

This is where the 'Astro' meets the 'Ecology'.

"(We) realised that actually the kind of problems that ecologists were facing in image processing had already been dealt with in astronomy," he continued. "We use a combination of what's called citizen science and machine learning. Citizen science is a relatively new idea where you can ask the public to label your data. This is being championed by a website called Zooniverse, based in Oxfordshire. You can upload your data and provide a guide for people on how to label it, and they'll do it for you, for nothing more than internet points and the enjoyment of doing it."

Once a substantial number of images have been correctly labelled, these can be used to train an AI to do likewise.

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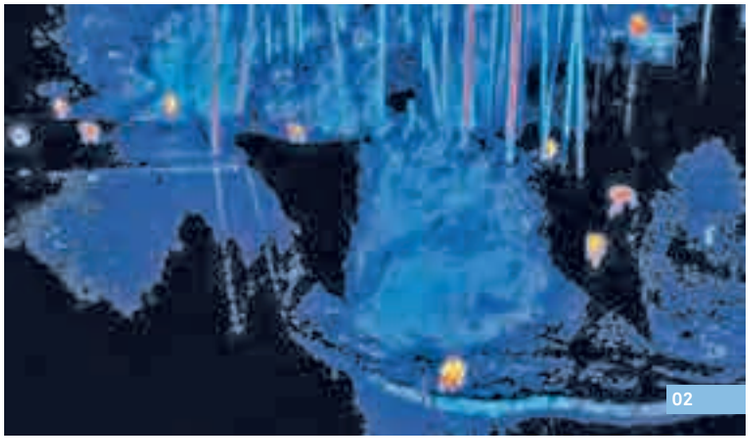

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01 Infrared thermal imaging of rhinos in South Africa

02 Thermal imaging of chimpanzees from a drone

03 The John Moores drone at sunrise in the Karoo desert

"And this is really what we think the future of ecology is," Veitch-Michaelis explained. "We want to build these systems to rapidly classify thousands of pictures... and ideally we want this running on a drone itself. So for things like anti-poaching, we want to fly around, process a live video stream and immediately alert a ranger or someone on the ground when we see a poacher."

While the John Moores team has trialled its technology in relatively familiar wildlife hotspots such as Madagascar and Indonesia, another of the conference's presenters had been further afield. Melissa Schiele is a marine ecologist at the Zoological Society of London. Using a fixed wing drone, she and her colleagues have been monitoring the waters of the Chagos Archipelago, a group of islands about 500km south of the Maldives in the Indian Ocean. "We believe that we are the first to develop a water-landing fixed-wing unit specifically designed for marine ecology, but also maritime surveillance as well," Schiele told the audience.

The islands – also known as the British Indian Ocean Territory (BIOT) – are the subject of an international dispute between Mauritius and the UK, with the UN's highest court recently ruling that they should be returned to the former. Apart from a US military base on the largest atoll, Diego Garcia, the Chagos are now uninhabited and were declared a marine protected area (MPA) in 2010. But with just one British vessel patrolling an area of more than 56km^2, the archipelago poses conservation challenges.

"That same vessel also has to do all the scientific expeditions as well," said Schiele. "So any solution that can increase enforcement capacity is welcomed."

Only around 3.7 per cent of the marine protected areas (MPAs) of the world are actively managed, leaving the vast majority open to various forms of exploitation. It has been claimed that the BIOT MPA was created primarily to frustrate the sovereignty dispute, making it more difficult for displaced Chagossians to return. For now, however, the area remains protected. Fishing is usually forbidden or heavily restricted, but the lack of policing often sees this openly flouted.

"The main concern for the BIOT are south Asian vessels, specifically targeting tuna stocks and sharks for fins," said Schiele.

Prosecuting offending ships is difficult, however, as catching fishermen with their gear in the water is rare. According to Schiele, clear pictures of boats actively fishing plus the hull identification number are the 'holy grail', and drones present an opportunity to obtain them.

The Chagos research took place largely from the BIOT vessel, which presented challenges. Dynamic home positioning will take a drone back to where it took off, something that becomes tricky when your launch site is the deck of a moving ship. Water landings led to seawater ingress and ecologist Schiele had a crash course in drone maintenance with several nights spent soldering into the small hours.

"We know that once the drone is fully waterproofed in the next iteration, it's going to be a very powerful tool in ecology and surveillance as well," she said.

What's more, the platform is affordable. "We believe our drone...is going to be the revolutionary tool that MPA managers – potentially in developing nations – will be able to afford, as well as marine scientists on limited funding." ■

Supercharging STEM

A recent event explored the benefits and challenges of a more joined-up approach to inspiring the next generation. Jon Excell **reports**

The need to engage and inspire the next generation to consider a career in engineering is one of industry's most talked about challenges. But what does an effective Stem (Science, technology, engineering and maths) engagement strategy actually look like? How do we measure its impact? And with a plethora of initiatives under way, of varying size and scale, how do we ensure industry is using every tool at its disposal to shore up the pipeline of future engineering talent?

This is Engineering Engagement, a one-day event held at the Royal Academy of Engineering late last year, brought together some of the UK's leading voices in Stem engagement in an effort to answer some of these questions, share best practice and explore the potential challenges and benefits of taking a more joined-up approach to this incredibly complex issue.

Setting the scene for the day, the academy's director of engineering and education, Dr Rhys Morgan, provided a sobering reminder of the challenge industry faces. With an annual shortfall of between 40,000 and 60,000 of the 130,000 engineers and technicians industry requires every year, inspiring children to view a career in the sector more positively is, he said, a critical challenge. And one of the keys to addressing this is understanding what is driving a dramatic decline in interest in maths and physics between GCSE and A-level. "Roughly 600,000 take GCSEs in May," he said. "Half will get good grades in maths and physics and are well placed to progress to do engineering. Then there's a massive collapse. By September, when they start their A-levels, we lose about 95 per cent of our cohort."

There are, he explained numerous organisations doing things to try to solve this problem: no fewer than 35 different institutions, 70 science learning institutions, and more than 500 Stem activity providers. This includes the academy itself, which runs the Ingenious programme (the only dedicated grant-funding scheme for public engagement in engineering) and has been a driving force behind campaigns such as This is Engineering and the 2018 Year of Engineering.

But despite more than a decade of such activities, the overall problem remains resistant to change. And according to UCL sociologist Prof Louise Archer, that's partly because many activities haven't been based strongly enough on evidence and a clear understanding of the problem.

Archer has led some of the seminal work in this field, most notably the Aspires project: a ten-year study that has explored how young people form ideas around Stem.

During the study, Archer's group followed a cohort of pupils from the age of 10 to 18, as well as carrying out a series of large-scale surveys involving around 40,000 individuals.

It led to some key observations on young peoples' attitudes to science that help explain why the engineering sector struggles to attract the diverse range of people it so desperately needs.

One issue it identified was the way in which physics is aligned with masculinity. As Archer explained to delegates, the research evidence shows that girls' higher attainment in the subject when compared with boys is often explained away by teachers saying that girls work hard but that boys have a raw talent. As a result, boys taking part in the study were more likely to agree that their teacher thinks they're good at physics more than girls.

The study has also raised questions about elitism of physics and the way in which it is aligned with the concept of innate "cleverness" in a way that other subjects aren't. It is, said Archer, much harder for certain young people – in particular girls – to feel clever and to be recognised as being naturally clever. "They tend to be seen as working hard," said Archer. "And working hard is seen as the opposite of being naturally clever."

Addressing this issue is vital, she said. "We cannot leave institutions like engineering or physics untouched in their eliteness and just expect to widen participation. We have to give up some privilege and make it less special if we want to widen participation."

The many findings from Aspires have helped Archer's group refine and introduce a concept that many agree can be used as the basis of a far more thoughtful approach to Stem engagement: science capital.

This is a way of measuring an individual's relationship with science that helps shed light on why particular social groups remain under-represented and why many young people do not see science careers as being for them. It takes into account how a host of factors – including what you know about science, how you think about it, what science-related activities you do, and who you know – influence your attitude to Stem. Taking all of these factors into

01 Engagement in action with the Guerilla Science Fire Organ

02 This is Engineering Engagement delegates share best practice

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> "Girls tend to be seen as working hard rather than clever"

consideration when shaping engagement activities is, explained Archer, the key to broadening participation. "An approach like the science capital teaching practice, whether it's applied to school science or out of school engagement, can really help. It's not just about showing them an engineering activity – it's also how that's framed. We think that approach could help more young people feel like 'it could be for me'," she said.

It's a highly complex approach, more nuanced than industry's traditional idea that all it takes to attract kids to engineering is a few explosions, but it's already being widely embraced by large corporations and independent Stem initiatives, and speakers at the event were quick to rubbish the suggestion made by one delegate that we risk over-intellectualising the challenge.

"If you're going to be effective, you need to operate on a large scale in order to reach enough kids in order to democratise the opportunities," said Shane McCracken, founder of online engagement initiative I'm An Engineer, Get Me Out Of Here! "You've got to think about what you're doing to ensure that you're not just shooting from the hip and doing what we've always done," he added. "You've got have a clear understanding of how the wider population view Stem. Unless you think about it, you're going to work from your own personal perspectives and that has been a large part of the problem to date in terms of providing more diversity within engineering."

McCracken's comments were echoed by BP head of UK communications and community development Ian Duffy. "There's a huge amount of money, time effort and resources gone in over the last 40 years into Stem outreach, and it's not made a whole deal of difference," said Duffy. "The science capital model is incredibly helpful in understanding why that is the case, and it's because most of the engagements have gone down very narrow channels that barely touch the sides of things that influence young people. Generally it's been about inspiration activities in schools but they only make a difference if they're in sufficient frequency and volume and planned into the curriculum and properly supported by teachers."

With this bigger picture in mind, BP's own Stem work has tended to focus on capacity building rather than direct engagement, Duffy explained. For instance, as well funding a big chunk of Prof Archer's work, the firm has also joined forces with the London Science Museum to found the Academy of Science Engagement, an organisation set up to improve and co-ordinate informal science learning across the country.

Other large corporations present at the event and equally engaged with the importance of the science capital approach included Siemens and Rolls-Royce. Commenting on the strategic business importance of trying to impact the wider world, Rolls-Royce head of community investment and education outreach Paul Broadhead said: "We need diverse talent coming into the sector – and in the long-term a more Stem-literate society has a circular impact on Rolls-Royce."

But arguably the most compelling examples of engagement in action came from the independent practitioners, specifically I'm an Engineer, an online engagement initiative for schools; SMASHFest, an annual disaster movie-themed science festival targeted at deprived communities; and the phenomenally successful Code Club , a volunteer-led after-school coding club fo nine to 13-year-olds that now involves 200,000 children at any one time.

All three of these projects contain valuable lessons on how to structure Stem activities to reach underserved audiences.

McCracken highlighted research showing that young people from areas further away from universities were less likely to benefit from outreach and therefore less likely to go to university themselves. Online engagement, he argued, creates an equality of opportunity that cuts through these geographical barriers. Meanwhile, SMASHFest founder Lindsay Keith talked about the importance of involving the wider community of parents and families and how that helps builds science capital.

Finally, Code Club founder Claire Sutcliffe put the initiative's success down to the way in which it has ensured it is relevant. "We try to make content relevant to the children we're trying to reach. We spend a lot of time asking them what they're interested in. It's a route to learning how to code, but they don't notice, a bit like sneaking vegetables into food."

Clearly, anyone looking to build a Stem activity could learn a lot from any of these practitioners. The big question is, is there an appetite for collaboration, and are the corporates prepared to listen? While the dialogue in the room was

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03 The one-day event heard from influential voices

04 Young people need to see the fun side of engineering

promising, McCracken believes there's still a long way to go and that, although big organisations such as BP, Rolls-Royce and Shell are at the heart of the intelligent discussions that need to take place, there are huge numbers of smaller engineering firms for whom it's not front of mind. It's only by bringing these firms on board that we can really begin to move the dial, he said.

BP's Duffy agreed that it is essential that everyone gets involved, and that big companies make sure that they're tapping into the expertise of independents. "Look at the range of influences wrapped around a young person and the choices they make and it's not just school: it's family, friends, their environment, the media, the whole societal context – you need everybody working alongside each other to change those influences on young people, and that's why big corporations on their own won't solve it."

Beyond the things that individual organisations can do, Archer believes organisations also need to work together to address some fundamental broader issues.

For instance, one of the keys to broadening participation, she said, is avoiding getting too bogged down in proscriptive definitions of what is or isn't engineering. The widely held notion that protecting the term "engineer" will somehow solve the sector's skills problems is, she said, particularly unhelpful. "Although there's a rationale to it, I think it works against the project," she said. "All we want to do is keep nudging people to the next step. The more we try to tightly define boundaries, the more it can exclude people. Engineering is quite a loaded term in the UK... so I think there are options for softening and broadening some of the boundaries."

At the same time, Archer believes we should be careful not to oversell the cool, glossy version of engineering in an effort to win over young people. "I can see the logic of why people want to promote a diverse image, but if the reality is that it's not 50 per cent women and it's not ethnically representative, then is there not an ethical issue there? Young people are not daft, most of them know what it's like, and it's important that a woman or minority ethnic person is prepared for going into a situation like that."

Beyond that, she argued that, there is also a pressing need to reform the education system. She said: "We have a system that makes it so hard for young people to continue in school science post-16... we have in our data lots of young people who are interested in science and engineering, but they cannot continue because we block their entry, particularly through A-level physics. This is disrupting efforts to engage and there's a strong case for lobbying for change." ■

■ Science capital: stem.org.uk/sites/default/files/pages/downloads/Science-Capital-Made-Clear.pdf
■ Improving participation: ucl.ac.uk/ioe/sites/ioe/files/improving-science-participation-policy-overview.pdf

This is Engineering Engagement took part on 16 November 2018 and was jointly organised by the Royal Academy of Engineering, I'm an Engineer and The Engineer.

How to really help – top tips for corporate giving

Code Club founder Clare Sutcliffe offered delegates some top tips on how large organisations can make sure their Stem charity donations actually mean something.

- Try not to ring-fence your donations for certain activities. The charity has spent a lot of time thinking about how to spend funds – trust them. If they're doing a good job, gift to them next year and tell them soon
- Try not to spread giving too thinly – it makes the financial impact less and spreads your attention among too many people
- Try to offer non-financial support as well as funding
- Be nice – answer their calls
- Try not to make extra work for the charity. Minimise the effort needed to apply for funding – think about who you want to fund and why
- Be very clear about your strategy and decision-making process
- Try not to make the charity waste valuable resources on you
- Think carefully before asking anything of a charity that doesn't focus on its core work

Aston Martin DB11 Volante at top of its game

Removing the roof sometimes proves the undoing of sports cars, but can the Aston Martin DB11 Volante buck that trend? Chris Pickering **certainly thinks so**

SPECIFICATION

Price: Aston Martin DB11 Volante from £159,900 (£191,085 as tested)

Engine: 4-litre twin-turbo-charged V8, 503bhp, 8-speed paddleshift automatic with manual mode

Performance: 0 to 62mph in 4.1 seconds; top speed 187mph

Fuel economy: Urban 20mpg; extra urban 37.2mpg; combined 28.3mpg

CO_2 emissions: 230 g/km

It's getting on for two years since *The Engineer* first drove the Aston Martin DB11, but there are some significant differences between the V12-engined Coupe that we sampled in 2017 and the new Volante. Most noticeably, Aston Martin has taken a can opener to its best-selling model to create the car you see here. And while that glorious 5.2-litre V12 is still available in the DB11 AMR, the open-topped Volante is currently only available with the 4-litre V8 found in the DB11 V8 Coupe.

At 503 bhp, the Volante's power output is down by 97 bhp compared with the DB11 V12 that we drove previously (and 127 bhp compared to the more hardcore AMR). On paper, then, it's not the most encouraging start for the Volante and it faces another problem that engineers have been wrestling with ever since monocoque construction became common in the 1960s: how do you provide adequate stiffness to what is essentially a box when the roof is no longer there?

Typically, the answer is to add more material elsewhere in the structure, and the DB11 Volante is no exception. In total, it tips the scales at some 110kg more than the equivalent V8 Coupe. The torsional rigidity has also fallen by around 35 per cent, from 34KN/deg for the Coupe to 22KN/deg for the Volante. It's important to put those figures in context, though. Anything over about 20KN/deg is generally regarded as a pretty good basis for a road-going sports car. What's more, it makes the DB11 Volante chassis around a third stiffer than that of its predecessor, the DB9 Volante, despite being some 26kg lighter.

In order to retain as much stiffness as possible, Aston Martin has increased the material thickness in the sills relative to those in the Coupe. There is also a revised rear cross member, which runs between the top mounts of the suspension, giving additional support. This also provides the anchorage for a pair of pop-up roll hoops, which smash through the glass in the event of a rollover. Other changes include slightly stiffer bushes for the rear subframe, which remains isolated from the rest of the chassis for the sake of refinement.

Look a little closer at the engine and things start to seem brighter here, too. It may lack the V12's outright power, but the 4-litre twin-turbo V8 comes remarkably close to matching it on torque at 675Nm, compared to 700Nm for the original V12 Coupe. Plus, the V8 is some 115kg lighter (comparing like-for-like installations in the Coupe) and its two cylinders shorter, which allows it to be placed further back in the chassis. Combine that with the fact that some of the additional mass comes from the hood mechanism and the rollover protection – both located near the centre of the vehicle – and you actually have a car that weighs round about the same as the original V12-powered Coupe with inherently better weight distribution.

Power, beauty and soul

Thumb the starter button and you're greeted with an unmistakably V8 burble. However, Aston Martin has gone to considerable lengths to ensure that the Mercedes AMG-derived engine has its own unique character. The intake and exhaust systems are completely bespoke to Aston Martin and help to provide more mid and high-frequency content. That translates to a soundtrack that is

Out in the open: The drop-top roof makes for a more visceral experience

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01 The DB11 Volante has a class-leading stack height when the roof is folded

02 The engine provides effortless power, but does not feel turbocharged

03 Drivers can adjust the chassis and powertrain settings independently

noticeably more sophisticated than the AMG cars' muscle-car drawl. As with the Vantage, though, what really strikes you about the engine in the DB11 Volante is that it simply does not feel (or sound) turbocharged. It provides plenty of effortless power when required – maximum torque is available from just 2,000rpm – and yet it still revs and responds like a naturally aspirated unit. For the record, 0 to 62 mph is dispatched in 4.1 seconds – just a tenth of a second behind the V8 Coupe – and top speed is a more-than-ample 187mph.

We didn't drive them back-to-back, but the Volante's performance doesn't feel noticeably diminished compared to that of the V8 Coupe. More impressively, the structure feels rock solid, there is the same incisive steering response and a palpable sense of balance to the chassis. As with the other cars in the range, you can adjust the chassis and powertrain settings independently using a 3-stage system that varies things like suspension stiffness, gearshift speed and throttle response. Where it differs from more hardcore models like the Vantage, however, is the calibration. In Normal – the softest of the three modes – the DB11 Volante rides with genuine comfort, the active exhaust is kept to a hushed level and the eight-speed rear-mounted transaxle shuffles away discreetly. In Sport or Sport+ mode, the Aston takes on an altogether more focused feel, while still retaining enough comfort to fulfil its GT credentials.

> "In Sport or Sport+ mode, it takes on an altogether more focused feel"

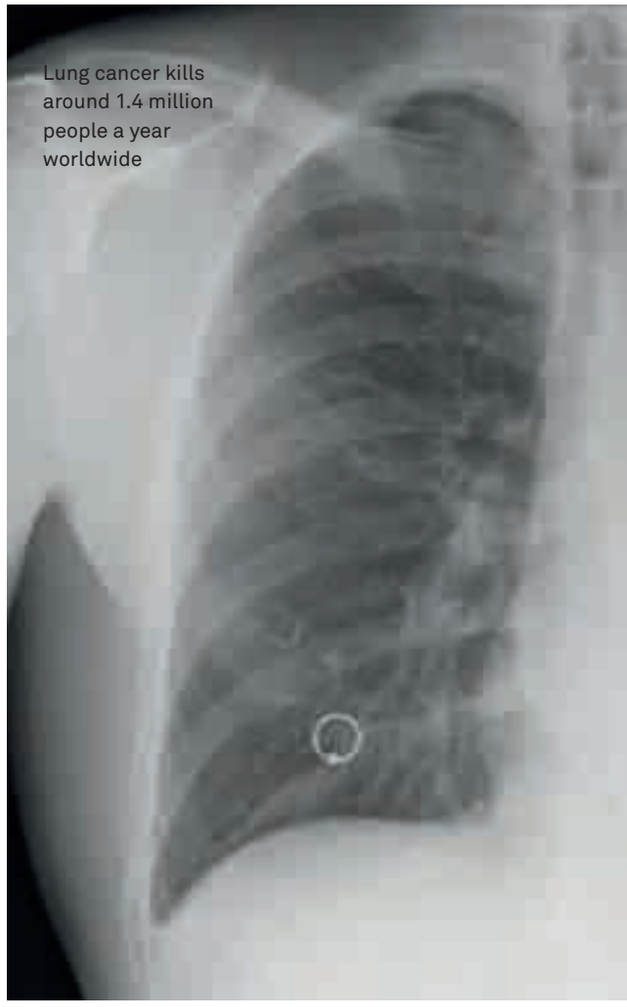
Not only is the drop-top roof great for cruising along during our fleeting moments of winter sunshine, but it makes the Volante a somewhat more visceral experience when you're in the mood for such things. B-roads can be attacked with real vigour and you soon forget you're in a 4.75m-long grand tourer. At the flick of a switch, however, the Volante transforms back into a fixed-head GT. Aston Martin chose to go with a fabric hood rather than a folding metal hard top, but it features an eight-layer design with the latest acoustic and thermal insulation materials, which means it does a remarkably good impression of a fixed roof. There is still a touch of wind noise, but it's not hugely different to the Coupe in that regard.

Aston Martin has achieved what it claims is a class-leading stack height when the roof is folded. The end result is that the DB11 Volante avoids the hunchbacked appearance that afflicts a lot of convertibles when their roofs are folded. Boot space is 206 litres (down 64 litres on the Coupe), but it remains on a par with the Jaguar F-Type Convertible and comfortably larger than the Porsche 911 Cabriolet. Incidentally, the hood mechanism does eat into that volume somewhat further when it's folded, but there is a sensor to ensure it won't crush your shopping in the process.

In summary, then, the DB11 Volante is that rarest of things: a convertible that might actually be the pick of its range. In the real world, it concedes next to nothing to the V8 Coupe in terms of performance or refinement and, while its engine can't quite match the V12 for operatics, in many respects it is a better fit for the car. What's more, the ability to revel in open-air motoring expands what was already perhaps the broadest skill-set in its class. There are more focused sports cars out there and more cossetting tourers, but none that combine those two qualities with quite so much aplomb as the Aston Martin DB11 Volante. ■

Lung cancer detection could receive graphene boost

Researchers at the University of Exeter have developed a graphene biosensor that they believe could enhance the speed of diagnosis



Lung cancer kills around 1.4 million people a year worldwide

Early detection of lung cancer is vital for effective treatment yet the biomarkers for the early stages of the disease are difficult to pick up. One of the most promising diagnostic developments are e-nose (electronic nose) devices, which analyse compounds in the vapour of human breath, combining electronic sensors with mechanisms for pattern recognition, such as neural networks. More sensitive electrodes lead to stronger patterns for the neural networks to analyse, leading to better detection of cancer biomarkers.

With this in mind, the team used multi-layered graphene to create electrodes for a biosensor, demonstrating sensing capabilities for three of the most common lung-cancer biomarkers – ethanol, isopropanol and acetone – across different concentrations. As well as exhibiting enhanced sensitivity for cancer detection, the sensor is also reusable, making it more cost-effective than alternative sensors used in e-nose devices. The research appears in the Royal Society of Chemistry's journal Nanoscale. Study co-author Ben Hogan, a postgraduate researcher from the University of Exeter, said: "The new biosensors which we have developed show that graphene has significant potential for use as an electrode in e-nose devices.

"For the first time, we have shown that, with suitable patterning, graphene can be used as a specific, selective and sensitive detector for biomarkers."

Although lung cancer is one of the most common and aggressive cancers, killing around 1.4 million people worldwide each year, the lack of clinical symptoms in its early stages means many patients go undiagnosed until the later stages. Using multi-layered graphene, the team believes current e-nose devices could transform breath diagnostic techniques and improve patient outcomes for lung cancer treatment.

"We believe that with further development of our devices, a cheap, reusable and accurate breath test for early-stage detection of lung cancer can become a reality," said Hogan. ■

First prosthetic hand with tactile sensations successfully implanted

Essex University researchers play lead role in landmark project for amputee patients

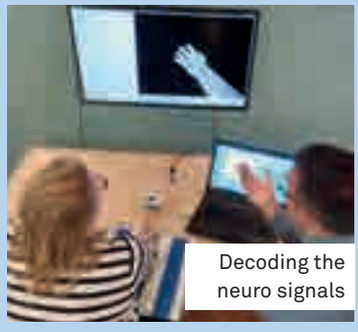
Researchers at Essex University have played a key role in a landmark project that has seen a person with an amputated hand become the first recipient of a prosthetic hand that provides tactile sensations and greater levels of dexterity.

In a pioneering surgical procedure at Sahlgrenska University Hospital in Gothenburg, Sweden, titanium implants were placed in the patient's two forearm bones, from which electrodes to nerves and muscle were extended to extract signals to control a robotic hand and to provide tactile sensations.

The team claims that this makes it the first clinically viable, dexterous and sentient prosthetic hand. The new implant technology was developed in Sweden by a team led by Dr Max Ortiz Catalan at bone-anchored prosthetics specialist Integrum AB and Chalmers University of Technology.

The surgery took place as part of a larger EU-funded project called DeTOP, which is led by Scuola Superiore Sant'Anna, and also includes Essex University, Prensilia, the University of Gothenburg, Lund University, the Swiss Center for Electronics and Microtechnology, INAIL Prosthetic Center, Universitá Campus Bio-Medico di Roma and the Instituto Ortopedico Rizzoli.

Dr Luca Citi, from Essex University's Brain-Computer Interfaces and Neural Engineering Laboratory, said: "The Essex team contributed to the development of algorithms which could decode and understand the neuro-muscular signals from the user's brain about what they intended to do and then send those commands to the robotic control of the prosthetic hand."



Decoding the neuro signals

Conventional prosthetic hands rely on electrodes placed over the skin to extract control signals from the underlying stump muscles. These superficial electrodes deliver limited and unreliable signals that only allow control of a couple of movements (opening and closing the hand). The new device delivers richer and more reliable information by implanting electrodes in all remaining muscle in the stump. In this, case sixteen electrodes were implanted in the patient.

Current prosthetic hands also have limited sensory feedback. They do not provide tactile or kinesthetic sensation so the user can only rely on vision while using the prosthesis.

The patient is now following a rehabilitation programme to be able to fully load the prosthetic hand. Two more patients (in Italy and Sweden) will be implanted with the technology in the coming months. ■

Morphing microrobots change shape according to environment

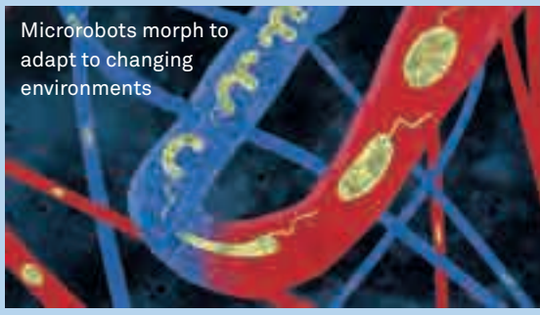
Researchers in Switzerland have developed a new breed of microrobots that automatically alter shape to navigate different environments, with potential for medical applications.

Inspired by bacteria, the tiny robots are made from hydrogel composites and contain magnetic nanoparticles that would allow them to be directed from outside the human body.

While this method of external control is not new, the robots manipulate their shape autonomously in response to their surroundings. Changes in viscosity, for example, prompt the microrobots to morph into more efficient shapes to maintain momentum. Led by engineers from ETH Zurich and its sister institution École polytechnique fédérale de Lausanne (EPFL), the research is published in Science Advances.

"Our robots have a special composition and structure that allow them to adapt to the characteristics of the fluid they are moving through," said Mahmut Selman Sakar, an assistant professor at EPFL's Institute of Mechanical Engineering.

"For instance, if they encounter a change in viscosity or osmotic concentration, they modify their shape to maintain their speed and manoeuvrability without losing control of the direction of motion." This 'adaptive locomotion' can be programmed using an origami-based folding technique.


Microrobots morph to adapt to changing environments

As the tiny devices are able to swim through fluids and modify their shape when needed, they can pass through narrow blood vessels and intricate systems with no loss of speed or flexibility.

The researchers conducted a number of tests that demonstrated the microrobots adapting to different physical and chemical environments, shifting from a paddling gait to helical momentum. According to the team, this flexibility could enable the devices to target areas of the body that are traditionally hard to reach, opening up new methods for more localised treatment of diseases. ■

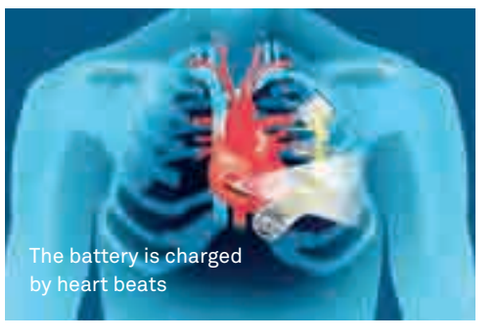
Kinetic energy from the human heart could power implantable medical devices

Kinetic energy generated by the heart could be used to provide electricity for medical devices, including pacemakers and defibrillators

Dartmouth engineers have developed a tiny device to capture and convert the kinetic energy of the heart into electricity to power a wide-range of implantable devices. Normally, implantable biomediacl devices are powered by batteries that need to be replaced every five to 10 years in surgical procedures that can be costly and create the possibility of complications and infections.

Now, in a study funded by the US National Institutes of Health, engineers at the Thayer School of Engineering at Dartmouth College, New Hampshire, have developed a device slightly smaller than a 5p coin that combines thin-film energy conversion materials with a minimally-invasive mechanical design to enable self-charging batteries. The results of the three-year study are published in Advanced Materials Technologies.

"We're trying to solve the ultimate problem for any implantable biomedical device: How do you create an effective energy source so the device will do its job during the entire life span of the patient, without the need for surgery to replace the battery?" said Dartmouth engineering professor John XJ Zhang, a lead researcher on the study his team completed alongside clinicians at the University of Texas in San Antonio.


The battery is charged by heart beats

"Of equal importance is that the device not interfere with the body's function," said Dartmouth research associate Lin Dong, first author on the paper. "We knew it had to be biocompatible, lightweight, flexible and low profile, so it fits into the current pacemaker structure and is scalable for future multi-functionality."

The team's work proposes modifying pacemakers to harness the kinetic energy of the lead wire that's attached to the heart, converting it into electricity to continually charge the batteries.

The added material is PVDF, a type of thin polymer piezoelectric film. When designed with porous structures – either an array of small buckle beams or a flexible cantilever – it can convert mechanical motion to electricity. The same modules could potentially be used as sensors to enable data collection for real-time monitoring of patients.

Zhang, who believes a self-charging pacemaker is five years from commercialisation, said: "We've completed the first round of animal studies with great results which will be published soon." ■

Inside Amazon's Baltimore technology test-bed

Automation in the aisles

Machines play a vital role in Amazon's Baltimore operation, finds Michael Kenward

After you negotiate airport-style security, and walk by the posters advertising free flu jabs, the first impressions on entering Amazon's high-tech warehouse near Baltimore are the noise and the lack of people. The din comes from miles of conveyors that carry the many thousands of packages leaving 'fulfilment centres' – as Amazon dubs its warehouses – every day.

A product's journey through Amazon's system begins with what at first glance appears to be a somewhat counter-intuitive approach to product stowing – whereby inventory entering the warehouse is randomly distributed by teams of 'stowers' into bins within two-metre-high storage pods carried by mobile robot drive units.

Such a chaotic approach to storing inventory – dubbed 'random stow' by Amazon – would have once been unthinkable. But by randomly distributing items in this way and using an overarching IT system known as Amazon Web Services (AWS) to bring together the data on every single item within the system, pickers are able to locate products far more quickly than if they had to visit a dedicated shelf for each product.

Although the system is underpinned by robotics and automation, Baltimore's technology testbed still employs around 3,000 workers, or 'associates' as the company calls them, most of whom stand at picking stations waiting for the robots to glide up bearing their 'pods'. Pickers then consult a screen and select from the appropriate bins whatever customers have ordered. These items are placed into 'totes' that travel along conveyor belts to packing stations where workers put orders into the cardboard boxes that go back on to the conveyors where more robots label the boxes for their destinations.

The rise of the robots at Amazon started in earnest in 2012, when the company paid $775m (£585m) for the robotics company Kiva Systems (now known as Amazon Robotics).

Since the acquisition the technology has evolved, and today's fourth-generation robots have more intelligence and carrying capacity in smaller devices than earlier models.

The robots are part of what Tye Brady, chief technologist at Amazon Robotics, describes as "a symphony of humans and machines working together". But in reality 'working together' means that robots and humans are kept well apart. The robots carry around those heavy pods in huge football-pitch-sized caged areas, on floors with bar codes that tell them exactly where they are, and communicating over a Wi-Fi network with a central control system.

Efficient: A robotic drive unit

Robots can be dangerous, especially when carrying heavy pods and moving around close to one another and, until recently, staff had to use a tablet to plot their intended path through the enclosure before they could enter the robots' work zone. That would then tell the control system to keep the devices away from the person. But Amazon has now started trials of a new robot avoidance technology in Baltimore, with RF beacons built into the drive units. Instead of mapping a route on a tablet, the operator dons a 'robotic vest' with an RF transmitter. Tapping a tablet creates an RF safety shield around the human worker and the control network causes the robots to slow down, and if necessary halt operation, as the human approaches.

The Baltimore site is also a proving ground for new technologies to track the bar codes on the assorted bins, totes, robots, and products flowing in and out of the warehouse.

One example of this is the technology that has been developed to eliminate the use of hand-held barcode scanners: a computer vision system that uses cameras and complex algorithms to track workers' hands and objects and figure out which bin an item went into.

The next move was to enlist the help of Amazon's machine learning and AWS, the company's cloud-based computer system, to train the algorithms to predict which bin something would end up in. The end result, said Eli Gallaudet, software development manager at Amazon Robotics, was "a very high accuracy on a large percentage of stows".

The power of AWS also sits behind Amazon's design and implementation of roboticised warehouses. It is impractical to test 5,000 robots, so before a robot gets anywhere near a warehouse, it is modelled to death. "Before a building goes live we have simulated the whole building," said Joe Quinlivan, president and COO at Amazon. "When a building goes up, we know it is going to work."

Software is also central to the running of a robotic warehouse. The drive units can diagnose their own health, and can work out when they need to go off line and recharge their batteries. The AWS 'central nervous system' also deploys machine learning and artificial intelligence to predict when a robot needs a motor changed.

Amazon's use of technology to monitor its workforce regularly creates headlines. Robots would not interest the media if automation took people out of the equation. Brady, who has clearly been asked many times if robot will replace people, said: "Humans will always be central to our equation. "There is no such thing as a 'lights out' fulfilment centre, it just doesn't work."

John Felton, the company's vice-president of global customer fulfilment, threw in some numbers. Over the time in which it has introduced robots, he said, it also added 300,000 people to its workforce. His take on new technology is that it is there "to improve the associates' experience".

What about productivity? That too, he agreed, but when it comes to putting numbers on the gains, Amazon won't let on. ■

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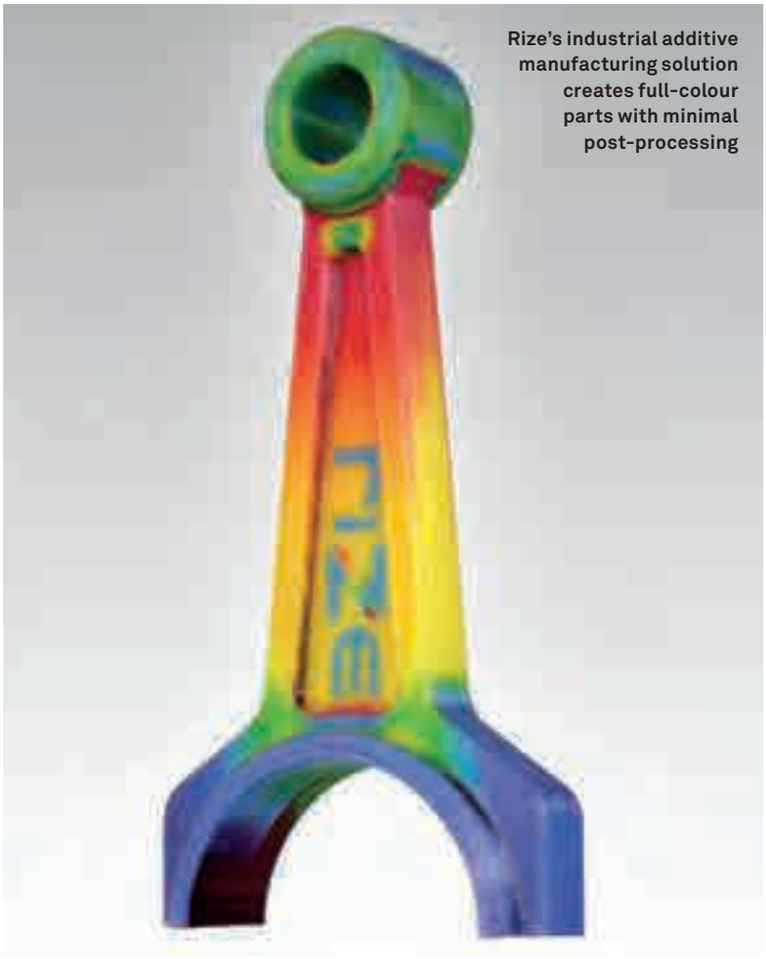
UNIVERSAL ROBOTS

Advanced Manufacturing

Partners targeting the Rize of 3D printing

Europeans team up with Boston firm to speed up processes

HELEN KNIGHT REPORTS



Rize's industrial additive manufacturing solution creates full-colour parts with minimal post-processing

European software company Dassault Systèmes has partnered with additive manufacturing firm Rize in a move designed to make 3D printing faster and more accessible.

Boston-based Rize uses a patented additive technology known as 'Augmented Deposition', which combines material extrusion and material jetting. Its machines can deliver production-ready polymer parts with minimal pre-and post-processing, which the company claims helps engineers to iterate more quickly. Rize also says its additive process creates zero emissions and particulates, so machines can operate on a desktop next to a workstation.

The partnership will see Dassault Systèmes' SolidWorks design software closely integrated with Rize's additive portfolio, as well as a licence for SolidWorks bundled with every Rize machine sold in 2019.

SolidWorks is part of Dassault's 3DExperience platform which encompasses multiple software brands across CAD, simulation, manufacturing, PLM and ERP.

"Design for additive manufacturing is one of our priorities and to get it right you need the rich set of applications from generative methodologies, material science and advanced simulation available on the 3DExperience platform," said Gian Paolo Bassi, CEO SolidWorks, Dassault Systèmes.

> "Mutual customers will benefit"
>
> Gian Paolo Bassi, SolidWorks

"Therefore, mutual customers will benefit immensely from the strategic partnership between Rize and SolidWorks because they will be able to accelerate product innovation through a better integration between design, engineering, manufacturing and service."

Rize's client base already includes the US Army and Navy as well as NASA and Merck. According to Andy Kalambi, the company's president and CEO, partnering with Dassault Systèmes will help Rize expand its reach and tap into SolidWorks' multiple millions of users worldwide.

"We are delighted to partner with them to ensure that every part that is designed in SolidWorks comes with a haptic experience that enables everyone in the value chain to collaborate, communicate and innovate," said Kalambi. **AW**

Sheffield hub sparks a revolution

A new hub led by Sheffield University that combines expertise in electrical machines and manufacturing is aiming to put the UK at the front of the global electrification revolution.

The £28m EPSRC Future Electrical Machines Manufacturing Hub, which is underpinned by a £10m award from EPSRC, has been launched to drive UK expertise in the manufacturing techniques required to design and develop the electrical systems driving developments across sectors including automotive, aerospace and renewable energy.

Through the hub, which is led by the university's Faculty of Engineering and Advanced Manufacturing Research Centre (AMRC), researchers will work with industrial partners including Rolls-Royce, Airbus, Siemens Gamesa, GKN Aerospace, McLaren and Dyson on solving the challenges that will enable UK industry to manufacture electrical machines at an appropriate cost and with the right levels of flexibility and quality.

The Hub will also help address the skills shortage in electrical machine design and their manufacture.

Academic partners include Newcastle University and Strathclyde University's Advanced Forming Research Centre, based just outside Glasgow. **JE**

Contents

MACHINING

Low-cost smart sensors will boost productivity

AMRC's prototype device offers in-process condition monitoring to reduce machining stoppages. HELEN KNIGHT REPORTS

A smart tooling insert could improve productivity by carrying out in-process condition monitoring. The sensing device, developed by the Advanced Manufacturing Research Centre (AMRC) with funding from Innovate UK, will allow operators to monitor the condition of cutting tools without having to stop the machine for a manual inspection.

In this way it could save both time and money, according to Hatim Laalej, AMRC Machining Group technical lead for control systems, sensors and data acquisition.

"The standard procedure is [for operators] to keep watching the tool, and if they see anything untoward to stop the machine to check its condition," said Laalej. "But any stoppage is undesirable because you lose production time," he said.

What's more, operators will sometimes change a tool before the end of its life, in order to avoid damaging an expensive part if it does become worn, he said.

Cutting edge: The prototype

The prototype device, which uses low-cost electronics, is embedded with sensors that produce data about the current condition of the cutting tool. This data is then converted and sent wirelessly to the machine panel or the operator's control pad, allowing them to determine the condition of the tool without stopping the machine.

To embed the sensors into the tooling inserts, the team used lasers to etch a trench-like groove into the device. They then attempted to print sensors inside these trenches.

However, when they tested the inserts during machining they found the printed sensors came off, as a result of the harsh environment of titanium cutting.

"But when we cut the laser trench into a polycrystalline diamond cutting insert, it became conductive," said Laalej.

In this way, they found the insert itself could act as a sensor, he said. "When the tool starts wearing down, the resistance within that trench changes. If the tool is wearing down badly the voltage will increase, and that will tell the operator that they need to change the tool."

> "The voltage will increase and tell the operator they need to change the tool"

If the tool breaks it will break the circuit, alerting the operator.

The Innovate UK project was a collaboration between fellow High Value Manufacturing Catapult partner CPI, alongside Element Six, Advanced Manufacturing, BAE Systems, Printed Electronics, the National Physical Laboratory and DMG MORI. ■

PRODUCTION

Steel industry receives £35m funding boost

SUSTAIN plan for a carbon-neutral future

A seven-year research programme aims to make the UK's steel industry carbon-neutral by 2040 while simultaneously boosting jobs and productivity by 15 per cent.

These are the goals of SUSTAIN, a £35m research network looking to transform the steel supply chain by making it greener and smarter.

Dr Rachel Woods with a steel sheet at SPECIFIC

Led by Swansea University and partnered with the Universities of Sheffield and Warwick, SUSTAIN involves more than 20 partners across the UK steel industry. It is supported by a £10m investment from EPSRC.

Dr Cameron Pleydell-Pearce, a steel expert at Swansea University and SUSTAIN's deputy director, said: "We are already on the road to clean, green and smart steelmaking, but this is another giant step forward."

According to Swansea University, SUSTAIN will focus on eliminating waste from iron and steelmaking and will look at new ways of making processes and products more environmentally friendly. It will do this by looking at energy harvesting, carbon capture and re-processing waste streams. Similarly, SUSTAIN will develop new ways of acquiring and using vast amounts of data generated by steelmaking and using it in new metallurgical processes.

Prof Claire Davis, from WMG, University of Warwick said: "It is an exciting time. There are opportunities to contribute to making the planet a greener place."

SUSTAIN marks the first time that UK steel representatives and producers from the manufacturing sector have lined up behind a co-ordinated programme of research. The effort is projected to double UK steel manufacturers' gross value added by 2030, boost jobs in the industry to 35,000, and increase productivity. **JF**

3D PRINTING

Orbex unveils the world's largest 3D printed rocket

Scottish space firm's prototype is at the heart of plans to develop the UK's satellite launch capability

JON EXCELL REPORTS

Orbex Prime is a commercial rocket that's said to be 20 per cent more efficient than anything else in its category

Scottish space firm Orbex has unveiled an engineering prototype of a rocket that's at the heart of plans to develop a UK satellite launch capability. Designed to deliver small satellites into Earth's orbit, Orbex Prime is a two-stage rocket that is claimed to be up to 30 per cent lighter and 20 per cent more efficient than any other vehicle in the small launcher category.

It is also the first commercial rocket engine designed to work with bio-propane, a clean-burning, renewable fuel source that cuts carbon emissions by 90 per cent compared to fossil hydrocarbon fuels. The completed engineering prototype of the Stage 2 rocket (the stage that will transit into orbital flight after launch) is made from a specially formulated lightweight carbon fibre and aluminium composite, and includes the world's largest 3D printed rocket engine.

This was manufactured in a single piece without joins in partnership with additive manufacturer SLM Solutions. Orbex said that, given the extreme temperature and pressure fluctuations involved in space flight, this gives the engine an advantage over other rocket engines, which can suffer from weaknesses associated with joining and welding.

Lukas Pankiewicz is the applications specialist who headed the consulting team inside SLM Solutions to develop the parameters for this particular geometry.

"Our aim during the process was to fulfil the quality expectations of the Orbex team, keep the functionality of the part and make it suitable for additive manufacturing," he said.

"Every single support structure used in data preparation has been customised to obtain the best quality in every section of the engine, taking post-processing into consideration as well."

The company, based in Lübeck, Germany, used an SLM 800 large-format metal additive manufacturing system that features a 280x500mm powder bed that can build parts 850mm tall, allowing the Prime engine to be built in a special nickel alloy in a single piece. The SLM HUB unpacking system for the SLM 800 integrates contactless powder handling and automated build chamber conveyors to transfer the finished part to an unpacking station that removes powder through vibration and rotation.

After production, reference samples built with the engine were analysed in the SLM Solutions' metallography lab, where porosity level and distribution were shown to meet project requirements. ■

FORMING

Aerospace epoxy resin breakthrough

NCC tech processes batches of 400kg

Technology designed and delivered by the National Composites Centre (NCC) and Composite Integration Ltd will allow the processing of up to 400kg of high-temperature epoxy resin. Developed during a year-long project, the Large Scale Resin Infusion (LSRI) technology has been designed to meet R&D demands of aerospace and wind industry manufacturing, where components can range from 17m to 120m long.

Liquid Composite Moulding (LCM) is used to produce high-integrity composite parts without the need for an autoclave. Using LCM, fibres are first assembled 'dry' into a mould, resin is then pumped into the fibres and drawn through under vacuum prior to being cured in an oven.

The NCC identified the need for LSRI capability as part of its iCAP Programme, a £36.7m investment in 10 digital manufacturing

technologies being installed. The first application of this technology, available to companies across Britain, will be to enable infusion of complete wing components as part of next generation wing technology developments. Data collected by the machine will help NCC deliver 'Industry 4.0' for composites.

The new system is capable of injecting high resin volumes into a variety of preforms primarily – but not limited to – using a vacuum bagged set up. The modular machine can process single or two-part resin systems with a 20m oven for curing.

"There was a need to develop machinery capable of processing up to 400kg of high temperature epoxy resin. This is the first machine that can process this resin in batches larger than 50kg," said Simon Vincent, design and engineering manager at Composite Integration. JF

Converging technologies

Machine tool giants celebrate market growth for traditional products, while keeping an eye on complementary AM developments. Mike Excell reports

The machine tool sector – is it healthy? Well, for Yamazaki Mazak, 2018 produced record sales, and despite marketplace uncertainty, user sectors such as automotive, oil and gas, and medical markets performed strongly.

Pointing to the welcome resurgence of the oil and gas market, the company's Alan Mucklow commented: "We saw great success with machines from the larger section of our portfolio, such as our Integrex e-H range of Multi-Tasking machine tools, as well as Megaturn vertical turning centres."

DMG Mori would no doubt support this positive take on the market. Last year, the company invested €60m (£51m) to extend and improve one of its largest factories, a key element being digitisation of the entire process chain, from receipt of order through to shipping.

At the Famot factory in Pleszew, Poland, 50 machine tools now work around the clock, handling over 140,000 parts a day. By 2020, it will be producing more than 2,000 CLX and CMX lathes and machining centres with 3D touchscreen controls; plus 2,000 machine frames, and components and parts for group companies worldwide.

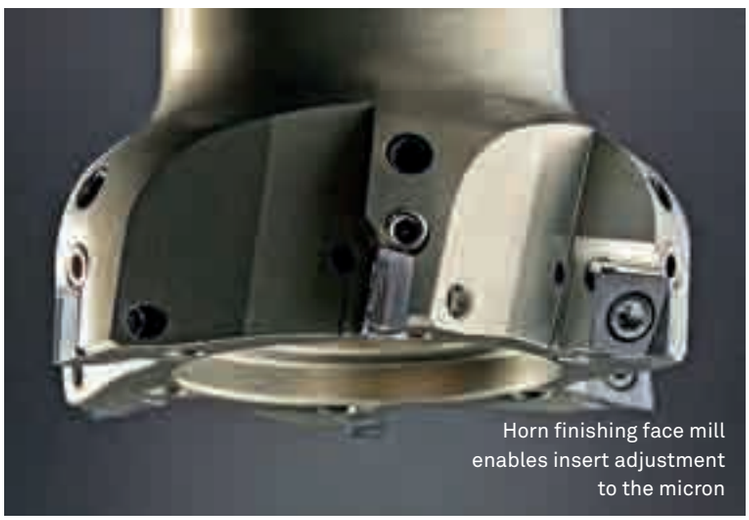
It is the first DMG Mori plant to operate digitally on all added value levels. Dr Michael Budt, chief strategy officer for the factories in Famot, Graziano (Italy) and Ulyanovsk (Russia) comments: "DMG Mori supports its customers on their path to Industry 4.0. If we are to offer targeted solutions, we have to develop our own digital infrastructures so we experience first-hand how digital transformation can be successfully implemented in practice. In this respect, the regenerated Famot factory represents a milestone for our group. New software systems have combined existing, isolated production areas into an integrated, agile network. The project has introduced efficient, fast and safe production processes as well as sustainable increases in productivity, quality, transparency and responsiveness."

Additive developments

Meanwhile the company has raised its profile in metal additive manufacturing (AM) by taking a 30 per cent stake in the Indian company INTECH, a developer of software for AM, machine learning and AI.

DMG Mori's Christian Thönes commented: "We are actively pushing ahead with integrated solutions along the whole generative manufacturing process chain."

AM is gradually becoming established as a complementary technology to traditional metal removal production methods, with many key machine tool suppliers forging partnerships with AM specialists. Matsuura Machinery for example has been appointed as an authorised reseller for DyeMansion, a Munich company specialising in finishing systems that transform raw 3D printed polymer parts into high-value products. The systems are compatible with most leading powder-bed technologies. Meanwhile Kingsbury reports that one of its principals, French AM equipment manufacturer AddUp and virtual prototyping pioneer ESI, have combined to create Distortion Simulation AddOn, an ergonomic simulation module designed specifically for metal 3D printing.



Horn finishing face mill enables insert adjustment to the micron

Protecting the roots

At the same time, Kingsbury stays close to its machine tool roots, introducing the FZH400, a 6-axis, horizontal machining centre from German manufacturer Zimmerman. The machine targets production of structural aerospace components.

It is equipped with an integrated, expandable pallet change system that automatically loads the component into the vertical plane for machining; the new configuration uses gravity to allow efficient removal of the large amounts of aluminium swarf generated from solid billets. A dedicated website – www.fzh400.com/en – demonstrates the machine's construction and operation.

Multi-axis strategies proliferate in what used to be regarded as the lathe market, and the sophisticated equipment now being used to make complex parts challenges definitions. Subcontract fastener specialist NDB Engineering exemplifies this, spending £500k during 2018 on turn-milling technology from Citizen. This budgeted spend (funded through Citizen's tailored finance package) covered two 5-axis Citizen Cincom L20-VIIILFV sliding head turn-mill centres, an 8-axis Miyano BNE-51MSY fixed-head, turn-mill centre plus Citizen's Alkart CNC Wizard programming aid.

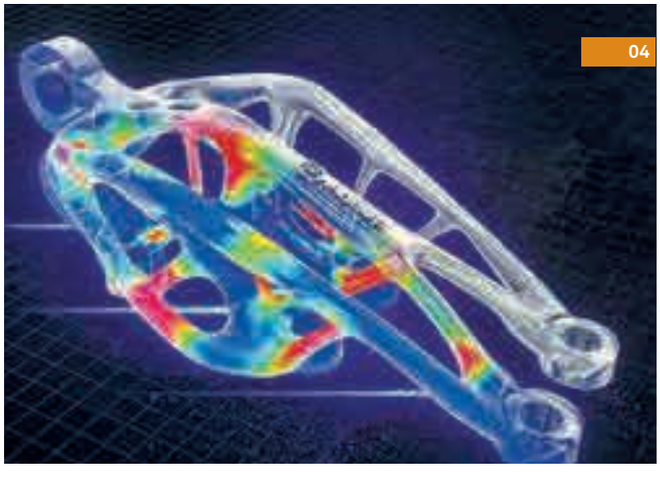
The Citizen machines feature Low Frequency Vibration (LFV) technology. NDB director Rebecca Dainter reflects on how, when this became available, the company saw the potential to bring greater security and control when machining difficult materials: "By eliminating swarf nesting problems that demanded constant attention from the setters, these have disappeared. We have improved productivity by having the confidence to run unmanned and on many parts we can go through the night – giving us a massive leap in capacity with the added bonus of one setter operator running three machines."

01

02 The enlarged production hall at DMG Mori's Famot factory

03 DMG Mori has taken a 30 per cent stake in an Indian AM specialist

03 AddUp and ESI collaborate on ergonomic simulation module



04

02

Meanwhile, XYZ continues to provide accessible technology to companies keen to enhance their CNC capability. Scottish Robotic Systems makes special-purpose machines, including printing systems used in the electronics industry to aid stock management of small components. For machined parts the company controls design, product development and manufacturing in-house, made possible through continuing investment in XYZ machine tools over two decades.

Three ProtoTRAK turret mills have recently been joined by two XYZ vertical machining centres, a VMC 710 and a high speed 1060 HS. The XYZ machines saved weeks in product development, as director Ross Walker explained: "We could make parts quickly, when we needed them without relying on external suppliers; we machined things ourselves, speeding up the prototyping process and spending less time drawing parts." Drawings are now done using CAD systems for prototyping and the files are then post-processed to be downloaded to the machines' Siemens controls. And there's a bonus: speed of operation has created opportunities to bring in some sub-contract work from other suppliers. It's a classic example of how targeted investment – always important – can nevertheless create unexpected growth potential ■

Cutting tool developments

Smart tooling

AMRC Machining Group has developed an intelligent, low-cost tooling insert with smart sensors to deliver in-process condition monitoring that reduces stoppages and improves productivity.

The prototype, developed with Innovate UK funding, allows an operator to determine the condition of a cutting tool without manual inspection. It is the first 'plug and play' system with no process learning time needed on installation.

The insert's embedded sensors produce data on the condition of the cutting tool. This data is sent wirelessly to the machine panel or operator's control pad to enable a decision about the condition of the tool, while machining continues.

AMRC successfully installed the prototype on its DMG Mori NT5400 DCG 5-axis turning machine. PCD and PCBN cutting inserts with embedded sensors were used to machine titanium Ti-6Al-4V and Inconel 718 bars respectively.

More productive drilling of aluminium

When drilling aluminium for automotive parts, grade and coating technologies must combine to deliver longer tool life and less built-up edge (BUE). Sandvik Coromant has developed an optimised drilling solution; both solid carbide and veined polycrystalline diamond (PCD) grades have been developed as part of CoroDrill 400 and CoroDrill 430. A new N1DU veined PCD grade provides PCD across the entire cutting edge, which means longer tool life. Due to PCD's low coefficient of friction and high conductivity of heat, the tool's cutting edges are less susceptible to BUE. In addition, the flute geometry on CoroDrill 400 and 430 is designed to perform optimised chip evacuation in solid or cored material respectively.

Lightweight face milling cutters

Horn has expanded its DTM lightweight milling system to include two new versions. DTM. CX09 arbour milling cutters are roughing tools for use in machining applications that involve high cutting depths and place fewer demands on surface quality. The DTM.CX09.AL.F face milling cutter for finishing adds an adjustable body to the existing product range. Axial run-out can be adjusted easily to the exact micron using a presetter. The aluminium body of the tool holders has low mass, resulting in reduced energy consumption during acceleration and deceleration. Its weight is less than that of a steel milling cutter for faster spindle speed changes and highly dynamic machining.

04 Zimmermann's new spindle head provides ± 140 B-axis motion

05 Sandvik Coromant's Corodrill in action

Uncertainty is the only thing certain with Brexit

While there are plenty of success stories to celebrate in UK manufacturing, the fear of no deal has created a real-world squeeze on business investment, writes MTA's Paul O'Donnell

Trying to write about Brexit is a bit of mug's game; on one level there are twists at every turn but on another, deeper level – the one that actually matters – very little is actually moving. The only constant has been the uncertainty that has faced manufacturers trying to plan for the future.

That uncertainty has had real-world effects. Business investment has slowed and companies up and down supply chains are stockpiling. That is tying up cash which could be used productively in stock. Companies that are unfamiliar with customs regulations because they have only traded within the single market (at least in the experience of those working there) are having to undertake crash courses to prepare.

Those with complex international supply chains are having to get to grips with Rules of Origin to determine which tariffs their goods will be subject to. Reassuring customers, wherever they may be, has been an important part of many jobs. And, of course, there have been many companies who have had to make sure that their staff from across the EU27 know they are valued and wanted in their roles.

All this has been played out against a backdrop of a slowing global economy, too. Uncertainty about the strength of the Chinese market, not least because of the threat of a trade war with the US, has had a damaging effect across the world. Add in the travails of an automotive industry struggling to come to terms with the speed at which consumers seem to be moving away from diesel (and huge regulatory change) and the picture can look pretty bleak. In some ways it is almost surprising the economy hasn't taken a bigger hit.

"In some ways it is almost surprising the economy has not taken a bigger hit"

But there continue to be plenty of success stories in UK manufacturing and the challenges of adapting to new technologies and maintaining international competitiveness are becoming even more urgent. If a deal which preserves for British companies many of the benefits of single market can be done, then there is reason to look forward to a future in which the UK can stay aligned to its biggest market while renewing its impetus in markets around the world. There are signs that is happening; this year has seen the MTA host the first UK Pavilion at India's biggest manufacturing technology show and, in Beijing in April, we will have a record footprint at China's.

Leaving the EU without a deal, though, risks not only short-term dislocation – and the arteries of supply, once severed, may be more difficult to reconnect than people think – but also making our firms less competitive in the longer run. The single market has enabled companies to cut costs out of their operations. Putting them back in will be detrimental; it's an incremental process but one which will add up.

Rules of Origin will determine which tariffs goods may be subject to

At the MTA we oppose leaving without a deal, not because we are pushing 'project fear' but because we can see what it already happening, know how competitive our globalised industry is and want to avoid our companies facing unnecessary barriers in the future. ■

Paul O'Donnell is head of external affairs at the Manufacturing Technologies Association (MTA)

Impact assessment

Expecting the unexpected: David Mold, left, and Mark Ridgway are having to deal with Brexit headaches

Three prominent manufacturing bosses describe how their businesses are dealing with the uncertainty over Brexit

Manufacturing industry bodies like MakeUK (formerly EEF) and MTA (see previous page) have worked hard to articulate their members' concerns over Brexit with a unified voice.

But to put some flesh on the bones of these warnings, fears and concerns, we asked a small cross-section of UK-based manufacturing technology suppliers about the current and anticipated impact of Brexit on their businesses.

- **DM:** David Mold is managing director of Blum-Novotest UK
- **DW:** David Wilkins is managing director of Kaltenbach Ltd
- **MR:** Mark Ridgway OBE is CEO of Group Rhodes Ltd

Has Brexit uncertainty affected your business? If so, how? If not, why do you think this is the case?

MR: Yes. Group Rhodes Ltd manufactures high-value capital equipment for a number of industrial sectors, including aerospace, automotive and construction. The majority of projects involve a degree of dedicated design work necessitating close communication with the end user. We have several instances where the project work has been completed and awaits customer order placement, but market uncertainty has been quoted as a reason for delay.

DM: Uncertainty has definitely affected our business and, in particular, some production decisions we have made.

After discussions with our parent company in Germany, we took the decision to increase stock levels for all of our laser-control, tool-setting probes, workpiece probes, roughness gauges, bore gauges and DIGILOG touch probes.

This is all about ensuring we have enough technology in place to meet an increasing demand from our UK customer base, guaranteeing the end user can have confidence that they can access the latest 'in-machine' metrology solutions.

As we still don't know what the 'deal' will look like, we have to make the necessary investment to ensure our clients are not left in the lurch. Feedback we've received suggests that this proactive response has been widely welcomed by both the machine tool dealers we supply and our end-user clients.

Regardless of which way Brexit plays out, Blum-Novotest is 100 per cent committed to the UK and still sees us as one of the world's leading industrial markets.

DW: At present, we have an unprecedented level of enquiries and quotations. We have made a lot of changes as a business here in the UK and I'm sure that has something to do with it but by no means all.

What are your customers saying to you about Brexit?

DM: If you looked at our order book and how well we have done at the start of 2019, you would be forgiven for thinking that Brexit isn't actually happening. We have seen a 20 per cent surge in orders and, after attending a very busy Southern Manufacturing Show, this is further reinforced by the tens of thousands of conversations we had with people over the course of the event.

There is definitely a nervousness in the air, but I think industry is just taking the approach that we'll press on regardless of the fun and games the politicians prefer to indulge in.

MR: The uncertainty is potentially more damaging in the short term than the prospect of the Brexit process itself.

DW: Most customers are expecting some slowdown, but not for 12-18 months. In the steel processing sector with contracts being awarded well in advance, these are already in process. It will be the next raft of contracts that are expected to be affected.

What impact do you think a no-deal Brexit will have on your business?

DM: It will have a significant impact, there's no getting away from it. Manufacturing is a global business with a big European footprint – you only have to look at the automotive and aerospace supply chains for evidence of that. Industry needs a deal.

MR: It is the indirect impact on our stakeholders that is the most concerning. As our supply chain is mostly UK-based and our exports are to territories outside of the EU, we believe the direct impact of Brexit is manageable.

It is the indirect consequences of a weakening manufacturing ecosystem, reductions in inward investment and customers losing market share that is the main concern.

How are you preparing for a no-deal Brexit?

DM: What does no deal look like? We have to consider what the worst possible outcome could be and put plans in place to mitigate those scenarios. This has taken up a lot of time and investment, which we hope we never need to call upon.

DW: We have made preparations. We issued a statement to our customers outlining our position and the steps we have taken to maintain certainty of supply and engineering support.

We have (with the backing of our group) taken a large volume of spares in stock to mitigate against any delays with customs and tariffs, whatever level they may be.

MR: The usual precautions. A Brexit clause in our conditions of sale, increased engagement with Brexit-readiness bodies, supply-chain mapping, currency-hedging on long-term contracts, consideration of AEO status, CE marking status, skills/employee nationalities audit, corporate resources available for increased import/export administration, checks on rules of origin exposure, confirmation of adequate cash flow in the event of trade delays, readiness to reapply for EU property rights status, etc. ■

Med-Tech puts you at the cutting edge

Featuring 4,000 designers, engineers and innovators, this event is the UK's leading showcase for medical technology

Running over May 15 and 16 at the NEC Birmingham, the Med-Tech medical device design and manufacturing technology event will bring together designers, engineers, innovators and manufacturers from the medical and healthcare sectors.

Expected to attract at least 4,000 attendees, this year's event will feature around 200 exhibitors showcasing the latest machines, technology, products and services, and carrying out live demonstrations.

Exhibitors include Renishaw Plc, Renfrew Group, Cambridge Design Partnership and Medilink UK, and span product areas ranging from diagnostic equipment to new materials.

Alongside the exhibition a dynamic conference programme spread across three separate stages will update delegates on some of the key trends and technologies that are shaping the future of the sector.

In the main Med-Tech Innovation theatre speakers will touch on some of the sector's most critical topics.

Dr Sam Roberts, director of innovation for NHS England's Research and Life Sciences Group, will be looking at the challenges of supporting innovation in the NHS.

Newcastle University's Prof Kenneth Dalgarno – a former winner at *The Engineer*'s annual Collaborate To Innovate awards – will give an overview of the growth of the use of 3D printing in the manufacture of medical devices and the potential for bioprinting in the generation of combination products.

Among the presenters on the second day will be Mark McIntyre, senior director of health economics and government affairs at Boston Scientific, who will be examining how the changing needs and demands of clinicians, patients, managers and policy-makers influence product design.

Over at the HealthTech Stage, delegates will be able to learn about some of the new healthcare innovations set to transform the sector. Presenters here include Dr Lydia Yarlott, founder of Forward Health, who will explain how she has navigated a tiny start-up through a UK regulatory landscape with a reputation for killing off technology.

In addition, Ilika Technologies' Denis Pasero will be talking about how some of the latest developments in energy-efficient sensing technologies are creating opportunities for continuous health monitoring.

3D printing is also a recurring theme in this theatre, with AMFORI Consulting's Steve Cox looking at how 3D design and fabrication technologies are influencing the disability sector, and Sarah Trenfield, director of innovation at FabRx exploring the world of 3D printed pharmaceuticals.

Finally, no conference stream would be complete without some mention of Brexit and this will be covered by Eleanor Charsley, external affairs manager with ABHI, the UK's leading HealthTech trade association.

The third stage, the Med-Tech Introducing Stage, is new this year and will provide a showcase for new product, service and even company launches.

Another innovation for this year's event is the Acceleration Zone, which will provide investors and business owners with an early view of some of the disruptive spin-outs and research projects that will shape the sector further into the future. ■

■ To find out more and to register for this year's event visit https://med-techexpo.com

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March 1948

Eco ahead of its time

The Engineer takes a trolleybus trip down memory lane

London has a well-documented problem with its air, the quality of which is estimated to cause 9,400 premature deaths a year

Consequently, efforts are being made across the capital to introduce an ultra-low emissions zone that will impose charges on road vehicles that fail to meet clean air criteria.

Efforts toward this laudable goal include the introduction this year of 240 electric double-decker buses on to the network, where they will join more than 2,600 diesel-electric hybrid buses helping to deliver over two billion passenger journeys a year. A further 4,100 Euro VI compliant buses are helping to improve air quality in a city that is phasing out diesel-engine buses.

Electric-drive is currently playing its part in solving a problem brought about by noxious vehicle emissions, but in 1948 London's transport chiefs were already part-renewing a fleet of zero-emission vehicles that were popular with passengers, very reliable and hadn't required major changes to infrastructure to roll them out.

London's trolleybuses first appeared in May 1931 and by September of that year London United Tramways (LUT) had 60 vehicles each carrying up to 56 passengers operating on five routes – formerly served by trams – in south west London.

By 1933 LUT was taken over by London Passenger Transport Board (LPTB) which took the same approach to using tramways to grow the trolleybus network and fleet. According to Transport for London's Corporate Archives Research Guides, the tram network suffered from obsolescence, was expensive to run, and seen by the public as being old fashioned and a cause of congestion. The motor bus as we know it was in its infancy and wasn't yet viable in terms of passenger capacity or operating cost. The tram network did, however, leave a legacy in the form of working power stations, substations and high-tension overhead cables that would help give trolleybuses the infrastructure to expand to 1,764 vehicles – 1,600 of which were 70-seat double-deckers.

The Engineer described this expansion as "by far the largest and most successful trolleybus undertaking in the world", little knowing that London's trolleybuses would operate until 1960 and, with the exception of two units, be sold to transport operators in Spain.

The new Q/1 trolleybus was 30ft long and 8ft wide, an extra six inches that added "very considerably to the comfort of the passenger" and widened the vehicle's gangway.

"A further concession... has made it possible to provide a larger platform, enabling the conductor to stand underneath the staircase, thereby giving unimpeded entrance and exit to and from the lower and upper saloons," said *The Engineer*'s correspondent. "Such a platform and the extra width of the vehicle render practicable a staircase with an additional step, allowing easier ascent to the upper deck."

The vehicle's two batteries – described as NIFE nickel cadmium LS5s with a 52-ampere-hour capacity – could also be found beneath the staircase and were connected in series for traction and in parallel for lighting. The Q/1's all-metal bodies were built by Metropolitan Cammell Weymann Motor Bodies, Ltd, and chassis were provided by British United Traction Ltd.

"They are of the six-wheel type, resulting, it is claimed, in improved springing, as compared with the two-axle design, and at the same time giving additional width between the facing seats of the lower deck and providing more space for standing passengers and movement generally," *The Engineer* said.

Westinghouse Brake and Signal Company Ltd supplied the Q/1's pedal operated electric and air brakes, with our correspondent noting "the air brakes have complete equalisation, in that the shoes on each of the six drums are operated by independent cylinders. A visual and audible low-pressure air alarm has been installed, whereby, if the air drops to a pressure of 50lb per square inch and the compressor fails automatically to restore the pressure, the driver has ample notice to enable him to stop with safety. An improved brake drum section to lessen distortion and the provision of high-lift cams will, it is anticipated, considerably lessen maintenance work and possible delays."

The Q/1 was preceded by a fleet of type 201 trolleybuses. Nicknamed Diddlers by those who travelled on them, the 201 gave London Transport "500 million miles of practically trouble-free service". Lessons learned from its operation were carried forward into the Q/1's design, including the vehicle's traction motor, which was designed and built by the Metropolitan-Vickers Electrical Company. Further improvements were incorporated, including flood-proofing and a redesigned fan giving improved cooling. ■ JF

Word of the issue

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

Activating a machine requires a device to change it from not operating to a state where it does what it is designed to do. The most obvious is the electrical switch but the same criteria applies to, for example, the steam engine when steam pressure is released into the system and the engine performs its task.

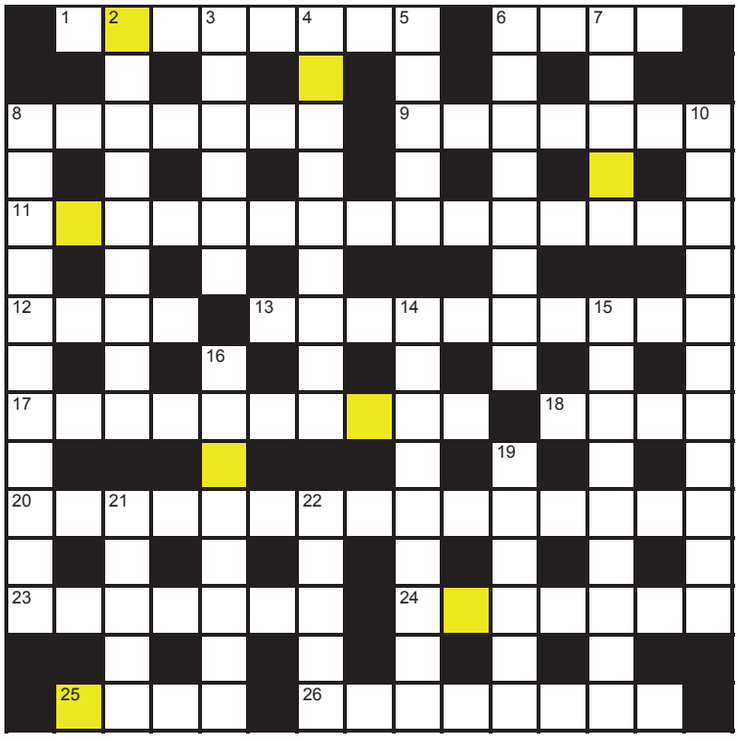
The idea of a switch to turn a machine on is a comparatively new concept. In the electrical field it is not seen before 1881. However, it was used from about 1853 (more often in the USA) to refer to points on a railway track.

A switch was also once an actual stick, as seen in the signal box levers of heritage railways or lights and electrical sockets before the 1960s. Tracing the word through our Germanic tongues, we find swijch (bough, twig), zwuske (long thin switch) and zwec (wooden peg). Compare those terms to 'switch' when referring to a slender riding whip and it retains the onomatopoeic origin of when used in a whip-like action to make a "swish" sound.

Bigpicture

ATIR being towed from Vigo at sunset

Magallanes Renovables' 2MW ATIR platform has been installed at EMEC's tidal test site at the Fall of Warness in Orkney, Scotland. The 350mt tidal energy device is 45m long and generates electricity via two 19m-diameter turbines placed underneath the vessel. The successful installation marks a major milestone in the Ocean_2G project, which aims to test, validate and pre-certify Magallanes' device. **Image: Magallanes**



Prizecrossword

When completed rearrange the highlighted squares to spell out **a solution that cools to form pearlite**. The first correct answer received will win a £20 Amazon voucher. Email your answer to **jon.excell@centaur.co.uk**

Across

1 Bugs in a computer system (8)
6 Component of a machine (4)
8 Colourful garden plant (7)
9 Suppress or crush completely (7)
11 Of the science of human relationships (15)
12 Prefix meaning identical to
13 Having a common centre (10)
17 Shiny solid resistant to corrosion or oxidation (5,5)
18 Cylindrical vessel that is open at the top (4)
20 Extraneous naturally occurring sounds (10,5)
23 Applied oneself to an occupation (5,2)
24 Device that measures the flow of electrical current (7)
25 Determines the sum of (4)
26 Cause to move into a new position (8)

Down

2 Glass housing with a filament (5,4)
3 Give life-time employment to (6)
4 Electric device worn over the ear (9)
5 Plant fibre used for making rope (5)
6 Filling or closing tightly (8)
7 Antiquity from the distant past (5)
8 Simple hand drill (5,3,3)
10 Coil-shaped toothed wheel (7,4)
14 Toothed devices used to cut timber (9)
15 Not abstract or ideal (9)
16 Chemical compounds used in reactions (8)
19 Paint that dries to a hard glossy finish (6)
21 Formed a coat over (5)
22 Rounded like an egg (5)

February's highlighted solution: **AUSTENITE.** Winner: **Mark Entwistle**

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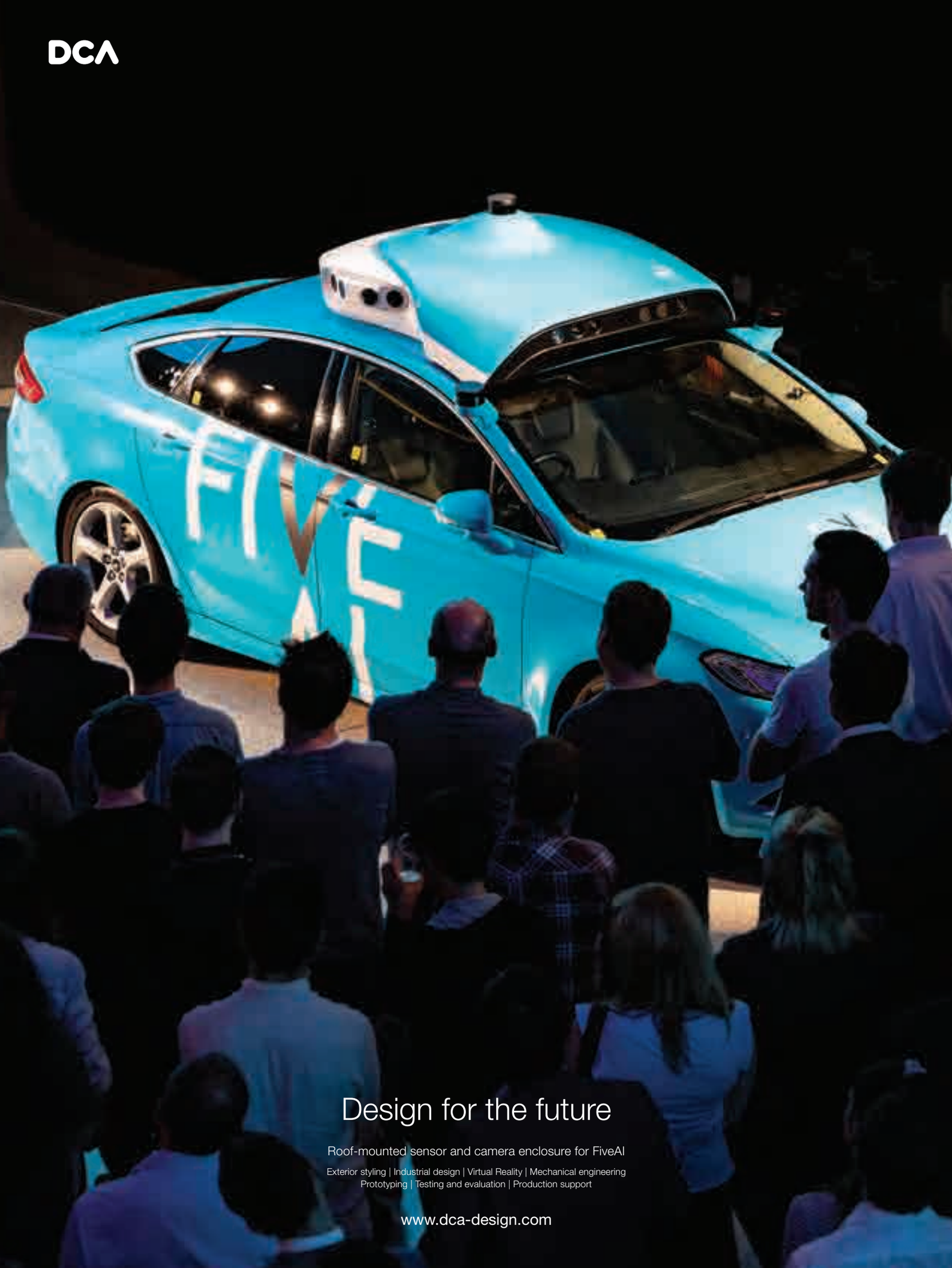

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