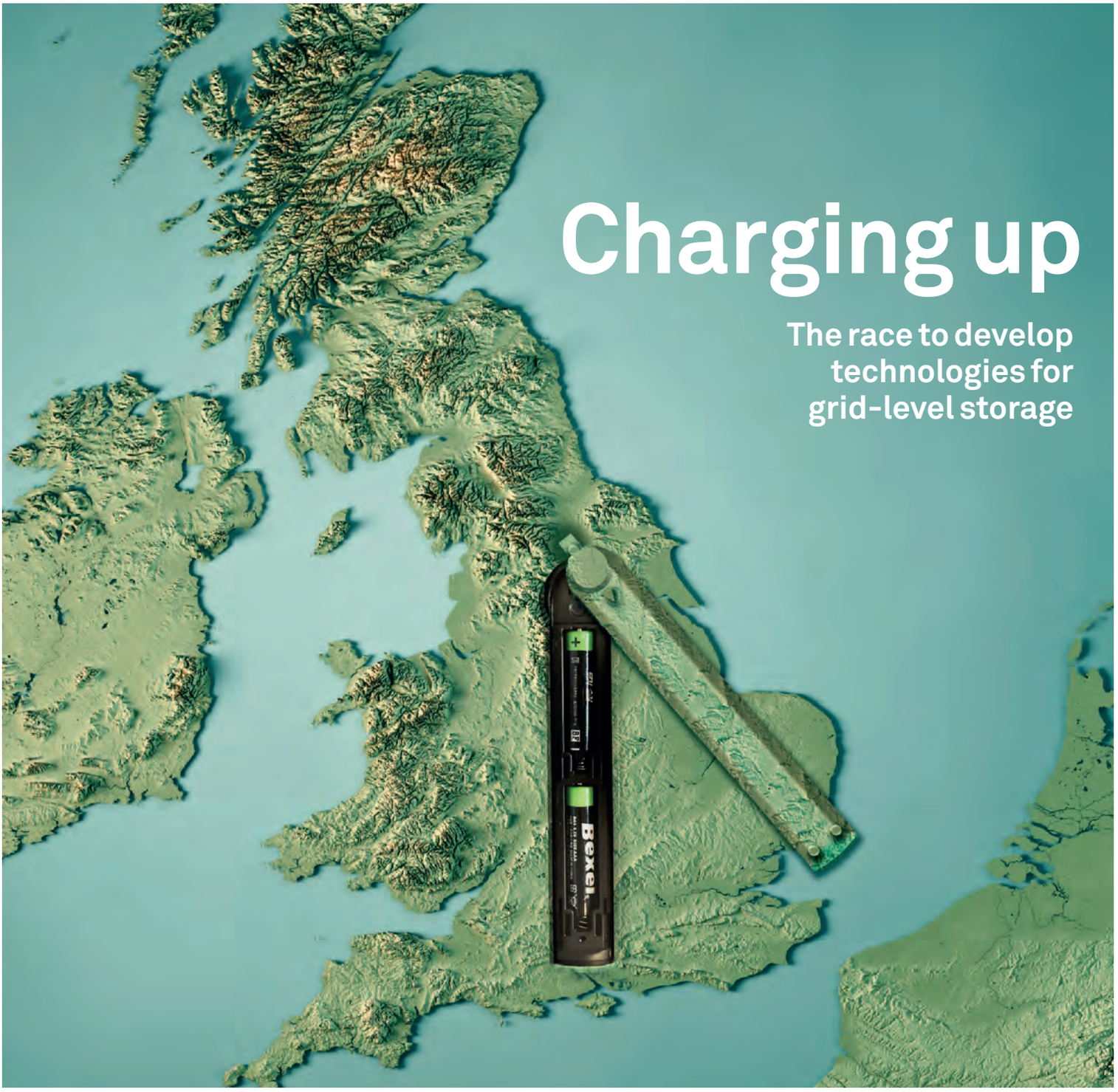
160 years of innovation
theengineer.co.uk
April 2018 | £3.70

the ENGINEER

FIRST FOR TECHNOLOGY & INNOVATION



Charging up

The race to develop technologies for grid-level storage

Smallholding

Why smaller farming machinery may be key to hands-free agriculture

»24

Contracting role

The chief technology officer of Assystem on the firm's new focus

»26

Ice, ice baby

Taking a spin on the frozen lakes of Sweden with GKN Driveline

»28

Future is plastic

Preview of the PDM plastics design and manufacture showcase

»34

Reinvent how you prototype and produce functional parts.

- Up to ***10 times faster*** than any 3D print technology on the market today.
- Print rate up to 4500 CM^3 per hour.
- Up to 80% recyclable and reusable material.
- Eliminate injection mould tool costs.
- Patented Multi Jet Fusion technology.
- Quick and simple installation.
- Full support with next business day service available from HP and XYZ.
- Full training from certified HP and XYZ staff.
- Perfect for long and short production runs.
- Quick and simple operation.
- No mess.
- Clean and easy to use HP smart screen programming.
- Import STL and other 3D solid model files.
- Multiple material printing.
- Unmanned operation.
- Configurable for continuous production printing.

HP Multi Jet Fusion 3D Printer with Processing and Fast Cooling Stations

Live at **MACH 2018**

STAND H18-640

FROM ONLY £29,450 +VAT

XYZ 500 LR

18 HP SPINDLE
580x400 mm TABLE
510x400x450 mm TRAVEL
8000 RPM SPINDLE
(12000 RPM optional)
SOLID CASTING 2400 KG

XYZ 750 LR

18 HP SPINDLE
830x410 mm TABLE
750x440x500 mm TRAVEL
8000 RPM SPINDLE
(12000 RPM optional)
SOLID CASTING 3500 KG

XYZ 1000 LR

18 HP SPINDLE
1060x500 mm TABLE
1000x500x500 mm TRAVEL
8000 RPM SPINDLE
(12000 RPM optional)
SOLID CASTING 4600 KG

Options on spindle speeds and tool changer capacities are available.

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

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

XYZ Machine Tools

Tel: 01823 674200 Fax: 01823 674201

MACHINE TOOL DEMOS ARE AVAILABLE AT ANY OF THE XYZ UK

SEE THEM ALL LIVE STAND H18-640

24/7

A fully integrated loading and tending system for both Milling and Turning.

Wheel in blank billets - wheel out the finished batch.

XYZ ROBO-TEND

- Minimise labour costs.
- Works 24/7 without holidays, tea, chatting or comfort breaks.
- Finance from less than £2 per hour.
- Payback can be just a few months if purchased outright.
- British designed and built.
- *KUKA Cybertech Robot* as standard.
- 10 kg Robot capacity (larger available).
- Vision system.
- Modular system cabinet or conveyor feed.
- Quick and easy change from one machine to another with conversational set up.
- Operates with machining or turning centres.

The **XYZ** ***ROBO-TEND*** will fit most makes of machine tools, and can be in production within hours of delivery.

XYZ UMC-5X

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

FROM £149,150 +VAT

DIRECT DRIVE HIGH TORQUE MOTOR 90 RPM NO WORM OR WHEEL

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

extended warranties, free programming helplines, nationwide service engineers.

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

SHOWROOMS DEVON BLACKBURN NUNEATON SHEFFIELD & LONDON

35 YEARS OF XYZ EXCELLENCE SINCE 1984

What did you want to be when you were young?

Your ambition has led you to the fast-changing world of engineering. And your ideas are shaping its future. But to do what you do best, you need the time to focus on what really matters.

For 80 years we've been helping customers achieve their goals through our extensive range of industrial maintenance and electronics products, and world-class service.

We're here

for the **inspired**

High stock availability | Expert technical help | Next day delivery

RS

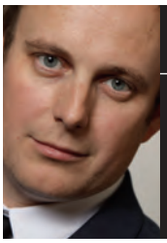
this**issue**

Volume 298
Issue No. 7897
Established 1856

news

opinion

features



our**opinion**

UK can take charge

As renewable energy sceptics never tire of proclaiming, wind turbines don't work when the wind doesn't blow and solar doesn't generate when it's cloudy.

Despite the fact that solar panels do actually generate when it's overcast, the naysayers do, of course, have a point, and it's an issue that the energy industry has been grappling with for a number of years.

Indeed, the development of storage systems to smooth out the intermittent nature of renewable energy sources (specifically wind and solar) and enable them to make a more meaningful and predictable contribution to the Grid has long been seen by many in the sector as a critical component of our future energy infrastructure.

> "It's an issue the energy industry has been grappling with for years"

Over the years, *The Engineer* has looked in detail at many of the technologies that could play a role here: from pumped hydro schemes utilising well-established technologies from the Victorian age; to systems that use surplus electricity to electrolyse water and generate hydrogen for use in fuel cells; as well as even more esoteric approaches, such as compressed air energy storage systems that could, for instance, store excess energy from offshore wind turbines in giant subsea air bags.

All of these technologies perhaps have their place, but in this issue (cover story, pages 20-22) we turn our attention to what is surely the most promising technology for mass deployment: the battery, or to be more technical, the very big battery.

Unsurprisingly, given its founder's talent for grabbing the headlines, the best-known grid storage facility today is Tesla's imaginatively monikered Big Battery: a 129MWh output facility in South Australia, set up to store energy from nearby wind and solar schemes. As previously reported by *The Engineer*, the facility uses a large array of the firm's Powerwall units: stationary lithium ion energy storage units originally developed for the home.

But Tesla's not alone. As we report, engineers in China are currently producing components for an even bigger 800MWh output battery, and here in the UK – where the lithium ion battery was invented – engineers and researchers are looking at a range of alternatives to lithium ion; making big strides in our understanding of how large-scale energy storage solutions can be integrated into the Grid, and working hard to position the UK as a major player in this critical transitional technology.

Jon Excell Editor
jon.excell@centaurmedia.com

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

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

Direct dial 020 7970 followed by extension listed Advertising fax 020 7970 4190 **Editor** Jon Excell (4437) jon.excell@centaurmedia.com **Features editor** Stuart Nathan (4125) stuart.nathan@centaurmedia.com **Senior reporter** Andrew Wade (4893) andrew.wade@centaurmedia.com **News editor** Jason Ford (4442) jason.ford@centaurmedia.com **Recruitment advertisement manager** Michael Maunsell (020 7970 4679) michael.maunsell@centaurmedia.com **Business development manager** Jason Padam (4677) **Commercial director** Sonal Dalgliesh (4487) sonal.dalgliesh@centaurmedia.com **Senior account manager** Richard York (4942) **Production** 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

The Engineer is available for International licensing and syndication. For more information please email simon.lodge@centaurmedia.com
NEWS 020 7970 4442 DISPLAY 020 7970 4487 RECRUITMENT 020 7970 4110 SUBSCRIPTIONS/CUSTOMER SERVICES HOTLINE 020 7292 3705

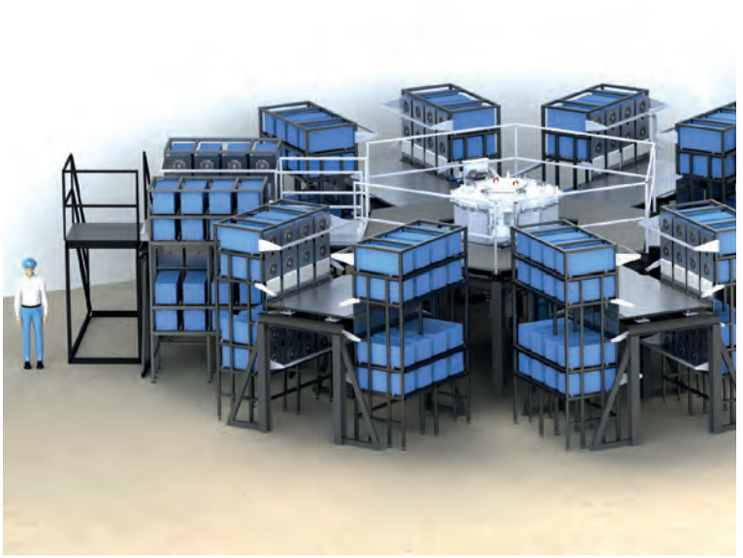
CENTAUR MEDIA

ENERGY

UK company looks to shrimp in bid to transform fusion

Sea creature's shock-wave technique is the basis for £3.6m machine

HELEN KNIGHT REPORTS



A UK company is hoping to take a step towards generating low-cost, sustainable energy from fusion, with the installation of a machine designed to trigger the reaction.

Fusion, the process that powers the Sun, involves fusing two lighter atomic nuclei to form a single heavier one, releasing huge amounts of energy in the process. It is seen as a potentially limitless source of cheap, carbon-free energy, since its main fuel is a heavy isotope of hydrogen called deuterium, which is contained in sea water.

However, despite decades of experiments around the world, no organisation has yet been able to produce a self-sustaining fusion reaction capable of generating more energy than it consumes.

Now Oxford-based First Light Fusion, which is investigating energy generation from a process known as inertial confinement fusion, is investing £3.6m in a machine designed to trigger a reaction at a much lower cost than existing technology.

Their approach is inspired by the pistol shrimp, which clicks its claw to produce a shock wave that stuns its prey – the only known example of inertial confinement found on Earth.

The device, known as Machine 3, is a pulsed power machine, designed to discharge the energy needed to fire a high-velocity projectile at a target, generating a process known as shock-driven cavity collapse.

As the projectile hits the target, it generates very high pressure, creating a shock wave that is transmitted through the target, according to Dr Nicholas Hawker, founder and chief executive officer of First Light Fusion.

"The shock wave hits a cavity, a circular void within the target filled with fusion fuel, and causes it to collapse extremely quickly," said Hawker. This should create the intense temperatures and densities needed for a fusion reaction.

Machine 3, which is already under construction and is due to be completed by the end of the year, will be capable of discharging up to 200,000 volts and in excess of 14 million ampere – the equivalent of nearly 500 simultaneous lightning strikes – within two microseconds.

The high-voltage machine consists of a bank of capacitors, all of which are charged to 100kV and discharged in parallel. Like all pulsed power machines, it is capable of storing energy over a long period of time and then discharging it very quickly.

If successful, the process should be far cheaper than laser-driven inertial fusion, the approach being pursued at the National Ignition Facility (NIF) in California.

"The cost per joule of energy is one of the most critical elements for fusion, and using Machine 3 to launch the projectile is 1,000 times cheaper, per joule of energy, than using a laser," said Hawker.

That is because the laser used for inertial confinement fusion requires extremely expensive optics and other components. The process is also very inefficient, he said.

Unlike more expensive pulsed power machines, Machine 3 will also be insulated in air, rather than by immersing the equipment in oil, to further keep costs down.

First Light Fusion, a spin-out from Oxford University, plans to begin experimenting with the machine in January 2019, and hopes to demonstrate fusion within the year. The next step in the technology's development will be to achieve 'gain', whereby the amount of energy created by fusion outstrips that used to spark the reaction.

The company was founded by Hawker and Prof Yiannis Ventikos, head of the mechanical engineering department at University College London. Its advisory board includes Nobel Prize-winning scientist Prof Steven Chu and Prof Arun Majumdar. ■

Readmoreonline

Automotive
New deals on wheels – the evolution of car ownership

Aerospace
UCL to lead European ARIEL mission to study exoplanets

Civil & Structural
US firm builds 3D printed house in less than a day

Defence
Lockheed's HELIOS laser weapon system brings triple threat

Electronics
Aqueous energy storage device promises rapid charging of portable electronics

Energy
How *Boaty McBoatface* is making Carbon Capture and Storage safe

Medical
Wearable 3D printed device monitors stomach activity over 24 hours

Manufacturing
3D printed amorphous metal alloys show material promise

Policy & Business
Government seeks assurances on GKN acquisition

Skills & Careers
If we allow our children to be unimaginative and dull, they will rarely be anything else

For news and jobs
theengineer.co.uk

Largest Test Lab. Widest Choice. 36 Month Guarantee.

zero

... zero Downtime ... From #1 in moving cables.


34 M strokes tested*


138 M strokes tested*


27 M strokes tested*


26 M strokes tested*


41 M strokes tested*


20 M strokes tested*


22 M strokes tested*


76 M strokes tested*


66 M strokes tested*


65 M strokes tested*


53 M strokes tested*


97 M strokes tested*


138 M strokes tested*


50 M strokes tested*


22 M strokes tested*

Guarantee igus chainflex 36 month guarantee

Zero Downtime solutions for your toughest moving cables:
1244 cables from stock make chainflex® the largest motion cable range - for torsion, motor, servo, hybrid, control, data, BUS, ethernet and FOC cables. chainflex® cables are developed and tested in the industry´s largest test lab. With 600 parallel tests on 2750 m², 1.4 million electric measurements and 2 billion cycles per year, you find cables that solve your toughest "zero downtime" challenge. And with up to 7 motion quality classes, you find just the right cable for your application - for less money. Calculate life online and order today with a 36 month guarantee.

* All test reports and more here: www.igus.co.uk/chainflextests

igus®.co.uk

Tel 01604 677240 sales@igus.co.uk plastics for longer life®

ENERGY

Material change for car charging

Contact lens research led to development of membranes for fuel cells

STUART NATHAN REPORTS

Materials originally developed for soft contact lenses have energy storage properties that could rival the best lithium ion batteries currently available, according to the developer.

These materials could form a vital link in systems to charge large numbers of electric cars, said Dr Donald Highgate, director of research for Superdielectrics Ltd and alumnus of Surrey University.

"I started this about 40 years ago with materials that went on to form the basis of extended wear contact lenses," he said. "So it's an aqueous hydrocarbon polymer. But we then wondered whether we could use this material as the basis for membranes in fuel cells. Conventional wisdom then said you could only use fluorocarbons because they were more resistant to corrosion. But we found that if you cross-linked all the polymer chains together the material became corrosion resistant because there are no loose ends. I put some sulphonyl into the mix so that it became electrically active and that material now forms the basis for the membranes and electrolysers produced by ITM Power.

"The next step was to determine whether we could make the material electronically active, and we found that we could. We were trying to make a biocompatible material that could be used to link prosthetics directly into the nervous system, and we sent samples to Bristol University for testing.

"They came back to us and said 'do you realise you've got dielectric properties a thousand times better than our best electrolytes?' At that point, which was at the end of 2016, we changed our focus away from biocompatibles and towards supercapacitors."

Production has been scaled up to the point where the polymer can be coated onto metal foil electrodes in demonstration devices. Single-layer cells can be charged to 1.5V for two-five minutes and then run a small electric fan. A three-cell series stack can be rapidly charged to 5V and run an LED light.

The material achieves practical capacitance values of up to 4F/cm2 with a smooth electrode; existing supercapacitors typically only reach 0.3F/cm2 and rely on complex extended surface area materials. Moreover, the researchers claim, using a specially treated stainless steel electrode – the details of which are classified pending a patent application – the material achieves results of 11 to 20F/cm2. ■

MATERIALS

Extending lifetime of tiny relays

Graphite coating protects against wear

HELEN KNIGHT REPORTS

Ultra-low power microelectromechanical relays that could be used for smart electronics such as the Internet of Things have been developed in the UK.

While solid-state transistors have long been the workhorse of electronics, there is a limit to their energy efficiency as they tend to leak current, particularly at higher temperatures.

Microelectromechanical and nanoelectromechanical relays have zero current leakage, and consume very little power. They can also operate at much higher temperatures and levels of radiation than transistors. The devices could be used to create extremely energy-efficient electronic components with integrated sensing, processing and actuation, capable of operating in harsh environments.

However, making the devices reliable has so far proven a challenge, according to Dr Dinesh Pamunuwa, who leads Bristol University's microelectronics research group. "They are essentially nano-switches, with two electrodes that come into physical contact and break contact millions of times," he said. "That causes the contact to degrade, so after a certain amount of cycling the relays stop working."

Now he and colleagues at the universities of Bristol and Southampton, working with California-based Microsemi, have demonstrated that the relays can be made to operate reliably by coating them with nanocrystalline layers of graphite. In a paper published in the journal *Carbon*, the researchers reveal that by coating the relay tips in a thin film of the graphite, just tens of nanometres thick, it protects them against degradation. ■

Newsinbrief

3D printing investmemt

Siemens is to invest £27m in a new 3D printing factory for Worcester-based Materials Solutions, a move that will create 55 new jobs. Set to open in September 2018, the new building will enable the company to increase its fleet of 3D printing machines from 15 to 50.

Clean energy partners

Britain and Saudi Arabia have signed a memorandum of understanding that will see the two nations work on the development of clean energy technologies. As part of the agreement, the two countries will share technical knowledge and expertise on clean energy, including smart grids, electric vehicles and carbon capture usage and storage.

German rail contract won

British Steel has secured a major German rail contract after investing in its manufacturing capabilities. The deal will see the company deliver around 20,000 tonnes of 120m rail a year to Deutsche Bahn. It comes after the company spent £1m enhancing its Scunthorpe Rail and Section Mill so it could manufacture rails for European customers, who often favour 120m rolled lengths over two 60m welded sections.

Printed house unveiled

Arup has joined forces with CLS Architects to showcase Europe's first 3D printed house. Named 3D Housing 05, the prototype one-storey house – which will be showcased at Milan's design festival, Salone del Mobile, this month – has a living area, bedroom, kitchen and bathroom and covers an area of 100 sq m.

STRUCTURAL

Cutting the cost of new wind farms

New pile-driving technique will reduce outlay and underwater noise

HELEN KNIGHT REPORTS

Constructing wind farms is expensive and noisy

The cost of electricity generated by offshore wind farms could be reduced, thanks to a European project testing new installation technology.

The Blue Pilot project will test a new type of pile driver, designed to reduce the cost and underwater noise associated with the construction of offshore wind farms. Conventional hammers used for installing offshore foundations use a steel ram that hits the pile to drive it down into the soil. This steel-on-steel impact results in high stresses in the pile, and also creates underwater noise that can impact marine life.

The new Blue Hammer pile driver was developed by Dutch technology company Fistuca, a spin-off from Eindhoven University of Technology.

The project partners, including the UK's Carbon Trust Offshore Wind Accelerator (OWA), E.ON, Statoil and Shell, among others, claim it could lead to savings of up to €33-40m (£29-£35m) over the lifetime of a 720MW offshore wind farm, or a cost of energy reduction of €0.9-1.2 per MW/h.

The Blue Hammer consists of a large water tank containing an open combustion chamber, according to Jasper Winkes, founder and managing director of Fistuca. "Instead of using a steel ram the Blue Hammer uses a large water column that is thrown up in the air using the combustion of a gas mixture," he said. "The water then falls back, creating a long-lasting blow that pushes the pile into the soil."

This cycle is repeated until the pile is driven into the soil. The hammer produces a blow that lasts between 100 and 200ms (milliseconds), compared to 4-8ms for conventional pile drivers, while the force builds up and reduces gradually. This limits acceleration and vibration, reducing noise.

"On top of that the energy level is very high, more than six times higher than the largest hydraulic hammer in the industry, meaning fewer blows are needed," said Winkes.

Consequently, it could reduce underwater noise levels by up to 20dB, and reduce fatigue damage during installation on the pile by up to 90 per cent.

A full-size monopile will be installed off the coast of the Netherlands this summer, for tests to validate the predicted noise levels and fatigue damage. ■

AUTOMOTIVE

Insect world could provide collision-avoidance answers

Lincoln team hopes to learn from nature

A project led by a team at the University of Lincoln is taking its inspiration from swarming insects to develop collision avoidance technology for driverless cars.

Funded by a €1.8m (£1.57m) grant from the European Union's Horizon 2020 programme, the so-called ULTRACEPT project (Ultra-layered perception with brain-inspired information processing for vehicle collision avoidance) is developing a miniature, trustworthy collision detection sensor system that could drastically improve the safety of autonomous vehicles.

Current approaches to vehicle collision detection have a number of limitations: radar is too sensitive to metallic materials; GPS-based methods face difficulties in cities with high buildings; vehicle-to-vehicle communication cannot detect pedestrians or any unconnected objects; and normal vision sensors cannot cope with fog, rain or dim light conditions at night.

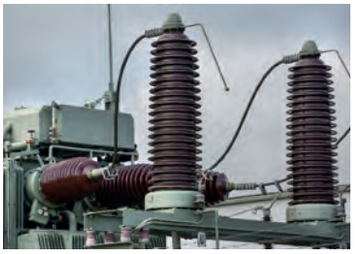
The ULTRACEPT team claims lessons from the insect world will enable them to develop a new system. JE

ENERGY

V2G control project in UK

Parked cars will send energy back to grid

HELEN KNIGHT REPORTS



A communication and control system for vehicle-to-grid charging points is being developed by a UK consortium.

Vehicle-to-grid (V2G) technology allows electric cars to supply energy back to the grid or to buildings when parked. This could help to stabilise electricity networks and support greater use of renewables.

The two-year project, part of a £30m initiative funded by the Office for Low Emission Vehicles and the Department for Business, Energy, and Industrial Strategy, will develop a system to control how, when and the rate at which electric batteries are charged and discharged.

The VIGIL (Vehicle-to-Grid Intelligent control) system will take account of local substation constraints and the energy requirements of the building and the electric vehicle itself.

The project is being led by Nortech Management and includes Birmingham's ByteSnap Design, Aston University and Grid Edge.

ByteSnap is developing a communications adaptor to allow the system to operate with a range of different manufacturers' V2G charging points. The company will also be developing a mobile app.

Grid Edge will develop the systems needed to manage the flow of electricity between the vehicle charge points and the building, while Nortech will manage the monitoring of local substations and communication with network operators.

Aston University will investigate the development of a model to predict battery-life performance.

MEDICAL

Project to extend use of prostheses in poorer nations

UK team involved in global research into improving existing technology

HELEN KNIGHT REPORTS

Losing an arm can have a huge impact on someone's quality of life, but for those in the developing world, it can affect a person's ability to support themselves.

Now, a team of researchers in the UK, Uganda and Jordan is hoping to improve the design of prostheses for use in developing countries, where conflict and high numbers of road traffic accidents mean demand for such devices often outstrips supply.

Body-powered (BP) prostheses, in which cables allow the artificial limb to be controlled by movement of the shoulders, are relatively simple to manufacture and maintain, making them well suited for use in lower and middle income countries.

However, the devices have seen very little development since the early 20th Century, and are often rejected by patients who find them hot and uncomfortable to wear, with limited functionality.

So the team, led by Prof Laurence Kenney at Salford University, is hoping to address some of these problems, as part of the EPSRC-funded project. The researchers will design and develop BP prostheses suited for use in countries such as Uganda and Jordan.

"Uganda has just three prosthetic clinics throughout the whole country, and none of these focus on upper limbs," said Kenney. In contrast, Jordan has well-developed clinical training, but regional conflicts mean there is a huge demand on prosthetics services, he said.

The researchers first plan to improve existing BP prostheses, including their thermal properties, socket design, mechanical efficiency and appearance.

"Due to the shortage of skilled technicians and specialist facilities, we're also looking to try to simplify the fabrication and manufacture as much as possible, particularly with respect to sockets," said Kenney.

They then hope to develop more advanced BP prostheses prototypes, based on technologies such as hydraulics, which they will test in the laboratory. The team also hope to exploit the growth in smartphone use in countries like Uganda and Jordan to develop a digital toolkit to evaluate the use of the prostheses.

This may include, for example, a sensor system capable of capturing the motion of the prosthetic arm as well as information on the opening and closing of the hand and its location, to provide feedback to designers and clinicians. ■

Upper-limb devices have changed little since their invention

AEROSPACE

Space Industry Bill opens up access to £10bn market

Spaceports present an exciting opportunity

British businesses will soon be able to compete in the commercial space race using UK spaceports, following the passing of the Space Industry Bill.

The bill is expected to build on Britain's expertise in the space sector by unlocking a new era of space innovation, exploration and investment. It is envisaged British businesses and institutions will be able to launch small satellites and scientific experiments from UK spaceports, which are also expected to facilitate future developments including hypersonic flight and high-speed transport.

UK spaceports would give Britain access to a launch market worth an estimated £10bn over the next decade. A quarter of all telecoms satellites are substantially built in Britain and satellite services already support more than £250bn of GDP in the UK.

Science minister Sam Gyimah said: "The Space Industry Bill offers an exciting opportunity for the UK to be at the forefront of the commercial space age." JF

ENERGY

New turbine benchmark

GE units will have a higher capacity factor

STUART NATHAN REPORTS

GE has unveiled the Haliade-X, an offshore wind turbine designed to generate 12MW with a 63 per cent capacity factor.

The new 260m-tall wind turbine will produce 45 per cent more energy than the current largest turbine available.

Each unit is claimed to have the ability to produce 67GWhr of energy per year, sufficient to power up to 16,000 typical European households. Its large size will enable offshore wind farm operators to reach their power goals using fewer wind turbines, thereby reducing capital expenditure, risk in project execution and simplifying maintenance and operation.

Each blade of the turbine is 107m long, making a total rotor diameter of 220m. The blades were designed, and will be manufactured, by LM Wind Power, a Danish blade specialist acquired by GE in 2016.

"The Haliade-X shows GE's commitment to the offshore wind segment and will set a new benchmark for cost of electricity," said Jérôme Pécresse, president and CEO of GE Renewable Energy.

The capacity factor of the turbine is a significant development. Indicating how much energy is generated compared with the maximum that could be generated at continuous full power operation, it indicates what fraction of the nameplate capacity can be expected during average wind conditions.

At 63 per cent, the Haliade X is five to seven points ahead of the current industry benchmark. ■

MEDICAL

New advance to prevent diabetic foot ulcers

Leeds team develops in-shoe sensors to measure pressures on feet

HELEN KNIGHT REPORTS

An in-shoe sensor to help prevent diabetic foot ulcers is being developed in the UK.

Diabetes affects over 4.5 million people in the UK, of whom 2.5 per cent will develop a diabetic foot ulcer (DFU), a debilitating condition that has a huge impact on the patient's quality of life, and costs the NHS up to £1.13bn annually.

Diabetes affects the nerve and blood supply to peripheral areas of the body, such as the feet, according to Dr Peter Culmer at Leeds University, who is leading the EPSRC-funded project.

"This means your skin is likely to become damaged and ulcerate, but you are also less likely to feel it," he said. "It can get to the point where an amputation is the only possible solution."

Diabetic foot ulcers can lead to amputation

Over 125 such amputations are carried out in the UK every week, according to Diabetes UK.

To prevent DFUs, and to diagnose and treat those that do occur, clinicians need to understand the behaviour of the sole of the patient's foot. However, existing in-shoe digital analysis systems are expensive and measure only a small part of the information needed.

So the research team, which includes specialists from Leeds Teaching Hospitals and the Leeds NIHR Biomedical Research Centre, plans to develop and test an in-shoe sensor capable of measuring pressures on the foot, including normal and sheer forces, and detecting abnormal regions with elevated pressures that are at risk of developing ulcers.

"We want [the device] to be able to monitor the pressures on the soles of people's feet and identify at-risk patients, and also to collect data that could be used to inform improved footwear for people with the condition," said Culmer.

The silicon-based tactile sensors will consist of small electronic coils that can be easily printed onto thin, flexible films. Each coil will be made up of three layers: a bottom coil layer, a thin, "squashable" middle layer, and a top contact layer.

An array of the sensors will be placed across the film, creating a sensing "sole" capable of taking measurements at various key regions of the foot. This will be combined with a mobile data logging system, to collect the information gathered by the sensors. ■

BIOTECHNOLOGY

Stepping stone to building materials that will self-heal

Bacteria could be used to repair structures

Cardiff University scientists are introducing the concept of biological self-healing with bacteria to buildings and historic structures.

The team have set out to produce a solution that can be applied to building stone and masonry to give it self-repairing properties.

Once applied, the team believe that any sort of damage to the stonework will trigger the release of bacteria and a range of precursor chemicals, allowing the material to repair itself.

Bacteria can produce mineral deposits when mixed with certain precursor chemicals, including calcium carbonate, which is one of the main components in rocks and various other masonry materials.

"When present in masonry, the bacteria that produce the mineral deposits become entombed as spores, alongside the chemical precursors, within the mineral that it is producing," said principal investigator Dr Mike Harbottle.

"When damage occurs to the masonry, the deposits within the mineral are also damaged, exposing both the bacteria and the chemicals, which react with each other again to produce even more mineral, thus healing the damage." JF

DEFENCE

Targeting enemy fire

Sensors will point out direction of attack

HELEN KNIGHT REPORTS

The British Army's new Ajax armoured combat vehicles are to be equipped with sensors designed to detect the direction of incoming enemy fire.

Thales has signed a £3.7m deal with General Dynamics Land Systems-UK to install its Acusonic sensor system on the Army's new fleet of armoured vehicles, which are due to come into service in 2020.

The sensors, pictured, are designed to enhance the crew's situational awareness, allowing them to respond more effectively to threats, according to Chris Wardman of the Acusonic team at Thales.

"When you are in large, highly protected military vehicles, it is difficult to see outside," said Wardman. "So you may get shot at, but you may not know where the fire is coming from, and where your threat is."

The Acusonic system uses sound to detect the source of enemy fire. It is based on Thales' work on naval sonar, and uses the same principle to detect sound travelling through air as in water, said Wardman.

Sensitive microphones detect changes in pressure as a bullet or other type of ordnance flies through the air. Complex algorithms then process this data to determine the range and bearing of the bullet.

"You can determine range by the time of flight, [by comparing] the time the supersonic wave hits you, with the time it takes for the sound to reach you, because one is travelling faster than the other," said Wardman.

Each vehicle will be fitted with three sensors, to give the crew a 360-degree threat detection capability. Software processes information from the sensors and displays it on a screen within the vehicle. ■

ENERGY

Formic acid provides fuel cell fix

Mobile unit to release the potential of hydrogen

HELEN KNIGHT REPORTS

Hydrogen has long been seen as the future of clean energy, but storing and transporting the gas safely and cost-effectively remains a considerable challenge.

Now an integrated power supply unit that can convert formic acid into hydrogen fuel and use it to produce electricity has been developed by a European team.

Unlike hydrogen gas, which must be stored at very high pressures and low temperatures, formic acid is liquid at room temperature, and so could be easily transported to vehicle filling stations or remote locations. What's more, just one litre of formic acid carries 590l of hydrogen.

The technology, developed by GRT Group, based in Swizerland, and researchers at École Polytechnique Fédérale de Lausanne, consists of a hydrogen reformer, known as HYFORM, and a proton-exchange membrane fuel cell (PEMFC).

The unit, which supplies hydrogen from formic acid

The reformer uses a ruthenium-based catalyst to convert formic acid into hydrogen, carbon dioxide and water. The carbon dioxide can be absorbed, to prevent it being released into the atmosphere.

The technology could allow large quantities of hydrogen to be stored without refrigerating or compressing it, according to Luca Dal Fabbro, CEO of GRT Group. "This would allow it to be used in places that would be impossible today, for example remote places such as villas in the mountains or hospitals in Africa," he said.

The HYFORM-PEMFC can produce 7,000kWh yearly, and its nominal power is 800W, with an electrical efficiency of 45 per cent. The unit is also low-maintenance, and the catalyst can be used for long periods. The technology is also scalable and does not require connection to the power grid.

GRT Group is also now hoping to develop the process so that it can operate in reverse, to produce formic acid from hydrogen, so it could be used to store excess energy generated from renewable sources.

"We are going to absorb that energy and transform it into formic acid, which could then be used when you need the energy," said Dal Fabbro. ■

MANUFACTURING

Speeding up the virtual testing of components

Team hopes to cut time dramatically

A team led by researchers at Swansea University has been awarded £1m by the EPSRC to develop new virtual testing techniques for manufactured components. Increasingly, researchers have been investigating so-called "virtual qualification" processes as an alternative to physical testing.

These processes typically use 3D X-ray imaging to create micro-accurate digital replicas of components – including any manufacturing flaws – which are then assessed to see how they perform. However, image-based modelling is very time-consuming, as images still need to be processed manually, and can take weeks for each component.

New software tools are expected to automate the process and speed it up, making it more viable for industry.

Project leader Dr Llion Evans said: "Virtual qualification can be a big boost for manufacturing industry. But to make it worth companies' while using it on their production lines, it has to be quick enough to work on the large scale they need."

The group hopes to reduce the time needed from weeks to hours. JE

MEDICAL

Total artificial heart revealed

Titanium unit pulses to mimic real bloodflow

STUART NATHAN REPORTS

Engineers from Oregon Health and Science University (OHSU) in Portland have designed what they hope will be the first permanent total artificial heart.

Suitable for adults and children over 10, the device is machined from titanium. The device replaces the human heart's two lower chambers, or ventricles, with a single cylindrical chamber that contains a titanium alloy-coated hollow rod that shuttles back-and-forth, providing a pumping action that moves blood to the lungs for oxygenation and then sends the oxygenated blood around the circulatory system.

The heart is powered by a combined controller and portable rechargeable battery.

It has no valves and the rod to provide the pumping action is suspended inside the chamber with hydrodynamic bearings, so it never touches the inside of the tube. The shuttling motion of the rod generates a blood flow that mimics a natural human pulse, unlike existing artificial hearts which send blood around the body in a continuous, pulseless flow. Pulsing reduces damage to blood cells and cuts the risk of clotting.

The device was designed by Dr Richard Wampler and is being developed by a team headed by Dr Sanjiv Kaul.

"Considering the human heart beats 14 million times a year, it's crucial that an artificial heart is durable and robust," Kaul said. "The simple, efficient design of our total artificial heart makes its potential for failure very low." ■

Weidmüller

Safe power supply to equipment in the panel with Klippon® Connect and maxGUARD for integrated load monitoring and control voltage distribution

Let's connect.

Potential distribution and electronic load monitoring in one complete solution: with maxGUARD, you save up to 50 percent of space and 20 percent of time compared to existing wiring solutions. For separate protection, use our tailor-made Klippon® Connect voltage distribution terminal blocks.

Sales: 0845 094 2006 **Tech:** 0845 094 2007
Email: marketing@weidmuller.co.uk
www.klippon-connect.com

---

simplyassetfinance

Working together to build your business

It takes hard work to build long term relationships but at Simply Asset Finance, that's exactly what we do.

We understand running a business isn't always easy but, by working together, we can provide you with simple solutions to achieve your goals, drive your business forward and build your Company's future.

Our innovative financial products are designed to keep your business operating at optimum efficiency, whilst you can be confident a member of our specialised team will be on hand to help you every step of the way.

Whether you are looking to purchase new equipment, or simply release funds from existing assets, we can help.

Interested? Then Let's Talk

Call 0203 369 6000

Email: **info@simply.finance** Web: **simply.finance**

people making business **work**

Let's be bolder in delivering change

The UK is missing an historic opportunity to decarbonise its energy sector – but a whole system approach holds the answers

In March, the Government announced that the UK's carbon emissions from fossil fuels have declined to levels not seen since the end of the 19th century. These reductions are mostly due to the closure of coal-fired power stations, and emissions have been declining for several years. Last year's decline, however, was less than it has been for five years.

This plateau has been caused in part because the UK has thus far focused its efforts on the most cheap and easy policy areas. What we've done in the past, however, will not get us to where we need to be. We must, therefore, have courage to continue to drive forward what we know is right for the UK.

The problem is that there is not sufficient integration between technologies or investment certainty to really make the difference in the UK energy sector. This places a strain on the UK's objectives. Most of the current solutions we need to meet carbon emission reduction targets lack economic clarity, cross traditional boundaries of government and utility, while others have not advanced because they challenge system reliability.

To take an example, electric vehicles (EVs) are currently feared by electric network owners and operators because of the impact mass adoption will have on the existing Grid. We have the imagination and capability to integrate them as network assets through vehicle-to-Grid technology, and we know they will bring pervasive benefits. But so far we have not done what is required to bring EVs into the mainstream. In short, the vision for the UK is grand, but we need to be bolder.

The fact is that the stagnant trend in carbon emissions reduction will continue, and the UK will not achieve its aim of decarbonising its energy sector unless it acts now to adopt a holistic view of the problems – a whole system approach. This approach is a fully integrated proposal for master-planning and delivering energy services at a district level. It encompasses the supply and demand of all interconnected energy vectors in order to optimise the UK's sustainability, reliability and affordability performance.

A new roadmap for our energy sector is required, which brings together all players, including market participants, technology, government and systems, to deliver a holistic framework. Burns & McDonnell's industry roadmap sets a course to deliver greater technology and network integration, and the further empowerment of consumers. This model incentivises investors and developers to take risks outside of their core business to consider whole system solutions, and rewards innovation based on the benefits provided throughout the value chain.

A future focused on the development of solutions such as microgrid technology and private networks will help us take full advantage of new technologies. By utilising energy assets and services, across all energy vectors, the UK will make the most of existing systems and keep costs contained. This includes gas and electricity, but also heat and hydrogen networks and, crucially, transport. This will enable consumers and businesses to gain advantage from the full benefits of the different energy resources and ensure that the take-up of new technologies is not held back.

The roadmap also details new approaches to put customers in control of their home and transport energy usage, empowering them to take an active role in reducing their bills. The recent Helm Review concluded that industry and government need to do more to reduce the burden on bill payers. We need new pricing models that put customers in control of their energy usage, helping them to be 'prosumers' who make active decisions using real-time price signals. Empowering people to take an active role in reducing their energy bills supports decarbonisation, enhances energy security and promotes affordability.

It is also imperative that network owners, generation asset owners, retail participants, regulators, customer groups and community representatives come together to address current barriers, such as a lack of harmonisation between regulations, policy and pricing. The whole system approach would engage stakeholders to assess how to flex capacity, develop new financial markets, and adjust policy to accelerate investment in clean solutions. Collaboration will create uniform policies that drive desirable outputs, without leaving the vulnerable behind.

It is the Government who must now sit in the driving seat, turn strategy into action and connect the dots between stakeholders. The Clean Growth Strategy is ambitious but, as the Committee on Climate Change recently said, we now need to urgently firm up policies and provide more detail in order to achieve required emissions savings. The energy market is changing rapidly, and the need for radical adaptation grows ever closer. Get it right, and the whole system approach has the potential to solve all aspects of the energy trilemma, to the benefit of all. This is the biggest opportunity in the next 30 years and we can't miss it. ■

Jonathan Chapman is UK managing director of Burns & McDonnell. He is a chartered civil engineer with 25 years' experience in the energy, water and telecoms sectors

The closure of many coal-fired power stations has helped the UK cut emissions

Mailbox

Thehottopic

Should we put a brake on this?

Not surprisingly, the fatal crash between an Uber autonomous test vehicle and a pedestrian has sparked a lively debate on driverless cars

Unfortunately, with motorised traffic (autonomous or not) deaths are always going to occur. Sad as it is, people have to realise that this technology can never be 100 per cent safe. If they cannot accept that then the only option is to discontinue autonomous vehicle technology. I do note two basic failures in this case: firstly, the car was travelling at 38mph in a 35mph zone; secondly, the car did not attempt to brake. To my mind these two points represent an avoidable technology failure which indicates maybe this particular implementation shouldn't have been allowed on public roads.
Steve

At 84 I can see my licence being withdrawn when I am longer safe. Autonomous cars are a way for people like me to keep our independence. Please let them be available soon.
Steve

It will be interesting to see who ends up in court for manslaughter (or whatever it is called in America), the "driver", Uber, Volvo or just the microchip?
Iain

With the best will in the world, these systems are not going to be faultless in the first instance – if ever. The question is, are they better than the present system. Suspend, investigate, learn, rectify and resume testing would be my advice. The resumed testing regime should be dictated by the flaws found in the software, or perhaps hardware. Autonomous vehicles are probably the safest way forward in light of the current high death toll on our roads.
Peter Melling

Driverless cars will happen one day, but there needs to be a considerable improvement in AI technologies before these cars exceed the safety record of the very best human drivers. I see a future in which automated driving is commonplace – where the current situation of 1.3 million deaths a year in road accidents becomes an outlandish nightmare.
Michael Morley

Because we can, should not translate into we should. I ask what is the actual goal of this development? Are we running short of taxi drivers? Are we almost out of lorry drivers or bus drivers? Maybe the people who drive today are saying they won't drive any longer. My guess is none of these things are happening, so why are technology companies so driven (no pun intended) to develop driverless vehicles?
Rod Evans

Whilst the fatality is tragic, would this incident have garnered the press coverage if the vehicle was being driven solely by a human? CNBC estimated that there were around 40,100 traffic related deaths in the US in 2017 – nearly 110 a day. Autonomous vehicles offer the opportunity to reduce these casualties significantly by taking the 'human element' out of the equation; imagine roads with no road rage, no driver inattention due to texting, no driver distraction.
Duncan Fallow

The first motor car on the road in the UK appeared in June 1895. The first pedestrian killed by a car was in August 1896 (the car was travelling at 4mph). I wonder if there was an outcry then. More than 270,000 pedestrians lose their lives on the world's roads each year (accounting for 22% of the total road-traffic deaths). If driverless cars reduce the number of accidents, it is worth pursuing.
Simon Williams

Inyouropinion

Trump tariffs

Tariffs are a double-edged sword. Safeguard home-grown industries and consumers will suffer, decreasing the flow of currency via spending. This is more a political tool than a safeguard. Used by a simpleton like Trump, it is to please the voters. It works if you have a very large economy of scale that can produce all of its own goods. Otherwise it can only work where specific tariffs are used to target sectors of industry that conflict with your own country's. Difficult.
Mike

We are exiting a tariff-free trading arrangement frying pan into the fire of WTO and tariffs. Did Farage and Johnson ever do a proper cost-benefit review before embarking on their blinkered pet project? And to mention our ongoing divorce bill that includes Farage's handsome pension.
Nick Cole

Perhaps Trump realises that American steel is not competitive with steel from outside the US. This move will force US firms to buy only American steel and allow the price to rise, to enable the US steel industry to survive. I wonder if Americans will accept price rises across the board. US exports will be more expensive too in a world where quality imports are available from many more countries.
Steve Gardner

3D-printed homes

I'm not knocking it, as it is at least an alternative attempt at affordable housing. But, I think the article was a little misleading. Looking at the video, only the walls appear to be 3D-printed rather than a whole house. This is a good start, but there are a lot of costs associated with foundations and roofing.
Steve Bee

Impressive technology... but usually with buildings, especially low-rise ones like this, the bit that takes the time is the groundworks and installing the services... which unfortunately I don't see this helping with.
intellimouse

Join the debate theengineer.co.uk

Thesecretengineer

From Lego to 3D printing, gadgets and toys are discouraging children from using their imagination, writes our anonymous blogger

Recently, for a brief moment, I thought I was going to get one of these pieces quoted back at me. Sadly, that little hoped-for vanity remains as yet unrealised, but I can let you know that it was during a chat with a colleague about creativity.

We were both expressing our disappointment in how the play of 'youngsters today' tends to be prescribed. One particular avenue we explored was the way that Lego sets are sold as being to produce a single finished item and, once the child has completed the task, this being how it generally stays.

Readers with long memories may recall that I once suggested how those of you with offspring should 'torch' all instructions supplied with the sets owned by your own progeny. What became apparent as we discussed this further was that the problem does not simply relate to the world of brightly coloured building blocks.

The age of 3D printing was heralded with the same sort of predictions for a bright new future that also accompanied the ideas of the flying car and the domestic robot. Everything would change, every home would have one and nothing would be beyond your grasp.

However rather than us having moved to a world of infinite possibilities, again it would seem that the prescribed route is usually the chosen one. Rather than, for instance, inventing cartoon characters to model and print out, the kids find ready-made models of their existing favourites then pay to download the programming. This is then fed into the 3D Printer which produces the desired statuette.

Of course, there is more involvement and interaction when compared to purchasing a boxed figure from a shop, but is there really that much more? You gain some intrinsic understanding of additive manufacture and the concept of the 3D model but nothing relevant to the normal range of manufacturing processes or design. With the availability of different coloured filaments there may even be no need for finishing.

Certainly when compared with more traditional means to similar ends, i.e. the 'plastic kit', you are actually removing the acquisition of skill sets and understanding. So rather than moving into a state where the child is encouraged to explore their own imagination and render it complete in the physical world, we are instead merely providing a more direct path to the acquisition of merchandise for existing items – be they figurines, cars or whatever.

We would perhaps expect this to a degree anyway because we live in a consumerist society and there would always be a market for the pay and download items, but I wonder why (admittedly from a small sample) this seems the norm almost to the point of exclusivity? Surely it cannot be mere laziness?

Is the human condition really such that the rollercoaster route to satisfaction found in creating something yourself will always be sacrificed for the low level but consistent anodyne payback of instant gratification?

Looking back at my formative self for reference, I realise I can only try to be detached and realistic. In assessing if things have changed it may well be impossible to entirely jettison the attitudes of what we have become, to avoid imprinting our mature selves over our half-recalled earlier self.

Taking this on board, although my finished model kits generally looked like crashed versions of the subject matter and I wasn't one for hand-carving emergency bicycle chains from bits of hedgerow – there was always the drive to create. Writing stories, drawing, inventing; wild imaginings of a future that I would like to inhabit. Then there was that battered biscuit tin full of Lego, ours being adorned with famous pub signs and even now instantly visualised with evocative clarity – the go-to resource for building the *inspiration de jour*. Assessing available materials and planning the best approximation to the chosen subject matter, be it steam loco or X-Wing Fighter – through such things are methods for exploring the imagination established and basic techniques for manifesting those ideas born.

By contrast, is it too much to suggest that a child who is allowed to be dull and unimaginative now will rarely be anything else? ■

Emerging technologies: disrupting the future

The Academy's scheme to support UK visionaries has given me renewed confidence that we will continue to be world-leaders in science and engineering

Emerging technologies are defined as new or evolving technologies with the potential to change the status quo – and in some instances, where their impact is very widespread and they displace old technologies, they might become what are known as disruptive technologies. The UK has a strong history of pioneering such technologies, building on its world-class research base and culture of invention and creativity.

As part of the Government's National Productivity Investment Fund, the Academy has been allocated money to accelerate the development and commercialisation of emerging technologies in the UK through 10 new flagship Chairs in Emerging Technologies (CET) at UK universities. The CET scheme identifies research and innovation visionaries and provides them with long-term support to enable them to build a global centre of excellence focused on emerging technologies with high potential to deliver economic and social benefit to the UK.

This type of public investment can be highly effective in stimulating co-investment from the private sector, enabling the UK to secure an early foothold in a potentially important future market and preventing UK companies from losing competitive advantage as other countries take a lead.

The call for the CET scheme has also shone a light on what UK engineering researchers consider to be today's significant emerging technologies. It is exciting to see both the diversity of technologies and disciplines represented among the chairs selected and the breadth of societal challenges and economic opportunities that have motivated the world-leading engineers appointed. The chairs also illustrate the fact that use-inspired research can be as intellectually rigorous as it is potentially transformative.

Perhaps unsurprisingly a number of the chairs focus on technologies with strong medical applications. One aims to deliver a step-change in personalised medicine by engineering cells that can combine precise disease diagnosis with therapeutic intervention in a closed loop circuit to prevent the disease developing, or provide a cure – sometimes called 'theranostics'. Another focuses on reducing the burden of brain disorders. The goal of the chair is to accelerate the translation of therapeutic bioelectronic systems – for example a 'brain pacemaker' – from lab to industry.

Robotics, autonomous systems and AI also had strong representation among the chairs selected. For example, one chair addresses the technologies underpinning soft robotics, which have the potential to impact upon many areas of our lives, from implantable medical devices that restore function after cancer or a stroke, to wearable soft robotics that will keep us mobile in our old age and biodegradable robots that can combat pollution. Other chairs address issues of safety and reliability associated with AI and robotic systems.

Another significant focus was on driving improvement in materials that underpin important industrial and societal applications. One of the chairs will develop novel interactive technologies using acoustic metamaterials; another is targeted at optimisation of next-generation battery materials for improved cost, performance and durability.

The remainder of the chairs draw upon other recent advances in the physical sciences to address novel areas. They include radical new space technologies that will underpin new satellite applications, an integrated approach to two-dimensional classical and quantum photonics and a platform for multiscale industrial design, from the level of molecules to machines.

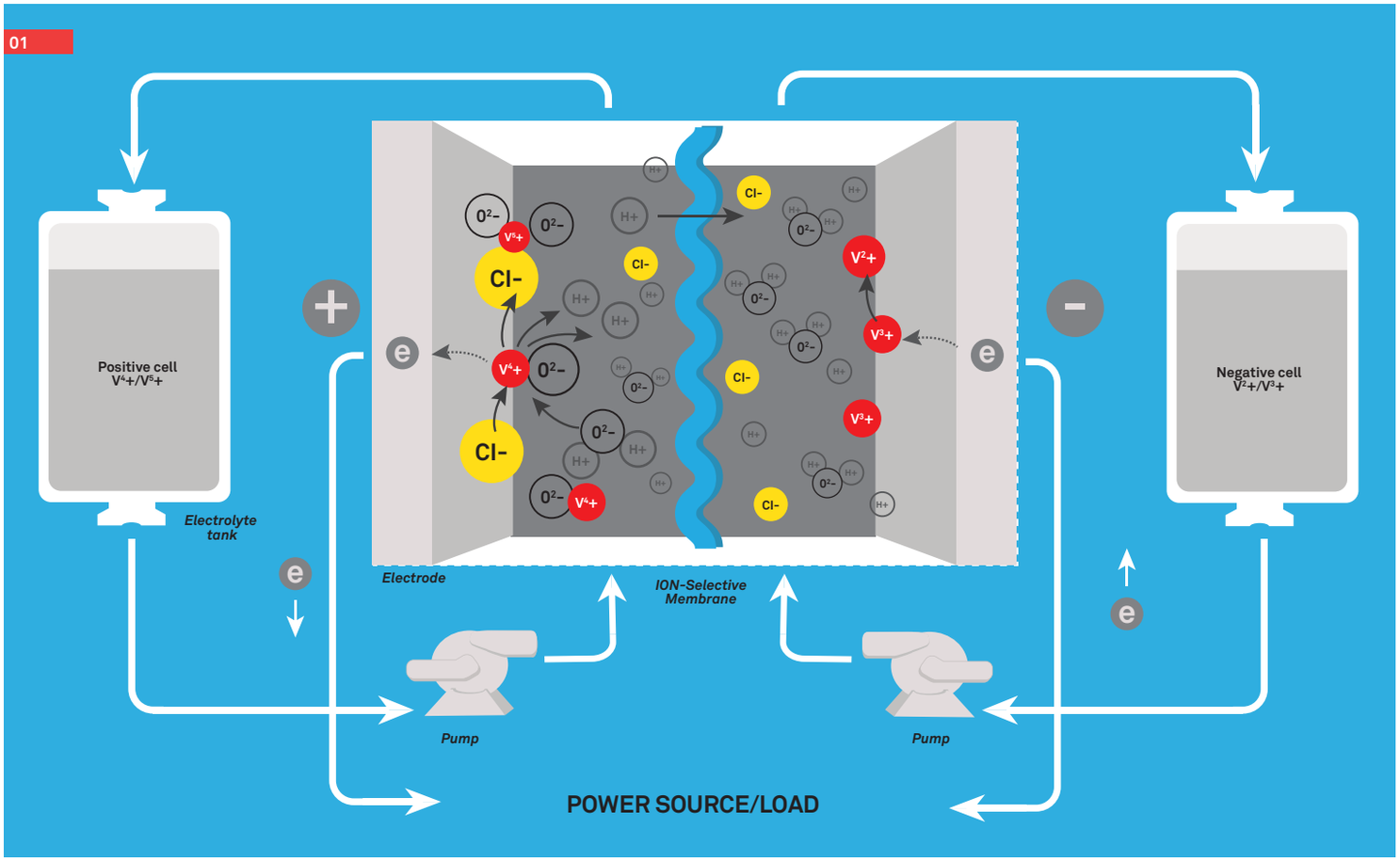
The CET scheme steering group, chaired by AI and open-data pioneer Sir Nigel Shadbolt FREng FRS, was deeply impressed by the quality of applications they reviewed, which bodes well for the UK's ability to continue to be at the leading edge of technology disruption. Nevertheless, it is notoriously difficult to forecast which technologies will turn out to have the most significant impacts long term. The profound extent to which mobile communications, the internet and World Wide Web have changed our lives is now taken for granted, but this future impact was far from obvious from early research.

Another hugely important disruptive technology which had a less than auspicious start is GPS, built on early work to help with the navigation of nuclear submarines. The US began deploying a more robust system in 1978, but full operational capability was achieved only in 1993, and the programme was almost cancelled in the meantime. Yet GPS is now ubiquitous – so much so that the dependence of critical infrastructure on this single platform has been highlighted as a significant risk by the Academy.

I was recently asked whether I thought there was a way of identifying which technologies would go on to have pervasive impacts before it became obvious that they would. Trying to predict the future is (famously) a mug's game but I am pretty optimistic that we can learn something from running competitions like this and tracking developments as our Chairs in Emerging Technologies get to work. Moreover, I am excited to see what insights will emerge when we bring our chairs together to reflect on what the future might look like. ■

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

Charging into



Perfecting large-scale battery technology is high on the agenda for the Government. Stuart Nathan reports **on the latest developments here and around the world**

Energy storage is often seen as the most important missing part in the electricity infrastructure of many countries, not least the UK. The main reason for this is renewable power. Wind, solar and marine energy (wave and tidal) have the potential to generate large amounts of electricity, but being dependent on natural processes they are not predictable and sometimes occur at periods diametrically opposed to when they are needed – for example, the sun shines during the day but we switch our lights on at night. Being able to store the energy in times of plenty – when it's windy, sunny or the tide is coming in or going out – and then release it to the grid when it's needed would allow renewables to be used to their full potential, and further reduce our reliance on fossil fuels.

01 How UET's vanadium redox flow cells work. *From information supplied by UET*

There are many ways to store energy. Pumped storage, where water held in a reservoir at a high altitude is allowed to run through a turbine flowing down to a lower reservoir, is among the most reliable and is used in the UK, Scandinavia and elsewhere. Compressed air storage is also increasingly scrutinised, as is using surplus electricity to liquefy air so that it can be allowed to evaporate through a turbine (Highview Power, a pioneer in this field and is a previous winner of an *Engineer* award for innovation). The so-called hydrogen economy, where surplus electricity is used to electrolyse water, and the resulting hydrogen stored to be converted back into

o the future

electricity through a fuel cell, has been touted as a solution for decades. All of these systems have been covered in *The Engineer*.

The technology that is currently receiving the most innovative engineering attention is, however, the energy storage solution that electrified the Industrial Revolution and we have all been familiar with from our childhoods: batteries. But these are not the Triple-As. They are large and highly sophisticated devices capable of holding very high amounts of charge and releasing them in the way that is required for the grid.

The workhorse for grid-scale storage today is the lithium ion battery; not just the same battery technology that is used to power electric cars, but literally the same battery. The best known large-scale grid storage facility in the world, built by Tesla in South Australia, is known simply as the Big Battery. This consists of a very large array of Tesla's Powerwall units, based on the same type of battery that powers Tesla's cars.

Properly known as the Hornsdale Power Reserve, it is rated at 100MW/129MWh and stores wind energy from the adjacent Hornsdale wind farm and solar energy from domestic photovoltaic panels across the state. According to Tesla, it stores enough energy to power more than 30,000 homes. "By allowing renewable energy to be dispatched during peak periods when the wind is not blowing and mitigating the need for expensive gas peaking generation, South Australian electricity prices will be both lowered and stabilised," Tesla said.

Elsewhere in Australia, in late March the Australian government announced that it would invest $25m (£13.5m), matching an investment from the State of Victoria, to fund large-scale grid-connected batteries, together providing 50MW of power and some 80MWh of energy storage. Both will be located near solar farms; one at Gannawarra, near Kerang, again using batteries supplied by Tesla, and one at Warrenheip, Ballarat, with batteries supplied by Fluence. "Both Victorian batteries will help demonstrate how large-scale batteries can provide different benefits to the electricity system, including improving grid stability and power quality, and how they can help integrate more variable renewable energy into the grid," said the Australian Renewable Energy Agency.


02

03

02 Inside Rongke Power's vanadium flow cell manufacture facility

03 An energy storage installation made by UniEnergy Technologies

But despite lithium ion batteries being the current preferred option, according to Prof Clare Grey, a theoretical chemist and specialist in rechargeable battery chemistry at the University of Cambridge, they are not necessarily the best option for this application. "Lithium ion is good for short-term storage," she said. "But how are you going to store energy for the weeks and months you might need if you went for an all-wind scenario? You either have absolutely massive storage facilities or you shunt electricity around over large distances, even between countries. The other issue is whether battery packs are going to last for long enough for the really big-scale applications. Lithium ion batteries last on average two to seven years, but a lot of utility companies work in 20- to 40-year timescales. That's a challenge, and although it's grossly straightforward to change out a spent battery, it will come with a cost."

Grey pinpoints other battery technologies such as sodium ion as a drop-in replacement for lithium ion, even being potentially cheaper, along with so-called "beyond lithium" solutions such as lithium sulphur. But she sees the ultimate solution is a different type of battery known as a redox flow cell (sometimes known as a vanadium flow cell). These are, in essence, a type of fuel cell rather than a traditional electrochemical battery. "They are much larger-scale batteries where you have vats of liquids of oxidised and reduced chemicals and you flow them in and out to recover power whenever you need it. In principle, they are completely scalable, but just as expensive as lithium ion, if not more so."

This will not necessarily always be the case. Redox flow cells are more like process engineering equipment than Tesla's solid-state batteries, consisting in part of components like tanks and pumps, which have benefited from economies of manufacturing scale. "We are waiting for the price to come down," Grey explained.

But that hasn't dissuaded China, one of the giants of the battery world. In Dalian, Rongke Power is operating a battery factory even larger than Elon Musk's Gigafactory in Nevada, which produces Tesla's batteries. Occupying an area larger than 20 football fields, the Rongke factory is producing components for what will take over from the Hornsdale Reserve as the world's biggest battery: a 200MW, 800MWh facility serving China's Liaoning province.

Writing in the American Institute of Electronic and Electrical Engineers journal, *Spectrum*, Z Gary Yang, who led a team at the Pacific Northwest National Laboratory in the US which developed vanadium flow cells in the early 2000s, describes the origins of the technology at NASA in the early 1970s as a possible technology to power deep space missions where solar energy would not be available and with no need to store the hydrogen that powered the fuel cells of the Apollo missions – and so nearly caused disaster on Apollo 13. Evolving through research at the University of New South

Wales, near considerable vanadium deposits, Yang's team created a new type of redox flow cell with a vanadium-based electrolyte relying on reactions in a chloride solution which doubled the energy density of previous generations of cells, because more vanadium ions remained stable in solution and were available during charging and discharging. This is more advanced than the type being deployed by Rongke Energy.

Yang now runs a Washington state-based company named UniEnergy Technologies (UET), which specialises in megawatt-scale battery installations that fit inside a standard shipping container. "We've also brought down the batteries' cost," he said. "A few years ago, the cost of a four-hour VRFB [vanadium reflux flow battery] system was about $800 [£565] per kWh. These days, it's about half that, comparable to the cost of a stationary lithium-ion system. But that's not an apples-to-apples comparison. Lithium ion's capacity degrades over time, and its life span is shorter. We've tested individual VRFBs through more than 14,000 cycles, fully charging and discharging each cycle, and they still perform at 100 per cent capacity. This should translate into a life span of 20 years or more."

Of course, batteries are not the only thing that you need in a grid-scale electrochemical storage facility. Prof Richard McMahon, an expert in power electronics at Warwick Manufacturing Group, specialises in the additional equipment needed for such facilities and is not so focused on the battery chemistry as Clare Grey. "There's a difference in perception between a research chemist and an applications engineer, which is me," he said. "I look at what I can get now and what I'm likely to be able to get in the foreseeable future because that's what I've got to do projects on. So I can perfectly understand that Clare comes from a more theoretical research standpoint, and can say that there could be better battery chemistries, and that may well be true and probably is, but I'm not going to see those battery chemistries as commercial batteries in, say, under 10 years. My projects are to put batteries into static energy storage working with my industrial partners; we are looking at what we can buy today. I'd be delighted if the theoretical or research chemists can produce some wonderful battery in five years that can outperform lithium."

There are two important factors to consider when designing a facility, McMahon explained. These are the total amount of energy you want to store, which is measured in kilowatt megawatt hours, and the other is how fast you need to push the energy out, measured in kilowatts, megawatts or gigawatts. The nature of the energy going into the system is much less important. "One of the very important grid services is a very fast frequency response when there's an increasing load on the system or a dropout in other generating capacity. National Grid would like some power pretty quickly, fractions of a second – it might want 100MW in the next few milliseconds."

The ancillary equipment that is McMahon's speciality varies according to what type of battery is being used. Lithium batteries, for example, need a battery management system to monitor the state of all the individual electrochemical cells in the battery. Electric vehicles are equipped with such systems, McMahon said, and static batteries need precisely the same monitoring. Moreover, he added, as batteries use direct current but the National Grid is alternating current, "a box of power electronics" is needed to convert DC to AC and vice versa.

In fact, with the increasing prevalence of DC electronics and equipment, McMahon believes that AC's days might even be numbered. "We've started to see developments in the DC world. Solar generation, wind are all DC, and batteries of course are DC. At the top level we are also seeing DC gridlines like the one that comes from Scotland down to North Wales; the UK isn't big enough really to have DC interconnectors, but of course we have the interconnectors to other countries: France, Holland, there is the Norway one in planning, and China's got a lot of long-distance DC cables."

DC microgrids, supplying for example a large supermarket, industrial facility, a group of up to 50 houses or university campus, are a distinct possibility, he added. However, when asked if he were designing a whole new city, whether he would build a DC grid from scratch, McMahon chuckled. "We are just so used to AC, we can get the equipment at Screwfix. You can buy consumer units with AC circuit protection for very little money – you can't buy those for DC – so it's a bit of a brave step."

Profs Grey and McMahon are part of The Faraday Institution, an organisation set up in the wake of business secretary Greg Clark's decision to identify energy storage as a key strategic strength for the UK that needs to be built up. The institution is part of a three-pronged initiative known as the Faraday battery challenge. Faraday Institution spokesman Matt Howard explained: "The idea was, can we identify that we have in the UK all the essential components, and can we maximise the opportunity space for making the UK a player on the world stage of batteries?"

In its initial phase, funded by a £42m grant, the institution is focusing on automotive batteries because of the strong UK automotive industry. "We have some of the best world-class researchers in the basic science here, and we have government interest in innovation and cleaner air, and there's an opportunity to maximise all this now. And there is some urgency, because I think the Government has recognised the world is racing forward and we can be part of that solution," Howard said.

04 Lithium ion units at Tesla's Hornsdale Reserve in South Australia

05 The Dalian 'gigafactory'

The institution's research projects will last for three years in the first phase, then this will be followed by a series of regional workshops to identify the top challenges in each area. Howard acknowledges that the UK has had a spotty history with battery development: for example, lithium ion batteries were originally invented in Oxford, but some years ahead of the development of camcorders and mobile phones, by which time the batteries were commercialised in East Asia and the US.

But it would be wrong to see the Faraday Institution as an attempt to correct that. "I see it as a much more optimistic investment, as opposed to trying to reclaim a historic loss," Howard said. ■

Leaders in the field

Precision agriculture, using drones and GPS, can push up yields for farmers. Jason Ford reports

The day-to-day needs of a growing global population may vary, but everyone needs to eat and feeding the world is going to put a huge strain on the world's agricultural resources.

The United Nations Department of Economic and Social Affairs predicts that the current world population of 7.6 billion will grow to 8.6 billion by 2030 and 9.8 billion by 2050.

According to Clive Blacker, director of Precision Decisions, a York-based supplier of precision farming services, there are estimates suggesting that crop yields will have to increase by 65-70 per cent in the 32 years to 2050. This could be problematic. "In the last 10 years we've hardly seen a five per cent increase in productivity," he said.

One of the reasons for this is the size of agricultural machinery, which has steadily grown bigger. A significant proportion of farming is weather-dependent, which gives famers in Britain unpredictable weather windows. Bigger machines get jobs done more quickly, and they also help compensate for the reduced numbers of available rural staff.

However, the trend to go big has had an adverse effect on soil through compaction, a situation that occurs when the weight of farm machinery literally squeezes the life out of soil by reducing its ability to hold water, nutrients and air.

Farming is going to have to get smarter if it wants to boost productivity, and doing this will require the deployment of a range of technologies to make farming more precise, sustainable and profitable. A research team led by Kit Franklin, an agricultural engineering lecturer at Harper Adams University in Shropshire, set out to do just that with the Hands Free Hectare (HFH) project.

Funded by Innovate UK and Precision Decisions, HFH is a world first proof-of-concept project. It started in 2016 with the aim of demonstrating that there are no technological barriers to fully autonomous field agriculture.

"[Franklin's team's] approach was for something that was open source and could challenge the current thinking," said Blacker. "They wanted to use existing off-the-shelf components that would challenge some of the thinking of some of the bigger manufacturers, in terms of trying to make products more available without people having to buy into a system that they might not want on everything – which is typically the way some manufacturers are looking to go. They want ownership of everybody's machines and data, which is becoming – at times – claustrophobic and restrictive."

The initial one-year project was undertaken with smaller machines that included a lightweight, 38HP Iseki tractor for spraying, drilling and rolling a crop of spring barley. One of the project's aims was to facilitate precision farming via automation with smaller, lighter machines that remove compaction issues and provide much greater resolution in relation to the application chemicals.

Jonathan Gill, mechatronics researcher and unmanned aerial vehicle pilot, flew regular drone sorties over the crop to acquire multi-spectral NDVI (normalised difference vegetation images) that would help inform agronomist Kieran Walsh, of crop production specialist Hutchinsons, about the condition of the crop and where to send a ground rover to collect plant and soil samples. The ground rover – a modified wheelchair – was also able to send video footage, giving Walsh more information about crop conditions.

> "It's essentially being more efficient and more sustainable"
>
> Martin Abell

According to Martin Abell, an engineer at Precision Decisions, this information allowed the team to apply fertiliser very precisely. "It's all about putting the right product in the right place at the right time," he said.

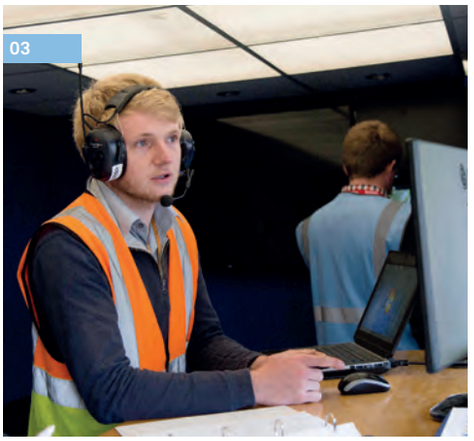
"Instead of putting a flat blanket rate across the field you vary that according to what the crop needs. It's essentially being more efficient and more sustainable."

When it was ready, the crop was harvested by a 25-year-old Sampo combine with a two-metre header unit. The team instructed and observed from 'mission control', a hut at one end of the hectare, but all tasks undertaken in the field were carried out by readily available machinery; open source technology; and an autopilot from a drone to help with navigation.

"This whole project revolved around taking the computer from a drone and

01


02


03

01 Iseki tractor and drill

02 From left: Martin Abell, Kit Franklin and Jonathan Gill

03 Martin Abell at mission control

placing it on the vehicles, so that the autopilot was then in control of each of the vehicles," said Abell.

"We had to work out how to convert the signals that would [translate] into the movements that the human operator would normally do. That revolved around linear actuators and electronic motors, and they were mounted onto the conventional controls. Then we basically used motor drivers and different feedback mechanisms to work out what they were doing and interpret those signals from the drone autopilot into movements."

With the drone autopilot installed for navigation, the tractor could then follow a predefined route in the field, making its way between waypoints, which are digital GPS markers positioned at the ends of the field for the tractor to navigate to. During the drilling phase, the waypoints incorporated lifting and lowering signals that picked the drill up at one end and placed it back down once it had turned around.

The tractor was first in line to undergo modifications for autonomous operation and, whilst the team was keen to prove open-source technology, it found also that systems designed for non-farming applications did not always translate in the field. "When you put a GPS receiver on top of a tractor – with a few metres of height and a lean angle – then suddenly that makes an offset in your GPS," said Franklin. "As the tractor would lean and wobble the programme within the autopilot software would chase that result, ending up with our tractor S-ing its way along the field."

The spring barley yielded 4.5 tonnes, missing HFH's predicted yield by just 0.5 tonnes. In November 2017 the HFH team received a boost from the Agriculture and Horticulture Development Board (AHDB), enabling it to embark on a second crop of winter wheat. The Harper Adams team has also been chosen to participate in RuralFirst, a UK government 5G project led by Cisco and backed with £4.3m in funding.

For HFH, mission control was receiving information from field vehicles via Wi-Fi, which had range of 150m. 5G promises nationwide coverage, and would give the HFH a range of benefits including improving the video link between mission control and the ground rover, which Franklin describes as "grainy".

"At the moment we have a radio connection for our video and it's all bit... crackly and we're hoping that with 5G we can potentially go to four or five full HD video streams," he said.

In February 2018 the Government announced £90m of Industrial Strategy funding to investigate the application of technologies such as AI, robotics and earth observation in agriculture. This, in turn, is expected to help boost rural economies and create new, high-skilled jobs. As Franklin noted, agricultural automation has the potential to boost jobs, rather than remove them.

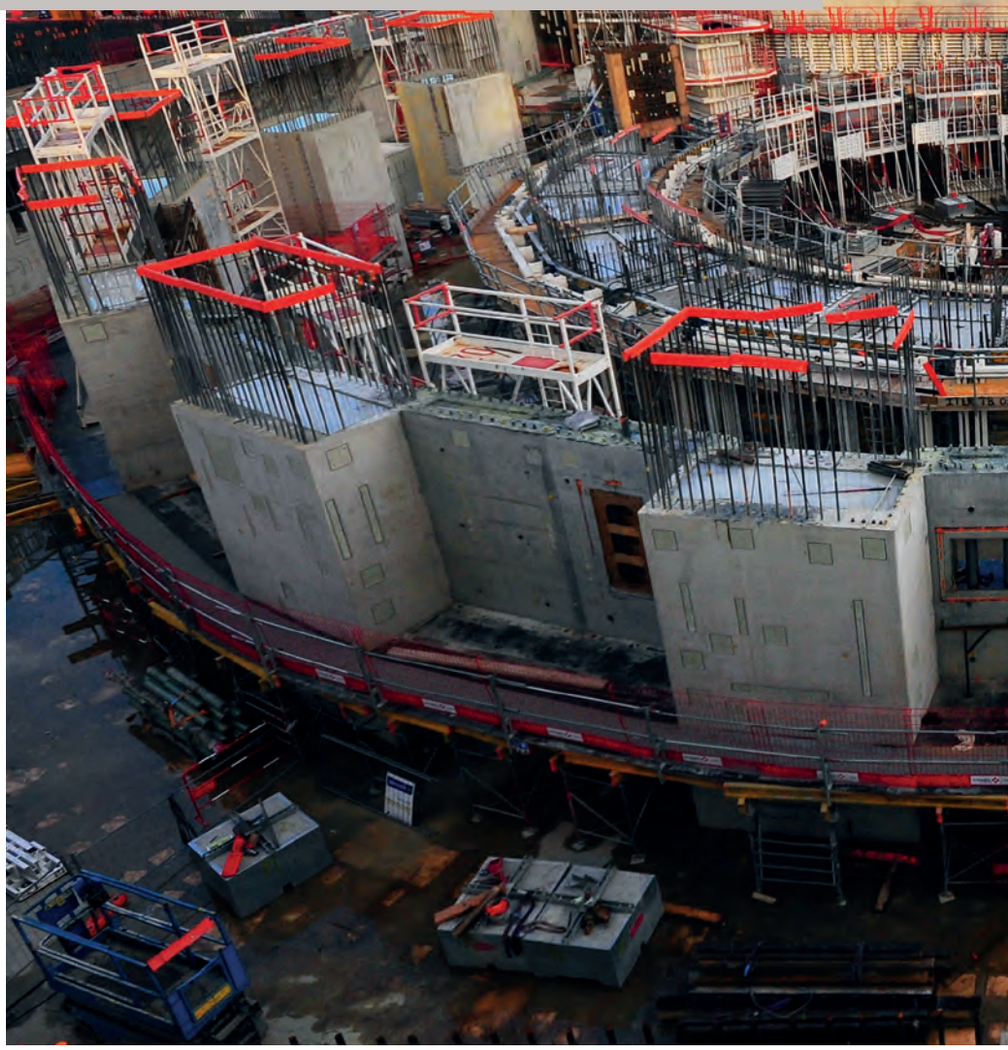
Willingness to invest in precision farming is welcomed, but Franklin, Abell and Blacker all agree that the approach has to appeal to the very people it's aimed at, namely farmers. "Farming is business and if you can offer a farmer a business case they'll be interested," said Franklin.

"Precision farming as a concept has been spoken about for the past 20 years and the reason for the slow uptake is because not much of the technology has had that really clear-cut business case attached to it.

"For things like spot spraying the maths becomes very easy. If I've put 80 per cent less chemical in my tank I've saved 80 per cent of what is one of my biggest current costs. That's where it [precision farming] will become easier." ■

Innovation at the nucleus

Stuart Nathan **talks to Assystem's chief technology officer about the challenges for engineering firms in the digital age**



Robert Plana has a lot on his plate. The chief technology officer of French engineering contractor Assystem joined the company last September as it was in the midst of refocusing its business. It has sold off 60 per cent of one division, Global Product Solutions (GPS), which works with clients from design through to marketing of products and services, and is now entirely focused on its remaining business area, energy and infrastructure (E&I).

Plana's career has taken him through several different sectors of engineering, and has spanned industry and academia. "I'm a scientist," he told *The Engineer*. "I have a PhD in physics and electronics. I've been a university professor in Toulouse, and I've had a long journey in science and innovation."

Before Assystem, Plana worked at GE Digital, where he was in charge of developing an ecosystem with research universities. Prior to that, he headed up innovation programmes for Alstom. He sees his role at Assystem as stimulating innovation across the group and making sure "we will continue being at the forefront of technology and knowledge". A second part of his role is "to draw a route map concerning the digital transformation of energy and infrastructures", while a third is "to develop an ecosystem of innovation through the co-development of projects with customers".

"So you can see the combination of my two previous positions makes me familiar with the roles I'll be taking on with Assystem," he said. "What is new for me is working with an engineering company and that's part of the reason I joined; the challenge is very exciting. I met very inspiring people and was enthusiastic about the project so decided to leave GE for Assystem."

E&I is active in a variety of roles, most importantly nuclear engineering, transport infrastructure and infrastructure for life sciences. "The idea is to become a leader in nuclear engineering, but with the evolution of the energy mix and increasing urbanisation, we want to take a position in renewable energy, smart grid and transportation systems on one side. On the other side, we have competencies in the qualification, verification and certification of the infrastructure for life sciences, chemistry and the steel industry and so on."

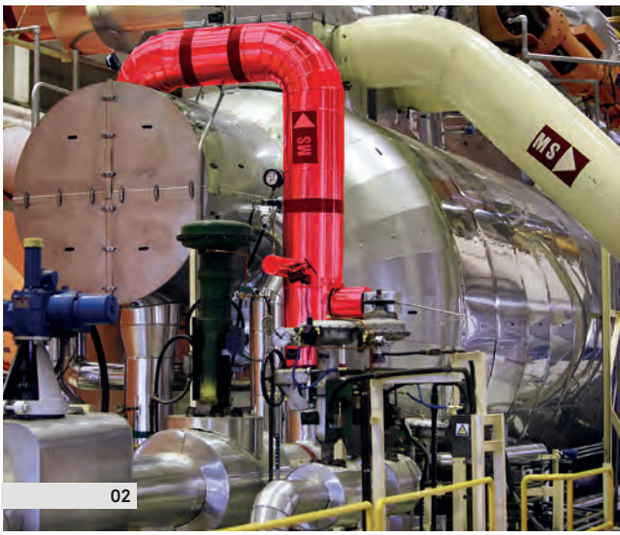
The life sciences side is complex. "We are designing, commissioning, starting and maintaining manufacturing sites where the life science industry is developing its products, so we will not develop products; we will develop the infrastructures in which the products and medicines will be developed," Plana explained. "That's very important, because today there is a strong need to optimise the energy infrastructures to make sure the qualification and certification will be done in the fastest and most efficient way using a paperless approach."

"SMR is somewhere we are going to be investing heavily in the future"

Another aspect of their work here will include predictive maintenance, which Plana regards as process optimisation rather than development; "it can be referred to as asset performance management," he said. "You might have a fleet of robots or some other equipment and you need to ensure that availability of these asset is

IMAGE: ITER ORGANISATION.

01



02

maximised and that the maintenance scheme is well handled and controlled." This is a key aspect of control of costs for such facilities, he added.

Assystem can be main contractor or a subcontractor on such projects, Plana said. "We can have a situation where we are running the project management and approaching different subcontractors, and we can also be in a position where we are installing and configuring the infrastructure, and later on we can be in a position where we are maintaining the equipment."

However, it is in the nuclear sector where Assystem hopes to really make its mark. "When we sold the GPS entity, we also took the opportunity to take some equity in Areva, so we hold five per cent of that company. We are also partnering with EDF, of course, and with Rusatom. In the UK, we are discussing with Rolls-Royce around a small modular reactor (SMR) programme. This is our flagship investment project; SMR is somewhere we are going to be investing heavily in the future."

Assystem is regarded as a medium-sized company, and in its new configuration will have about 4,000 employees. It is, however, well known for its ability to handle complex projects and can therefore compete with much bigger companies. Like many engineering organisations, it is currently coming to grips with the Internet of Things (IoT) or industry 4.0. "IoT will modify the way we do systems engineering in the future," Plana said. Up to now, he elaborated, systems engineering was mainly driven by the clients' requirements. The hallmark of IoT is its capacity to generate huge quantities of data, and while this can be challenging, Plana sees it as a key advantage.

Fresh data can be consolidated with the core data from a facility, and this creates "new patterns concerning the behaviour of an asset," Plana said. "That creates an opportunity to do systems engineering driven by both requirements and data. We believe this is an original way to approach the future of systems engineering, where we will be able to do design in the fastest way and a more efficient way, respecting the client's deadline with higher accuracy and also installing digital continuity along all the engineering process."

This will be an advantage because previously design was done on one side of the project, commissioning on another and operations on yet another. "With digital continuity we can overcome that, and product life-cycle management (PLM) is one way to do that, but PLM reaches limits when you want to introduce real-time data."

A key advantage of IoT is its ability to handle real-time data. IoT integration platforms will allow Assystem to connect technology and tools, Plana said, thereby allowing them to develop a customised application for each customer designed specifically to release value. "There are two levers," Plana said. "One is systems engineering driven by data and requirement, and secondly there is integrating IoT platforms for our customers."

In a world of increased connectivity, Assystem plans to be a key connector, and Plana wants to hold that key.

01 The concrete protective wall that will surround the ITER nuclear fusion reactor currently under construction near Marseille, one of Assystem's major projects

02 A steam generating vessel for a nuclear power plant

Taking on the Arctic with GKN

The frozen lakes of northern Sweden provide the ultimate test-bed for the latest torque vectoring technology. Chris Pickering reports

You can almost sense the impending accident in the stillness of the Arctic air. Two-and-a-half tonnes of Volvo XC90 is bearing down on a perilous 90-degree corner, covered in sheet ice. The surface has a light dusting of snow and glassy blue patches where it has been scraped bare.

And yet, somehow, the inevitable crunch never comes. Instead, the nose of the car tucks obediently in to the bend and the driver floors the throttle to ride out a long, lurid slide.

It soon becomes apparent that he's doing it on purpose. Not very relevant to everyday driving you might argue, but the car in question is one of GKN Driveline's fleet of technology demonstrators. And the important thing here is that it's bending physics in a way that a vehicle of this size simply shouldn't be able to do.

As with the production Volvo XC90 T8, on which this prototype is based, the combustion engine powers the front wheels alone, with drive to the rear coming from an electric motor. The key difference here is that the standard rear drive unit has been replaced by a GKN eTwinster system, which uses a pair of active clutch packs to distribute the torque in place of a differential.

Next, it's our turn. Having previously been out in the standard car the difference is night and day. The big Volvo reacts crisply to even the smallest of control inputs, with noticeably less steering lock required. Absurd as this sounds, there's a hint of Lotus Elise to the leviathan's responses.

As our guide so willingly displayed, the car's angle of attack is now far more sensitive to the throttle. The same principle applies when you lift off, with the regenerative braking effect split through the clutches to control the car's attitude; too much understeer or oversteer and the system will adjust to compensate. What's more, because it reacts in around 100 milliseconds, the Twinster unit can apply an aggressive initial response to bring the car back into line, followed by a gentle yaw-damping effect to prevent things from going too far. It's the ultimate form of automotive flattery.

The calibration settings on this demonstrator vehicle have been tweaked to allow a degree of showboating, but the fundamental effects would be just as relevant in normal conditions. The same freakish levels of agility would be beneficial every time you went to thread the car down a winding country lane, while the greatly improved stability could be a potential life-saver in emergencies.

GKN has been developing the Twinster technology for some time now, with the electrified eTwinster first previewed in 2016. The core technology has been evolving ever since, though. In particular, the company recently introduced the eTwinsterX. This uses a two-speed seamless shift transmission to extend the electric axle's speed range up to a theoretical 155mph (250 kph). Above that, the electric motor disconnects and the vehicle can continue in two-wheel drive mode.

We won't be going that fast today, but it's back onto Sweden's frozen lakes of Arjeplog to sample GKN's 2018 Technology Demonstrator (or GTD18 for short). Based on a Mercedes GLA 45 AMG, it does

01 Volvo XC90 T8 demonstrator with an electrified eTwinster unit on the rear

02 eTwinsterX cut model with sideshafts

GKN GTD test car, aka Merc GLA45 AMG

IMAGE: DEAN SMITH

away with the production car's mechanical all-wheel system. Instead, like the Volvo, it becomes a 'through the road' hybrid, with an eTwinsterX unit on the rear. What makes the GTD18 particularly intriguing, however, is the fact it also has a Twinster unit fitted to the gearbox at the front, splitting the torque from the combustion engine across the axle. That means, at the touch of a button, it can be driven in front-wheel drive, rear-wheel drive or four-wheel drive configurations with an infinite torque split across all four wheels. And that gives it some rather unique abilities.

Its first trick is familiar. By adjusting the degree of torque vectoring, the GKN engineer next to me can make the car feel noticeably more agile from one slalom run to the next. Again, there's a serious point here. You reach a stage where the Twinster-equipped configuration will swerve around the obstacles and the regular setup will not.

Next, we switch to electric-only mode. Because the front Twinster system allows the combustion engine to be decoupled completely, GKN says it could add up to 15 per cent to a hybrid vehicle's zero emissions range.

Under our low-speed conditions of our test, it makes for quite a potent driving experience – not to mention an entertaining one with the electric motor's 120kW (161HP) and 210Nm (155lbft) of torque sent to the rear wheels alone.

> "The torque vectoring resulted in a turning circle that would shame a London taxi"

The biggest surprise, however, comes when we switch to front-wheel drive mode. For all the packaging efficiency benefits of front-wheel drive cars, they have a tendency to understeer at the limit. But not this one. By carefully manipulating the torque split and selectively overspeeding the outside wheel, GKN has created a front-wheel drive car that will power-oversteer. It feels surprisingly natural, too – much like the same car operating in rear-wheel drive mode.

The engineers have saved the car's party piece until last. After another tweak to the calibration, I'm invited to turn the steering onto full lock and do a U-turn. The GTD18 promptly whirls round in little more than its own length – the torque vectoring function resulting in a turning circle that would shame a London taxi. As with all these demonstrations, it's possible that the low-grip surface is flattering the system's abilities, but it's still a vivid illustration of the potential benefits.

The timing is also rather apt. Hybrid and electric vehicles are the industry's hottest topics right now and GKN is a keen advocate of the so-called P4 or through-the-road architecture. The company points out that this would enable carmakers to pursue a modular approach; by selecting different modules they would be able to scale the drivetrain up from two-wheel drive to four-wheel drive and from combustion-only to hybrid or fully electric. It also allows the electrical half of the system to operate without the driveline losses that come from mounting the electric motor on the engine (P0, P1, P2) or the transmission (P3).

The other major factor when it comes to electric and hybrid vehicles is weight. For all the talk of super-light composite materials and high energy density batteries, plug-in capability still comes with a weight penalty measured in hundreds of kilos. You can never entirely suppress physics, but GKN's work proves that you can take a vehicle built like a moose and make it handle like a gazelle. ■

Improving patient outcomes

Smart implants are changing the way bone diseases and injuries are treated, writes Matt Parkes**, senior medical development engineer at Renishaw**

Since the early 1900s, surgeons have been using metal implants in healthcare, typically to treat bone diseases including osteoarthritis and inflammatory rheumatoid arthritis, as well as in reconstruction therapy.

Though a long-established technology, traditional implants often cause challenges for patients and surgeons. One area being worked on is smart implants, which improve patient outcomes and bring the technology into the modern age.

Implants can be smart in two ways, either by being additively manufactured to produce patient specific implants (PSIs) from computed tomography data, or by incorporating sensors. Still in the early phases of development, inbuilt sensors could collect patient-specific data, enabling surgeons and other healthcare professionals to tailor treatment to the needs of individual patients.

One of the key challenges that traditional implants present is loosening. Particularly common following joint replacement procedures, loosening can be a result of poor osseointegration – the structural and functional connection of the implant with the patient's bone.

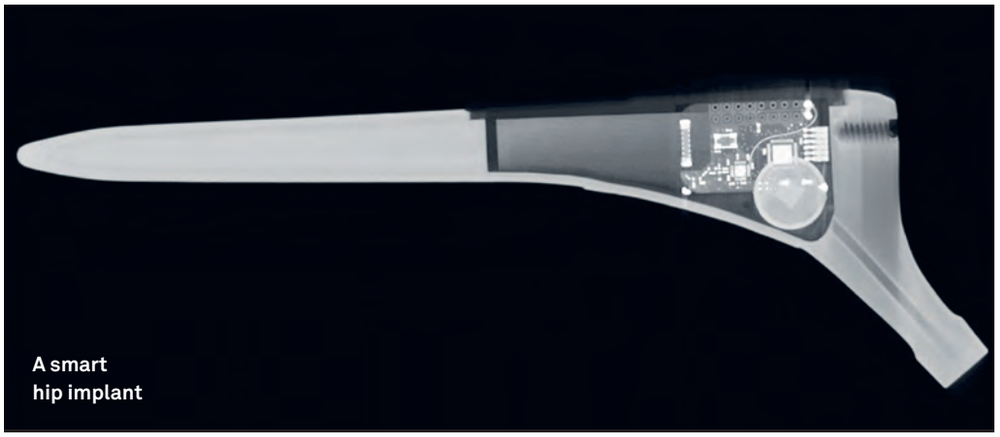
Another limitation of traditional metal implants is that they are only manufactured in a discrete number of shapes and sizes. Therefore, it is unlikely patients will receive an implant that fits them accurately. This can cause poor physical function and contribute to loosening.

Poor physical function can also occur because of stress shielding – the process whereby metal implants remove stress from the patient's bone. The bone responds by reducing in density and therefore becomes weaker.

The increasing incidence of obesity is one reason joint replacements are becoming more common in young people. This poses longevity issues as implants can reach their maximum lifespan and need replacing several times.

To combat these issues, researchers and engineers have been developing implants in new ways, using techniques such as additive manufacturing (AM). The technology aims to improve the form, fit and function of implants.

Because AM builds an implant layer by layer, it's possible to produce PSIs that are a more accurate fit for the patient. The manufacturing method also has fewer geometric constraints than subtractive manufacturing. PSIs designed and manufactured according to a patient's CT scan encourage the implant to integrate with the bone, reducing the risk of loosening. As a result, patients are less likely to suffer pain or require revision surgeries.



A smart hip implant

As well as being able to manufacture an exact shape, AM enables surgeons to control additional properties of the material. They can design implants that mimic the patient's bone stiffness, density and trabecular structure, which can reduce stress shielding and improve osseointegration and physical function further.

Sensors

Implants can also be made smarter by adding sensors. This allows clinicians to accurately measure patient data, such as temperature, which is the key to evidence-based medicine.

Sensors can also be incorporated into bone reinforcement implants, which are used to help fractures heal. In this example, sensors can measure the strain exerted on the implant, which indicates the extent the fracture has healed. From this information, surgeons can determine the best time to progress the patient to the next stage of therapy and could identify healing problems earlier than currently possible.

As implant loosening can be affected by non-compliance with physiotherapy, technology has been developed to overcome this. Incorporating accelerometers to monitor the movement of patients would allow healthcare professionals to obtain data remotely. This could be used to determine whether a patient is complying with their prescribed physiotherapy and rest regime.

One institute developing technology in this field is a collaboration between Renishaw and Western University in Ontario, Canada, who have set up the Additive Design in Surgical Solutions (ADEISS) Centre to bring together clinicians and academics to generate novel 3D printed medical devices. ADEISS recently showcased the smart hip concept, which uses temperature sensors and accelerometers to collect patient data that can be communicated to a remote device.

By making use of advanced sensor technology, there is now potential for the development of implants that can detect an infection and subsequently secrete the appropriate dose of antibiotic to treat it. This could reduce the number of patients admitted to hospital.

For widespread clinical adoption of smart implants, there are still challenges to overcome. Clinicians must run clinical studies to collect data on the safety and performance the implants offer. This must all be done in line with regulations such as the EU Regulation on Medical Devices. A further key consideration is the processing of personal data in smart implants and how that data is used.

The treatment of bone diseases and injuries has come a long way since the days of bone setters and blacksmiths. Patients can now receive metal implants designed to their individual requirements. Pioneering research is improving the technology, so the uptake of additively manufactured and data-driven implants is set to rise, improving outcomes for patients and hospitals. ■

From part to system: next steps for AM

Additive Manufacturing (AM) is moving beyond creating 'dumb bits' and evolving into a tool that can produce 'smart technology'. Prof Richard Hague **and** Prof Christopher Tuck **preview the next generation of AM technology**

Additive Manufacturing (AM) has come a long way since its early years in rapid prototyping and, later, as a means for creating end-use parts. The learning gained over decades of the technology's evolution, coupled with ongoing efforts by an increasing number of researchers have driven AM to become a manufacturing platform fit for the 21st century.

AM is beginning to transition beyond simply creating metal, ceramic or polymer 'bits' for industry and we are now looking at the bigger picture beyond these single-material components. Co-deposition of both structural and functional materials is now being investigated with a view to creating 'smart', multifunctional technology. This will be applied to improve, for example, delivery and dosing in industries including agrochemicals and pharmaceuticals, as well as to generate functional 3D printed electronics.

And we've learned some important lessons along the way; namely that science needs to be part of AM from the beginning – we can't just launch machines without an understanding of how they work and expect success. AM also needs to advance beyond engineering and fixed processes. It requires a comprehensive approach that encompasses:

- repeatable processes
- useful materials
- appropriate designs.

By joining up these three key developments we are adding function to AM's historical roots in creating structures, which will result in the true 'next generation' of AM: a movement from parts to a multifunctional system.

More than machines and speed

Although we're still seeing improvements and changes to AM machines – the shift from single-point energy sources (lasers and electron beams) to multipoint sources like those in Renishaw's quad laser system comes to mind – speeding up parts' production is only a small part of AM's new generation. This is not to say that traditional manufacturing markets have no place for AM as it evolves; in fact, it's quite the opposite. It is these industries where AM has become truly embedded.

Pharmaceuticals, medical, chemical, food production and semiconductors are industries where AM is, comparably, still very much in its infancy and therefore fuelling research projects. Whether we're looking at nutraceuticals, polypills or printed electronics, precision is required in the deposition of materials using AM, and jetting-based technologies are currently viewed as the best approach for printing these smart systems. This is primarily because they allow the selective deposition of individual materials. High throughput is also essential for these processes to work to ensure each dosage is delivered accurately and efficiently – hence the current research on the 'jettability' of a range of materials. The goals of more precise drug delivery and dosing, nutrition and conductivity are all the remit of these markets. This integrated approach to AM combines the structural together with the functional with a view to improving our health and everyday lives. Most definitely not technology for technology's sake.

Not just for engineers

The diverse range of industries AM's expanding capabilities serve tends to attract people from a wider range of backgrounds, interests and disciplines than many of the other manufacturing sciences. And candidates are entering academic, training and apprenticeship programmes with more prior knowledge and experience of AM than ever before. Our undergraduate, and indeed post-graduate, AM courses at the University of Nottingham are all over-subscribed and students are coming in with their own ideas. Some of them now have their own 3DP machines.

Industry is catching on too – we're starting to see more people enter workplaces with a better understanding of what can be achieved with AM. Companies are beginning to hire graduates as AM decision makers and investing in in-house training and apprenticeship programmes, recognising AM is no longer the reserve of mechanical engineers.

Alongside the investment in the workforce, funding and grant support from organisations such as EPSRC, Innovate UK and other industry players will ensure that AM continues to evolve. ■

If you would like to learn more about the next generation of AM and its latest research and applications, join Profs Hague and Tuck from July 10-12 at this year's Additive International – www.am-conference.com

01 Christopher Tuck – professor of materials engineering, faculty of engineering, University of Nottingham

02 Richard Hague – professor of innovative manufacturing; director, Centre for Additive Manufacturing (CfAM), faculty of engineering, University of Nottingham

Seeing is believing

Flir Systems' thermal imaging and SICK's entry-level vision-guidance are providing hi-tech solutions for clients

Flir Systems

Technology supplied by thermal imaging specialist Flir is being used by Red Bull Racing to keep a close eye on its data centre

In top-flight motorsport, data is king. And the ability to rapidly access this critical information and share it around the world is frequently one of the key areas of competitive advantage

For Formula One's Aston Martin Red Bull Racing, the epicentre of this data operation is its Milton Keynes-based data centre. And to ensure that things run smoothly, the IT team there relies on the thermal imaging capabilities of Flir's ONE Pro.

Flir Systems has been an innovation partner with Aston Martin Red Bull Racing since 2014. Initially, it supported the team by gathering temperature data from race cars, but the collaboration quickly expanded to other areas.

The team uses Flir thermal cameras and test and measurement equipment for other company assets, and for thermal management of the wind tunnel. It also uses Flir's end-to-end security solutions, utilising a combination of thermal and visible security cameras to monitor both the inside and outside of their factory buildings.

The main challenge for a data centre is to prevent and manage electrical and cooling issues. Unless you have the right tools to highlight areas of concern, these type of issues are invisible.

"Our latest data centre has advanced power usage and temperature monitoring, but this will not highlight a poor electrical connection that is getting hot and could risk a potential fire, explained data centre manager Gary French. "Nor will it highlight poorly installed hardware that is causing hot air circulation."

To monitor these potential risks, French and his team needed a small and simple thermal camera to carry out basic visual checks around the data centre infrastructure, and they turned to the Flir ONE Pro thermal imaging camera.

"When the Flir ONE Pro was demonstrated to us we were sold right away," said French. "The size and weight allow you to keep it in your pocket, and you can perform checks on-the-go for both electrical and airflow concerns whenever this is required. The quality of the thermal images allows us to give management visibility of any issues and to immediately submit budget requests for remedial work. The integration with your smartphone makes it so easy to share concerns right away."

01 Flir's ONE Pro offers integration with smartphones

02 The SICK Inspector PIM60 URCap

SICK

Cobot collaboration delivers entry-level vision-guidance

Industrial sensor specialist SICK has collaborated with Universal Robots to develop an entry-level vision-guided cobot system for pick and place, quality inspection and measurement.

The SICK Inspector PIM60 URCap is a simple yet powerful toolkit for creating vision-guided robot tasks with the minimum of time and effort.

"With the SICK Inspector PIM60 URCap, it's easy to add eyes to your robot application," said Neil Sandhu, SICK (UK) vision specialist. "This entry-level package allows engineers to set up the robot to be guided to pick randomly positioned objects, as well as to inspect or measure the objects prior to picking." And because it doesn't need specialist programming expertise, it makes an ideal 'starter' vision-guided robotic solution for a production line, even on a small scale, and is sufficiently adaptable to equip a pilot process facility for production development work.

Sandhu said: "The in-camera software guides you through the set-up and calibration process, so even if an engineer is new to 2D vision robot guidance, development of an effective solution is simple. Experienced users will relish the directness and simplicity of the set-up and parameter change procedures, as well as the handling capabilities of the range of Universal Robots that the SICK Inspector PIM60 URCap supports."

The software ensures easy integration between a UR3, UR5 or UR10 robot and the SICK Inspector PIM60 2D vision sensor. Standard configurations, such as changing jobs and pick-points, calibration and alignment, are done from the robot control pendant, making everyday operation fast and straightforward. More advanced operations, such as inspection and dimension measurement of objects prior to picking, can be done through SOPAS – SICK's standard device configuration tool. The SICK Inspector URCap is also ready to expand through extra data fields that can accommodate results from both detailed object inspections and measurements.

Highlighting excellence in the plastics industry

Showcase is an opportunity to see the latest developments and to discuss how the material's external image can be improved

PDM, the UK's annual plastics design and manufacture showcase, returns to the Telford International Centre from June 19-20. The show will incorporate multiple elements of the plastics industry, with a focus on design, moulding, packaging and recycling. Exhibitors will include product design companies, moulding machinery suppliers, toolmakers, rapid-prototyping specialists, moulders and mouldmakers, plastics recycling specialists, masterbatch specialists, software suppliers and materials-testing specialists.

Alongside the exhibition, the free-to-attend PDM conference will run on both days and cover the latest in plastics design and manufacture, including moulding processes, rapid prototyping, materials innovation, plastics recycling and sustainability issues. The conference also promises to tackle some the most challenging issues facing the industry: from Brexit and the Chinese import ban to the recent demonisation of plastics by the media and politicians.

The PDM conference will feature expert speakers from the British Plastics Federation (BPF), CEEMET (the European employers' association) and Made in Britain. It will also include a panel discussion on how the industry can improve plastic's image.

Philip Law, director general of BPF, will provide an opening address on where the plastics industry is headed. Mike Baxter, the organisation's director of external affairs, will then present a session on the Chinese ban on plastic waste exports and the implications for the British recycling industry. He will be followed by Kinza Sutton, marketing manager of Plastipak, who will explore why plastic has become 'enemy number one', looking at how myths and negativity being perpetuated by the media and politicians are affecting public opinion. Her presentation will remind delegates of the positive role plastic plays in our everyday lives, and call for a joined-up approach across the industry to redress the balance.

By way of example, the BPF recently issued a statement in response to recent government announcements on plastic waste. It said: "We are very disturbed that the tone of language used does not recognise the important benefits that the plastics industry brings to the UK, including 170,000 jobs. Plastics themselves save energy. They are low-carbon materials, crucial in the fight against climate change. Their light weight and durability cuts fuel consumption in vehicles and aircraft and reduces pollution. They provide protection for products and prevent food waste. By encouraging plastic-free aisles, the Government is creating an impression that the use of plastics is inherently wrong. Typically, food waste in stores increases by a third without packaging. For example, a wrapped cucumber lasts 14 more days than one that is not. Cutting out plastic packaging for fresh produce will actually harm the environment through increased CO_2 emissions because the energy used to produce food is much greater than in the packaging protecting it."

01 PDM has a wide variety of exhibitors

02 The conference will help the industry set the agenda going forward

Matt Barber, event director for PDM, said: "We have a really strong line-up of speakers who will not shy away from tackling the difficult issues facing the plastics industry. The conference sessions and panel discussion will provide an important opportunity for the industry to find solutions and set an agenda for action."

Waste-management solutions will be discussed. The Sustainability sessions will include a presentation on stopping ocean plastics by Professor Ed Kosior, CEO and head consultant at Nextek, and another on the use of recycled materials in the future, led by Stephen Mancey, CEO Europe of Logoplaste. In Design and Differentiation, Keith Freegard, director of Axion Consulting, will explain the importance of "circular thinking" in sustainable product design. ■

The PDM Event exhibition and conference is free to attend. For more information visit www.pdmevent.com

World's biggest industry fair turns attention to skills

Top employers looking for employees of tomorrow

Digitisation is revolutionising the world of work: robots work hand-in-manipulator with humans or travel autonomously through warehouses. Technologies like augmented reality will connect workers with the factory, while exoskeletons will support them on the job. Meanwhile, energy consumers are developing into energy suppliers.

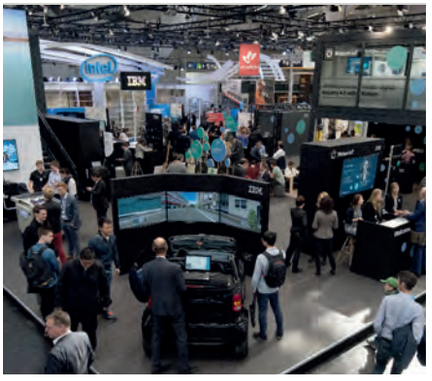
But industry is still confronted with some major challenges. According to an economic survey commissioned by the German Chamber of Industry and Commerce, German manufacturers view the shortage of skilled labour as their main business risk, since it means having to turn down new orders, postpone investment in new technologies and cope with the related wage hikes. By 2030, the economic research and consulting firm Prognos is forecasting a skilled labour shortage of approximately three million people.

Career 4.0 at Hannover Messe is dedicated to examining the steps needed to resolve this shortage and build a qualified workforce. The programme consists of three main elements – Job and Career, WoMenPower and Young Engineers Day – with a shared focus on questions like, "What can industry offer me in terms of my career? How can I move up the ladder? How can I balance work with family life? What training courses are important for me?"

"Not only does Career 4.0 provide students, young professionals and experienced workers with comprehensive information on job vacancies and career opportunities, it also shows them the radical impact of digitisation on the world of work and the kind of requirements they need to prepare for," said Sonia Wedell-Castellano, director of sales and operations at the event. "This is our way of supporting our exhibitors in terms of their training and recruiting measures."

WoMenPower

On Friday, April 27, Deutsche Messe will stage the WoMenPower Career Conference at Hannover Messe for the 15th time. Aimed at specialists and managers as well as career novices and students, the programme will consist of presentations, panel discussions, workshops and networking events. The motto in 2018 is "New Work – Careers in a Changing World", with the keynote delivered by Janina Kugel, chief human resources officer and member of the managing board at Siemens Group. A networking night the evening before the congress gives an opportunity to make new contacts.



01 The Messe is geared to both industry and job seekers

02 Large employers will be there

The Engineer Powerwoman award will be announced at WoMenPower. This career award honors women who have made special contributions to the technical environment of their companies. The prize is €5,000 (£4,380) and the award ceremony takes place on the same day as part of the official WoMenPower opening ceremony.

Job and Career

Job and Career is the job exchange at Hannover Messe – an event geared to professionals and managers from industry on the one hand, and to university students and graduates on the other. Apart from chatting with potential employers, job seekers can learn about training and career planning. In the Job and Career area, technical and career specialists will discuss business topics and provide training and workshops – ranging from personal and professional development to career tips.

The Job and Career online portal carries more than 1,000 job vacancies posted by Hannover Messe exhibitors, such as Audi, Aerzener Maschinenfabrik, Ferchau Engineering, Festo Didactic, the Fraunhofer Academy, the Karlsruhe Institute for Technology (KIT), the Leibniz Association, Phoenix Contact, Pilz, Rittal, the Association of German Engineers (VDI) and the German Electrical and Electronic Manufacturers' Association (ZVEI). Job seekers can use the portal to search for potential employers and schedule appointments with them.

Young Engineers Day

Staged jointly by the Association of German Engineers (VDI) and Hannover Messe, Young Engineers Day on Thursday, April 26, is geared to students with technical and engineering majors, featuring topic-specific guided tours and information offerings. Students and young engineers from the VDI network can visit exhibitors in the fields of robotics, Industry 4.0, lightweight construction, energy and drive technology. Participants stand to benefit from direct contact and dialogue with representatives of industry.

The topic-specific tours start at 10am and 2pm on April 26. Registration takes place on site at the VDI stand in Hall 2. From 6pm onwards, all students are invited to attend the Young Engineers Party in Hall 18, with DJ Aleksey and refreshments. ■

The post-Brexit recruitment challenge

Like many UK manufacturers, the car industry relies on skilled people from Europe to fill key posts. What will be the impact of leaving the EU? David Fowler reports

Much has been said about the potential of Brexit to disrupt manufacturing supply chains. The automotive industry in particular depends on lengthy supply chains criss-crossing Europe and is usually cited as the sector most vulnerable if the movement of goods becomes more difficult when Britain leaves the EU.

Given the fact that the large car makers and major suppliers are mostly multinational organisations, there is also considerable movement of engineering staff between the EU and the UK. So what does Brexit mean for the supply of automotive skills, and how reliant is the UK automotive sector on skills from the EU?

According to figures from EEF, the manufacturers' organisation, UK manufacturing in general is highly reliant on EU skills. "Three-quarters of EEF members have at least one EU national working in their business, and on average around 11 per cent of the manufacturing workforce is from the EU," said EEF head of education and skills policy Verity Davidge.

These employees fill positions across the skills spectrum, but are most likely to work as process plant and machine operatives, and in technician and associate professional engineer roles. EEF surveys have looked into the reasons for their recruitment. "The top reason is an insufficient number of applicants from the UK, followed by the fact that UK applicants don't always have the skills that EU nationals have," said Davidge. The first of these is more likely to apply at the lower skill levels, and the second at higher, professional engineer levels.

An impact from Brexit has already been seen, said Davidge, with 26 per cent of member companies reporting a reduction in applications from EU nationals since the Brexit referendum in 2016, and a 15 per cent increase in EU nationals leaving their businesses in the period immediately after the referendum.

Bosch UK president Dr Steffen Hoffmann said the UK automotive sector relies on skills from the rest of the EU "quite heavily".

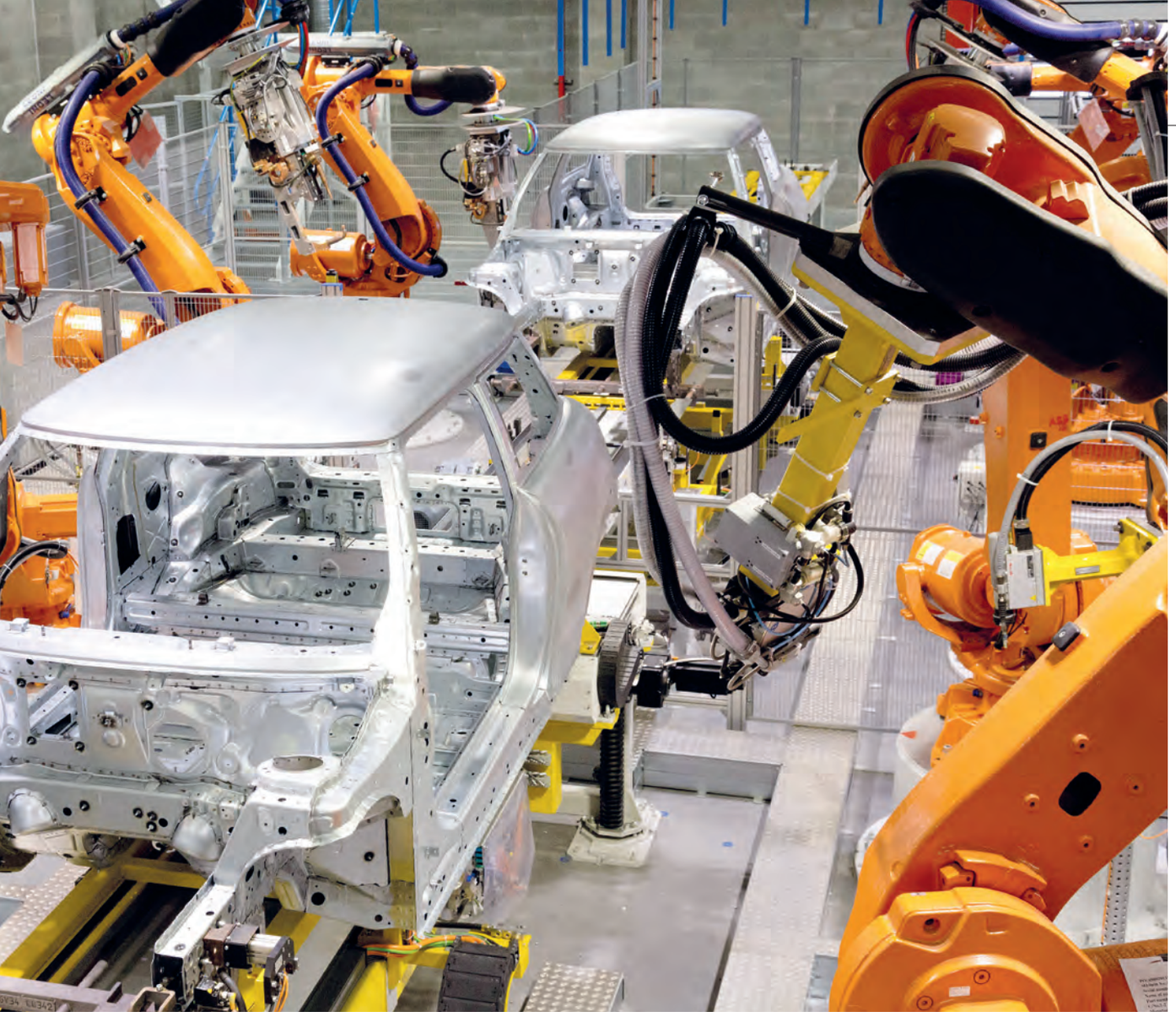
"Currently we have just over 300 people on our workforce who come from the EU," he said. With a total workforce of 5,200, that might not seem a particularly high total, he adds, but the positions that they fill are typically highly skilled and experienced engineering roles with specialist qualifications. He continued: "Even now, we battle to fill open positions in engineering – currently we have about 50 open positions. We've had this situation for some time, even before the referendum, and of course we don't know what Brexit solution we are going to get regarding free movement of people, immigration and so on. But there is the potential that Brexit could make the situation worse, for sure."

The most difficult posts to fill are in the area of application and software engineering, followed by electrical and mechanical engineering – "so across the whole board, but it's probably most difficult in software engineering," Hoffmann said. "The more specialist the qualifications are in automotive, the more difficult it already is."

Recruitment agency CBSbutler specialises in recruiting engineers for the most specialist, hi-tech end of the market, with clients such as Formula 1 teams including McLaren, and in the past Jaguar Land Rover.

Its clients seek specialists in concept design and the design of hi-tech prototypes, in composite materials and ultra low volume production, and quality assurance experts and software engineers. In general they will be qualified to masters' degree or PhD level. CBSbutler director Simon Bartington said that to an extent such vacancies are filled by people moving within the sub-sector, for example from one F1 team to another, but that some are recruited from hi-tech industries in Eastern Europe, attracted by higher salaries, as well as the prestige of working at what is seen as the cutting edge of the industry. Because the numbers of engineers sought for such niche specialisms are relatively small, there is by no means a shortage of individuals seeking to fill these positions, but since the referendum Bartington says has detected a "lethargy" or concern among Eastern European candidates about whether

All of the UK's major automotive OEMs rely on skilled workers from across Europe



Many British-built cars, such as the BMW Mini, are at the heart of complex Europe-wide supply chains

coming to work in Britain is still a viable option for the long term. With Germany's car market buoyant, he said, "quite a lot of people from Eastern Europe are now going to Germany instead". He added: "This will remain a concern until we know what the final [post-EU] immigration system is."

Is any shortfall in engineering skills likely to be filled by staff from non-EU automotive economies such as India and China? Immigration of skilled employees from the EU has fallen since the referendum and there has been an increase in demand for non-EU skilled workers, in which applicants are prioritised according to a points system and on the basis of the salary offered. There is a monthly cap on numbers, which has been reached for the last four months in a row, and last December the minimum salary needed to qualify rose to £55,000. In addition, employers are charged an annual fee of £1,000 for employing a non-EU national. Davidge said: "I question whether Brexit will drive immigrants from non-EU countries. The non-EU immigration system is complex and expensive. A lot of companies don't bother with it."

CBSbutler's Bartington said that he thought it more likely that hi-tech organisations would set up centres in the Middle East, as Williams F1 has done, where they can have access to Indian or Malaysian skills. "I'm sure that's on the horizon – to outsource some of the testing, they are more likely to set up centres overseas, where the costs are lower and they still have access to a skills base, especially on the software side," he said.

> "There is the potential that Brexit could make the situation worse"
>
> Bosch UK president Dr Steffen Hoffmann

Davidge said that companies are working to enlarge the UK skills pool. "They are investing in training for existing employees and bringing in more apprentices and graduates," she said. Some are also supporting EU employees in the process to get settled status in the UK.

Bosch's Hoffmann said: "We've always had the wish to fill vacant positions locally if possible." Bosch participates in a range of activities, he said, from supporting eight local schools in the IET Faraday Challenge in which students research, design and make a prototype solution to an engineering problem, to the Primary Engineer Leaders Award for pupils from five to 11. It also supports two local teams in the Formula Student competition to design and race a small-scale racing car, and has forged relationships with technical universities such as Warwick.

Hoffmann added: "To be realistic, you can get in touch with young people and students, but it will take years or decades until they have the experience that is required for some of those specialised positions."

The large car makers contacted for this article were reluctant to speak about Brexit and skills or, like Ford, said they had nothing specific to say on the subject. Ford instead referred to the wider problem of recruitment and activities it undertakes to attract young people. It said: "There is an overall challenge for the industry on the recruitment of engineers which is why we, like other OEMs, are active in talking about STEM and initiatives to attract young people to consider engineering."

Davidge said it was important for the Government to provide clarity about what future immigration system will operate after December 2020 when the transition period is due to expire: "Employers will need time to adjust to the new system." But so far there is no detail. "There is a lot to do and very little time," she said.

Hoffmann added that the agreement on the proposed transition period "makes me a bit more optimistic than I used to be. It will create a bit more stability in the mid-term, but let's not forget we are only talking about a period until the end of 2020. What happens after that is still quite unclear at this point". ■

KING
Group of Companies

The King Group (est. 1962) manufacture and convert specialist trailers, vehicles and plant for the construction, highways, rail, defence and nuclear industries with a prestigious end client portfolio of Government and blue chip organisations.

Senior Mechanical Design Engineer

£50,000 plus + Bonus + Benefits

Based at Riverside, Market Harborough

Exciting opportunity to work at a senior level on diverse and interesting projects for UK and Global top companies.

We are looking for a skilled and practical Lead Engineer to join a business working to deliver a solution focused service to our customers.

Reporting directly to the Engineering Director, this role will work closely with Operations and a flexible and proactive approach is required. You must have excellent problem-solving skills, capable of assimilating project information quickly, work well as part of a team and have kept up to date with developments in design technology.

This is a unique opportunity to develop your career with a market leading business with an enviable Client list and excellent long-term prospects. The role will provide a high level of personal autonomy from a supportive and experienced Director as well as the opportunity to coach and mentor junior Engineers and develop a small but dedicated team.

The benefits:

- 25 days annual leave, plus Bank Holidays.
- Secure employment with a long established Company.
- Support with Continuous Professional Development.
- Non-contributory Company Pension scheme + Life Insurance.

Next Steps:
To apply, please send a completed application form to: humanresources@hwmartin.com at your earliest convenience. The King Group (www.king.uk.com) are a wholly owned subsidiary of the Group of Companies. We are an equal opportunities employer and welcome applications from any suitably qualified persons.

Over 100 years invested in the UK's future

Leonardo has over 100 years of history at the leading edge of advanced design and manufacturing in the UK.

Over 7,000 highly-skilled employees and a vast network of suppliers and partners design and develop industry-leading aircraft, electronics, space, defence and security systems for UK and export customers, worldwide.

Inspired by the vision, curiosity and creativity of the great master inventor - Leonardo is designing the technology of tomorrow.

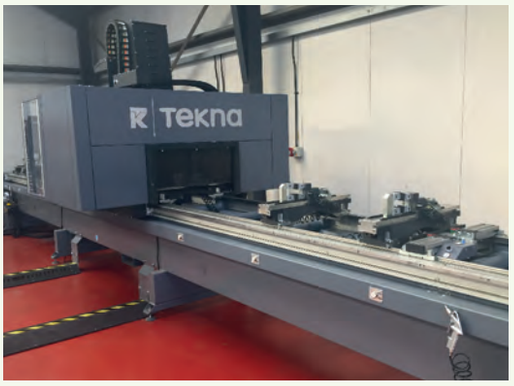
leonardocompany.com

Helicopters | Aeronautics | Electronics, Defence & Security Systems | Space

LEONARDO

CSI chooses Tekna TKE for new curtain walling installations

4-axis machine brings benefits to Hull-based glazing fabricator Sponsor: Emmegi (UK)



CSI Aluminium has chosen a Tekna TKE 944-7 heavy duty machining centre to fabricate its new, bespoke unitised curtain walling system. The system, which has been designed for installation from a tower crane for sites with limited access, uses 7m sections of Aluprof profile, so the large capacity machine with a 7-metre bed was the ideal choice.

CSI already has an Emmegi Phantomatic machining centre and Classic Star and Twin Ferro saws in its factory. However, in the years since it purchased these machines, the global Emmegi group has acquired both the Tekna and Keraglass machinery businesses, so Emmegi (UK) can now offer a much broader range of machine options to suit any budget and virtually any drilling, machining or threading requirement.

The team recommended the Tekna TKE 944-7 because it can achieve the technical and performance levels required for CSI Aluminium's new curtain walling, has the large machining capacity required at the right price point, and can link easily to the rest of the Emmegi machines in the factory. The TKE machine will be on display on Emmegi (UK)'s stand at the upcoming MACH show (stand H7-350). It features a mobile gantry and 8kW high torque electro spindle which moves along the A axis, allowing machining through a full 180° around each section.

Next-generation smart sensors put ease-of-use first

'BluePilot' alignment leads radical upgrade Sponsor: SICK UK

SICK's next-generation W16 and W26 smart sensors with "BluePilot" alignment are at the helm of a streamlined portfolio of photoelectric sensors, radically-upgraded to optimise ease-of-use with complete object detection reliability.

The W16 and W26 proximity, reflex and through-beam sensors are manufactured at a purpose-built, fully-automated production facility in southern Germany. They mark the culmination of a two-year, €multi-million research and development project involving extensive consultation with SICK customers worldwide.

For usability, the W16 and W26 sensors are launched with SICK's new BluePilot assistant, which features a line of five LEDs mounted on top of the sensor for quick, easy and accurate alignment of the light spot even over long distances.

SICK W16 and W26 sensors bring together the best of SICK's optical sensing technologies including Twin-Eye for detection of reflective materials; LineSpot linear optics where the object has mesh, perforations, integral gaps or breaks and ClearSens optical filter technology for detection of semi-transparent and transparent objects.

The sensors are immune to interference from unwanted light sources and reflections, including LED lighting, hi-viz safety workwear or reflections. SICK's AutoAdapt function means if the reflector or the front screen of the sensor becomes contaminated, the photoelectric sensor automatically adjusts its switching thresholds for reliable detection.

An industry-first in-built Bluetooth option allows easy monitoring and advanced commissioning from smart phones or tablets.

Riveting and drilling in one step

GESIPA® FDR® Sponsor: GESIPA®

FDR® is a riveting technology by GESIPA® that combines the mechanical joining technology of flow drilling a hole and riveting an application in a single step.

Whilst preserving the classic benefits of blind riveting technology such as one-sided processing and high-quality, durable connections, FDR® also removes possibility of incorrect alignment and bore hole tolerances in the application thereby giving a secure joint.

The specially designed rivet head, rotation and joining force enables the new blind rivet to pierce light metals as well as plastics. Proven GESIPA® technologies such as the jaws system and three window process monitoring have also been integrated into the development of the automated processing tool. This brings together both functionality and reliability saving cost and time in the application process.

This technology provides many solutions for the joining of different materials for example, a material mix of high-strength steel, light metal as well as carbon fiber materials and is therefor a step forward in the automation industry.

April 1954 Deep in the Cold War

World's first nuclear sub enthralled readers of *The Engineer*

Spring of 1954 saw *The Engineer*'s American Correspondent reporting on the work of the US Atomic Energy Commission. With the Atomic Age well and truly under way, there was no shortage of news to fill the column inches, including the progress of plants at Savannah River, Paducah and Oak Ridge. But, nearly 65 years on, it's the report on the USS Nautilus that stands out.

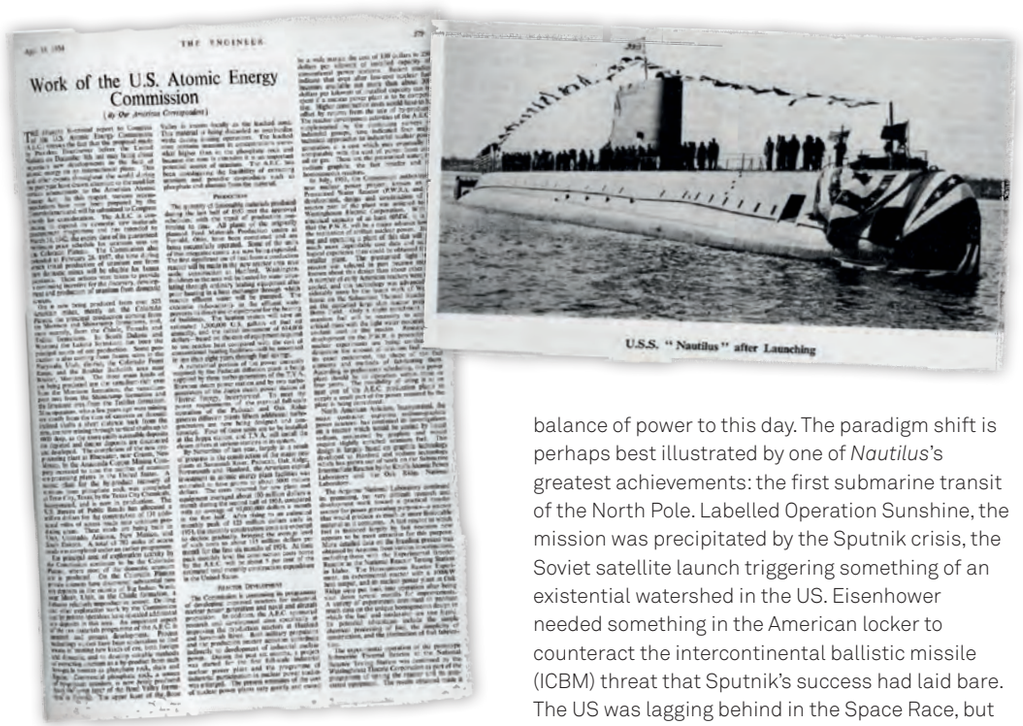
Authorised by Congress three years previously, *Nautilus* was the world's first nuclear-powered submarine, a pioneering piece of engineering that heralded a new era of military strategy and geopolitics. Its reactor had been even longer in the planning, with Westinghouse Electric Corporation instructed to develop a nuclear power plant for a submarine as far back as 1947. The result was the Submarine Thermal Reactor (STR, later redesignated the S2W), a pressurised water reactor that delivered 13,400hp (10,000kW) of power.

"A number of early American reactors were water cooled," *The Engineer* wrote, "and this technology was advanced considerably more by the recent work of Westinghouse on the Submarine Thermal Reactor and on the cancelled large ship reactor project at Bettis Field."

When our predecessors were reporting on developments, details were still relatively thin on the ground. It was known that the STR had evolved from a prototype constructed and tested by the Argonne National Laboratory in 1953 at the National Reactor Testing Station in Idaho.

The design was also influenced by the Homogeneous Reactor Experiment at Oak Ridge, where potential advantages were thought to include the simple chemical processing of fuel, the simplicity of construction and the elimination of fuel fabrication.

"The experimental operation of the prototype Submarine Thermal Reactor at the National Reactor Testing Station was continued by the Westinghouse Electric Corporation as part of the programme of testing the reactor and its associated equipment," it was reported by our predecessors. "The results obtained made it possible to improve the actual STR power plant being fabricated by Westinghouse for the first American atomic-powered submarine, which has been christened the USS 'Nautilus'."



THE ENGINEER

Work of the U.S. Atomic Energy Commission

(By Our American Correspondent)

U.S.S. "Nautilus" after Launching

Commissioned on 30 September 1954, *Nautilus* would go on to claim numerous records and world-firsts, its onboard nuclear plant delivering capabilities far exceeding what had gone before. Journeying south in 1955 from the port of Groton, Connecticut, she covered 1,100 continuous nautical miles submerged and clocked a total of 1,200 nautical miles in under 90 hours – both records at the time. This level of performance effectively rendered obsolete the anti-submarine warfare that had evolved during the war. An entirely new game of sub-surface cat and mouse was emerging, one that played out through the Cold War and continues to shape the global balance of power to this day. The paradigm shift is perhaps best illustrated by one of *Nautilus*'s greatest achievements: the first submarine transit of the North Pole. Labelled Operation Sunshine, the mission was precipitated by the Sputnik crisis, the Soviet satellite launch triggering something of an existential watershed in the US. Eisenhower needed something in the American locker to counteract the intercontinental ballistic missile (ICBM) threat that Sputnik's success had laid bare. The US was lagging behind in the Space Race, but *Nautilus* could provide a submarine-launched ballistic missile (SLBM) capability that could keep the Russians in check. For the gambit to work, however, the sub had to be able to transit the pole.

An initial effort in June 1958 was thwarted by drift ice in the Chukchi Sea, but a second attempt that began in late July proved more fruitful. On 3 August, *Nautilus* became the first vessel to reach the geographic North Pole, and after 96 hours and 1,590 nautical miles under the ice, surfaced north-east of Greenland. A helicopter airlifted Commander William R Anderson from the deck of the sub, and he connected with a military transport plane which took him to Washington DC. At a White House ceremony on 8 August, Anderson was awarded the Legion of Merit and the crew received a Presidential Unit Citation – a mark of just how strategically important the polar transit had been.

Decommissioned in 1980, today *Nautilus* is a museum ship in Groton. She was designated a National Historic Landmark in 1982. **AW**

Word of the issue

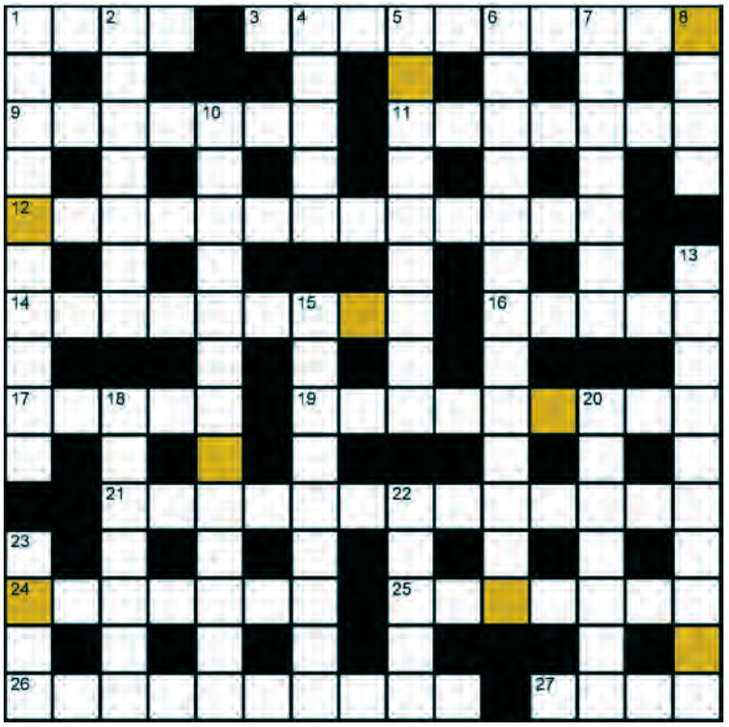
Anthony Poulton-Smith explores origins of the word ‘coal’

Not until the 13th century did the word ‘coal’ mean the fossilised carbon we would think of today. Prior to that, and indeed afterwards, it referred to charcoal. Such would not have been used for heating but for smelting ore. From Old English col and through Proto-Germanic kula to Proto-Indo-European geu-lo, the latter meaning ‘live coal’, the word has hardly changed in millennia. It is referred to as ‘live’ because, unlike charcoal, it occurs naturally.

The name of one type of coal, anthracite, has a quite different history. While the Germanic described the usage, ancient languages tended to refer more to its shape. Lumps of coal are first referred to in 370BC by Theophrastus, who penned a work entitled *On Stones* and wrote about lithos anthrakos. For the Greeks, and also the Latin anthrax, they were referring to ‘charcoal’ or ‘live coal’. Eventually they used anthrax to refer to a ‘severe boil or carbuncle’, the Latin meaning ‘virulent ulcer’.

Bigpicture

An electric air taxi that can take off vertically and fly autonomously has been undergoing testing in New Zealand. Dubbed Cora, the prototype two-seater aircraft has been developed by Kitty Hawk, a Silicon Valley-based aviation start-up. The aircraft takes off using 12 independent lift fans and is powered in fixed-wing flight by a single propeller.



Prizecrossword

When completed rearrange the highlighted squares to spell out a brick laid with its long side to the face of the wall. Email your answer to **jon.excell@centaur.co.uk**

Across

1 Brick that is laid sideways at the top of a wall (4)
3 Promotion by means of an argument and demonstration (5,5)
9 Language of northwestern India (7)
11 Pieces of meat cooked slowly in its own fat (7)
12 Area for receiving and entertaining visitors (9,4)
14 Infantryman equipped with explosives (9)
16 Point on the compass (5)
17 Unit of magnetic flux density (5)
19 Establish after a calculation (9)
21 Ancient natural building material (6,3,4)
24 Slight but appreciable amount (7)
25 Distinguished conductor (7)
26 Performing well in the marketplace (10)
27 Curved shape that spans an opening (4)

Down

1 Documents granting exclusive right to publish work (10)
2 A dashing stylish manner (7)
4 Excuse given in court (5)
5 Not having a common centre (9)
6 Temporary floating structure across a waterway (7,6)
7 Capacitor having variable capacitance (7)
8 Fastener for a door or lid (4)
10 Tiny body emitted from radioactive isotopes (5,8)
13 Kiosk for a telephone (5,5)
15 Czech tennis player (4,5)
18 Waste at timber mill (7)
20 Device that enables something to be used in a new or different way (7)
22 Governing section of a company (5)
23 Capital of Norway (4)

March’s highlighted solution was Brindle. Winner: **Edward Kingham**

Awards Entry Deadline **28th May 2018**

the ENGINEER collaborate to innovate

Celebrating the best engineering collaborations and innovations

The Engineer is pleased to announce the return of the Awards and Conference celebrating great examples of engineering collaboration

Enter collaborative projects in 9 categories

AUTOMOTIVE · AEROSPACE · INFORMATION, DATA & CONNECTIVITY · HEALTHCARE & MEDICAL · ENERGY & ENVIRONMENT · DEFENCE & SECURITY · ACADEMIC INNOVATOR · YOUNG INNOVATOR · MANUFACTURING TECHNOLOGY

Whether you are a small business, large corporation, or academic research department – share your collaborative success stories, shout about your achievements and tell us why you are the best!

Find out more at: conferences.theengineer.co.uk

Brought to you by: the ENGINEER

In association with: FRAZER-NASH CONSULTANCY

Sponsors: BAE SYSTEMS INSPIRED WORK

In partnership with EPSRC Engineering and Physical Sciences Research Council

WE DON'T 3D, WE WINDFORM.

F1 front nose: Aerodynamic application for F1 wind tunnel.

WINDFORM, THE NEXT GENERATION OF 3D PRINTING.
SINCE 1996, WINDFORM MATERIALS HAVE MADE IT POSSIBLE FOR LASER SINTERING TECHNOLOGY TO CREATE HIGH-PERFORMING PARTS. HIGHLY-FUNCTIONAL, BEAUTIFULLY FINISHED AND PROVEN RELIABLE. FREE-FORM DESIGN AND THE ABILITY TO BUILD SUPERIOR PROTOTYPES.

WINDFORM, IMPOSSIBLE APPLICATIONS ARE NOW POSSIBLE.

WINDFORM®
FOR ADVANCED 3D PRINTING
www.windform.com info@windform.com

CRP
www.crp-group.com

CRP USA
www.crp-usa.net