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How artificial intelligence is revolutionising medical diagnostics



Driving force

Meet the UK engineer heading up Tata Motors' European R&D division »18



Reef encounter

How engineers hope to save one of the wonders of the natural world »24



Car of the issue

Three decades on from its launch, the Honda NSX still impresses »36

Roundtable report

An expert panel discusses the challenges and benefits of deploying digital manufacturing technologies »26



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this**issue**

Volume 299
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news

04 **Environment** Floating farms promise year-round crops
06 **Materials** Graphene allows water through but blocks smallest ions
08 **Marine** New testing area for autonomous vessels
12 **Communications** Burrowing robots could speed fibre roll-out

opinion

14 **Viewpoint** Graeme Wright
16 **Mailbox** Your letters to the editor
18 **Interview** Mark Sealy of Tata Motors

features

20 **Cover story** How artificial intelligence is advancing healthcare
24 **Environment** Engineers in race to save the Great Barrier Reef
26 **Roundtable report** Exploring the factory of the future
34 **Energy** Could hydrogen be the fuel of tomorrow in homes?
36 **Car of the issue** Honda NSX
38 **Software** Calculating the cost impact of early design decisions
40 **Product news** Advances in drives, motors and bearings
45 **Archive**
46 **Digest**

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our**opinion**

Digital will deliver

We need to become more like Germany; a misguided national obsession with keeping old manufacturing equipment running as long as possible rather than investing in the latest technology is holding UK firms back and hampering productivity.

This was just one of the claims made during a recent roundtable debate chaired by *The Engineer*, and covered in detail in this issue (p26).

As one of our recent polls on the topic illustrated, despite the hype around so-called digital manufacturing techniques, many in UK industry are sceptical about the benefits, and often not even sure what the buzzwords and terminology actually mean.

The discussion featured in this issue – which brings together a diverse group of experts from the OEM, SME and research communities – helps to address some of these questions by providing some tangible examples of the factory of the future in action, and highlighting some of the steps that manufacturing organisations of all sizes can take to embrace the productivity-enhancing benefits of digital technologies like AR, AI and additive manufacturing.

> "The next generation of engineers is equipped to embrace digital"

It's clear that the UK still has a long to way to go – but as our panel agrees, there are plenty of reasons to be optimistic about the future, not least because the next generation of engineers, steeped in digital technologies from an early age, is equipped to embrace its potential in a way that often eludes many of the sector's more experienced professionals.

Clearly, manufacturing is just one of many sectors that is being reshaped by the rise of digital technologies, and in this issue's cover story we take a look at how AI is helping to transform the field of medical diagnostics, underpinning advances that could help clinicians save lives by detecting potentially fatal illnesses far more rapidly.

The prospect of AI-based healthcare may alarm those who value the patient/doctor relationship. However, despite this issue's chilling cover image, this is not about abandoning the personal touch and replacing human experts with robots, but enabling clinicians – like manufacturers – to do their jobs more effectively by making the best possible use of all of the available data.

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ENVIRONMENT

Floating deep farms promise year-round crops

Containers could grow crops and act as a sink for carbon dioxide HELEN KNIGHT REPORTS



With the global population expected to reach over nine billion by 2050, food production will need to increase by almost 70 per cent to meet the increasing demand.

However, rising sea levels caused by climate change are likely to lead to increased erosion and inundation of salt water, reducing the land available for farming, particularly on small islands and in low-lying coastal regions.

Now researchers at the University of Nottingham have developed the idea of floating deep farms, consisting of large vertical shafts or containers, submerged under seawater near coastal areas.

The containers, which could grow a variety of crops, could also act as a sink for carbon dioxide.

The project is the brainchild of Professor Saffa Riffat, chairman in sustainable energy at Nottingham's faculty of engineering, and research fellow Professor Yijun Yuan, a specialist in mining engineering and sustainable energy.

In October 2018 the pair unveiled their plans to build underground farms within the disused tunnels of depleted coal, salt and gold mines in countries such as the UK and China. They have since had interest in the concept from the US and South Africa.

To develop the idea further, the researchers have recently filed a series of six patents on the use of such deep farms in land, seawater and rivers.

"For areas close to the sea, which are vulnerable to sea level rise caused by climate change, one option is to go into the water, so they can still carry on producing food," said Riffat.

The floating containers would be sealed at the bottom, and then covered with a dome at the top. Crops would be grown using either hydroponics, in which plant roots are fed with nutrient-rich waters, or aeroponics, in which they are housed in a mist environment.

The containers would be lit by LEDs of appropriate wavelengths in order to maximise photosynthesis, while also having to consume as little power as possible.

Waste heat from the LEDs could also be combined with solar energy and used to convert seawater into fresh water by desalination. The solar energy and LEDs would heat the salt water, causing it to evaporate, and this vapour would then be condensed inside tubes to produce fresh water for the plants.

Unlike conventional farming, which is restricted by annual seasonal changes, the controlled environment within the containers means crops can be grown all year round. The enclosed farms also allow plant diseases and pests to be more easily controlled.

What is more, submerging the farms in seawater provides a stable temperature all year round, unlike conventional greenhouses and vertical farms, which rely heavily on expensive and energy-intensive heating and cooling systems to regulate the environment.

To provide the necessary power for the LEDs and other systems, the vertical shafts could be directly connected to offshore wind turbines, or wave or tidal power devices, to utilise locally available renewable energy.

The floating farms would also be able to incorporate aquaculture for fish and shellfish, with oxygen produced by the plants fed directly to the sea creatures.

They could also provide protection for coastal communities from erosion, according to Riffat.

"You could have a number of these farms around coastal areas, and they could also work as a barrier, a defence system across the coastal area," he said.

The researchers have also filed a patent on the use of deep farms in desert regions. The vertical shafts could be sunk into the sand, with solar panels used to power desalination of brackish water from the water basin. ■

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MATERIALS

Atom-wide pores block smallest ions

Graphene capillaries act like aquaporins, allowing water to pass through STUART NATHAN REPORTS



The National Graphene Institute has made pores that admit water but block the smallest ions, an advance that could lead to high-flux membranes for water desalination.

Sir Andre Geim, a co-discoverer of graphene and a Nobel laureate, led the team at Manchester University's National Graphene Institute, which developed the artificial channels that block hydrated ions larger than around 7A (0.7nm) in diameter.

The channels, made using Van der Waals assembly, are 3.4A in height, allowing water molecules (2.8A in diameter) to pass through but blocking even the smallest hydrated ions, such as K+ and Cl–, which are 6.6A in diameter because the ions themselves are surrounded by a shell of water. The team describes its technique in *Science*.

"We cleave atomically flat nanocrystals just 50 and 200nm in thickness from bulk graphite and then place strips of monolayer graphene on to the surface of these nanocrystals," said physicist Radha Boya, a co-author of the paper. "These strips serve as spacers between the two crystals when a similar atomically flat crystal is placed on top." The resulting three-layer structure contains a flat void that can accommodate only one atomic layer of water, she said.

Previous studies had suggested that such structures would collapse because of attractive forces between the opposite walls, but the team's calculations suggested that water molecules inside the void could act as a support and prevent the "ceiling" of the void from falling onto the floor.

The team assembled the capillaries on top of a silicon nitride membrane that separated to isolated containers, so the channels were the only way that any material could flow from one container to the other. They built more than 100 channels in parallel, and used plasma etching to remove any potential blockages from the openings of the capillaries.

The researchers then filled one container with water, applied an electric field to the assembly to force charged ions through the channels, and monitored the weight of the full container to determine how much water passed through the channels.

"If our capillaries were two atoms high, we found that small ions can move freely though them, just like what happens in bulk water," said Boya. "No ions could pass through our ultimately small, one-atom-high channels. The exception was protons, which are known to move through water, as true subatomic particles."

The capillaries act like aquaporins, proteins found in membranes of biological cells that allow water to flow through membranes but block ions. ■

COMPETITION

£10,000 Launchpad for start-ups

Prize includes free stand at Subcon 2019

A new iniatitive, set to take part at this year's Subcon show, aims to propel manufacturing and engineering-based start-ups to success by giving them a platform to share their innovations with thousands of professionals.

As part of the so-called Subcon Launchpad competition, eight entrepreneurs will be given a free stand in the Launchpad area, as well as being entered into the inaugural Subcon Launchpad Awards. Each exhibitor will be asked to present their innovation on stage to a panel of expert judges. The winner will receive a £10,000 package including a stand on the main floor at Subcon 2020 as well as comprehensive PR and marketing support.

To qualify, businesses must be less than three years old with a product or service that relates to engineering and/or manufacturing. Alongside a stand, the successful applicants will receive expert advice and marketing support, valuable industry exposure, plus entry into the awards.

"The Launchpad initiative is set to showcase not only cutting-edge engineering but also the entrepreneurial drive that will propel UK manufacturing and engineering forward," said Subcon event director Gordon Kirk. "With a judging panel headed by *The Engineer* editor Jon Excell, we are on the hunt for the very best British engineering and manufacturing start-ups have to offer." ■

■ Subcon, the UK's premier subcontract manufacturing supply chain show, runs from 4-6 June 2019, at the NEC, Birmingham. For further details on the Subcon Launchpad or to submit your entry, visit www.subconshow.co.uk

Newsinbrief

JLR to cut 4,500 jobs

Jaguar Land Rover, the UK's largest car maker, has announced plans to cut 4,500 jobs, most of which are expected to come from its 40,000-strong UK workforce. The company said the cuts, which are expected to mainly affect managerial and office staff and which follow 1,500 losses in 2018, are being made as part of an ongoing effort to reduce costs by £2.5bn over the next 18 months.

Airbus factory off ground

Airbus has broken ground on a manufacturing facility in the US where it will build A220-100 and A220-300 aircraft for US customers. The assembly line, the company's second US-based commercial aircraft production facility, will be located at the Mobile Aeroplex in Brookley, Alabama, adjacent to an existing A320 production line. Airbus said aircraft production is planned to begin in the third quarter of 2019.

No-deal aerospace fears

Failure to secure a Brexit deal that maintains the current strategic relationship with the EU will cause significant problems for the UK aerospace industry, warns IMechE. Its report, UK Aerospace: The Impact of Brexit, warns that if Britain leaves the EU without an appropriate deal, then aerospace companies will face supply chain disruption and higher manufacturing costs if imports from the EU are subject to tariffs and restrictions.

AR wearables partnership

Didcot-based WaveOptics and Compal, a Taiwanese designer and manufacturer of consumer electronics, are to develop augmented reality (AR) wearables for the AR smart glasses market. WaveOptics CEO David Hayes said: "Through our work with partners like Compal, we will be able to meet enterprise and mass consumer demands for high-quality AR wearables that can be manufactured at scale – a challenge the industry has struggled to achieve to date."

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

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

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

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

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

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

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- Technical and commercial project management







MARINE

New test site for unmanned boats

AI sensor system provides proving ground for autonomous vessels

HELEN KNIGHT REPORTS

Plymouth Sound is to become a proving ground for autonomous marine vessels after the installation of a sensor system with artificial intelligence (AI) machine-learning technology.

MSubs, a Plymouth-based specialist in manned and unmanned underwater vehicles, has installed the system, which includes a network of cameras, radar, anemometers, and automated information systems (AIS) for tracking ships, as well as wind turbines, solar panels and 4G communications technology.

"Several years ago, we started working with the city to look at how we could create a proving ground, where we could safely operate unmanned vehicle systems," said managing director Brett Phaneuf.

Working alongside Thales, the company is now in talks to convert part of a building on the waterfront into a "traffic control centre" for autonomous vessels.

This centre will combine sensor data from out at sea and within the harbour to create a model, allowing the machine-learning algorithms to identify and track any objects in the water.

The system will also look at how vessels behave when they are in the Sound, in order to spot signs of distress, such as being somewhere they should not be, said Phaneuf.

The team plans to insert a synthetic ship into the model, which will navigate through this dynamic environment, taking account of the wind and weather conditions.

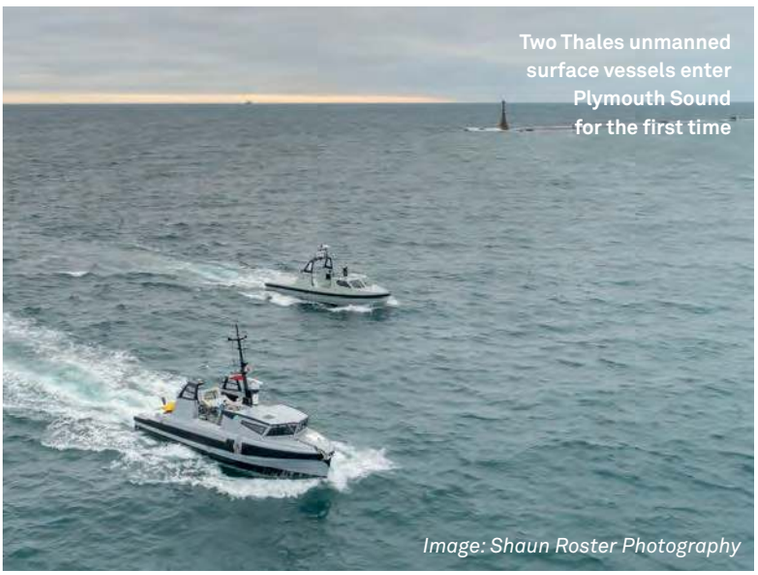
This will allow thousands of algorithms to be tested simultaneously on the same data set. And by carrying out post-mission analysis of the data, they will be able to further enhance the algorithms, said Chris Wardman at Thales.

Real autonomous vessels will also be inserted into the test range, with which the AI system will communicate, said Phaneuf.

"[The ships] can then talk among themselves, and figure out the optimal course to avoid hitting each other, and to achieve their objectives."

The sensor system currently reaches a few kilometres out to sea, but within the next five years the team hopes to cover several hundred kilometres with instrumentation.

They also plan to test their systems on the Mayflower Autonomous Ship, which will be sailing from Plymouth, Devon, to Plymouth, Massachusetts, in September 2020, to celebrate the 400th anniversary of the sailing of the original Mayflower. ■



Two Thales unmanned surface vessels enter Plymouth Sound for the first time

Image: Shaun Roster Photography

AEROSPACE

Rolls-Royce sets sights on electric flight record

ACCEL aircraft team harnessing Formula E expertise in bid to achieve speed of 300mph

A team led by Rolls-Royce is developing an electric aircraft known as ACCEL, which is targeting a speed of 300mph (480km/h) in 2020.

Short for "accelerating the electrification of flight", ACCEL is seeking to become the fastest electric aircraft in history and is harnessing expertise from the world of Formula E to achieve this. The project, which also includes electric motor and controller manufacturer YASA and aviation start-up Electroflight, will be based out of a hangar at Gloucestershire airport. According to Rolls, the single-seater propeller aircraft will carry the most powerful battery ever flown and will have a range of 200 miles.

An all-electric powertrain will deliver a maximum output of 750V with over 90 per cent efficiency. The propeller will be driven by three high-power-density 750R electric motors designed and manufactured by YASA in the UK. Together, they will provide more than 500hp when ACCEL takes on the world record attempt next year. AW

TRANSPORT

Auto braking on TfL trams

New safety system in wake of 2016 crash

ANDREW WADE REPORTS



Transport for London (TfL) will equip its trams with automatic braking after recommendations made in the wake of the 2016 Croydon tram crash that killed seven people.

Set to be introduced by the end of 2019 the system will bring trams to a stop if they are exceeding the speed limit in certain locations. The 2016 accident happened when a tram travelled at excess speed (73km/h through a section with a 20km/h limit) into a sharp bend near the Sandilands stop. When the tram derailed, passengers were thrown through the glass in the windows and doors. In addition to the seven deaths, 19 other passengers were treated for serious injuries.

The contract for the design and installation of the automatic braking system has been awarded to Derby-based Engineering Support Group Limited, a subsidiary of Deutsche Bahn. It will operate alongside the driver-protection device that has been in operation since September 2017, alerting to any signs of driver distraction and fatigue. A Rail Accident Investigation Branch (RAIB) investigation after the Croydon crash found that fatigue – possibly resulting in the driver momentarily falling asleep – may have been a factor in the incident.

"Awarding the contract for a new automatic braking system is a first for trams in the UK, and not only will it improve safety for customers in London, but we hope it will lead the way for other tram operators across the country," said Mark Davis, TfL's general manager of London Trams.

TfL is also set to introduce a new emergency lighting system that will operate independently of the tram's battery, based on recommendations made by RAIB. ■


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ENERGY

One giant step for synthetic fuels

High-temperature co-electrolysis system demonstrated in Germany

HELEN KNIGHT REPORTS

A single-step process to produce hydrogen and carbon monoxide for synthetic green fuels has been successfully demonstrated in Germany.

Dresden-based Sunfire has developed a high-temperature co-electrolysis technology, which uses water, carbon dioxide and green electricity to produce synthesis gas.

The system, developed as part of the Kopernikus project Power-to-X and funded by the German government, has been successfully tested for over 500 hours.

Previously, a two-stage process has been needed to break water vapour down into hydrogen and oxygen and to turn carbon dioxide into carbon monoxide, through electrolysis and the reverse water-gas shift reaction.

In contrast, the co-electrolysis process recovers hydrogen and carbon monoxide in a single step, significantly improving the efficiency of the process and lowering costs.

The system is based on a ceramic ion transport membrane, which conducts oxygen ions, rather than hydrogen ions or hydroxide ions. In this way it can be used to reduce both steam and carbon dioxide, according to Karl Hauptmeier, senior product manager at Sunfire.

"Since we are working with oxygen, it gives us the capability to also reduce CO2, so we are not limited to hydrogen-based compounds," said Hauptmeier.

"We can separate the oxygen out of the water vapour and out of the CO2, which gives us the opportunity to do this in a one-step electrochemical process."

Within the next few weeks, the Sunfire-Synlink system will be delivered to project partner the Karlsruhe Institute of Technology (KIT), where the system will be combined with direct air capture technology developed by Climeworks, which filters carbon dioxide out of ambient air.

This CO2 will then be combined with steam, and supplied to the co-electrolyser unit, which reduces the two feedstocks to a hydrogen and carbon monoxide mixture.

This gas will then be processed in a micro Fischer-Tropsch Synthesis system, developed by Ineratec, which will combine the hydrogen and carbon monoxide into hydrocarbons.

Finally, hydrocracking technology from KIT will convert the hydrocarbons into synthetic fuels.

The team plans to demonstrate the integrated production of e-Crude, a synthetic crude oil substitute, by the end of August 2019. ■



Sunfire's co-electrolysis plant in Dresden

MEDICAL

Robotic arms could lend a hand in spinal surgery

Semi-autonomous robots can drill holes into individual vertebrae with pinpoint accuracy

Spinal conditions such as scoliosis and kyphosis could be rectified with the help of robots that semi-autonomously drill holes into individual vertebrae.

The advance forms part of research being led by Professor Philip Breedon at Nottingham Trent University's Medical Design Research Group. The team also explored the use of augmented reality to provide surgeons with live visual feedback to illustrate the depth of each hole as it is drilled. Accuracy of drilling has been recorded at 0.1mm.

According to Nottingham Trent, the holes drilled in the vertebrae are used to insert pedicle screws, which are attached to deformity rod reducers that allow surgeons to lever individual vertebrae and realign the spine.

The two robotic arms – datum and tooling – work together during the procedure. The datum robot is secured to vertebrae and moves in unison with it to relay data on this movement instantaneously to a computer. The tooling robot then adjusts automatically so that it remains on its pre-defined path. JF

PHYSICS

The even larger hadron collider

CERN plans cyclotron 10 times more powerful

STUART NATHAN REPORTS

CERN has revealed plans for a £20bn Future Circular Collider that would be 10 times more powerful than the Large Hadron Collider (LHC).

The 100km-diameter cyclotron would be capable of smashing subatomic particles together with 10 times more energy than the LHC.

The Future Circular Collider (FCC) commission, involving 1,300 contributors from 150 universities, research institutions and industrial partners, has published its four-volume Conceptual Design Report (CDR), detailing the technical challenges, cost and schedule for building the proposed device, which it hopes would discover a new class of subatomic particles involved in mediating the forces at work in the universe.



A tunnel at the LHC

Image: CERN

The CDR is part of a road map to be drawn up by particle physicists as an update to the European Strategy for Particle Physics.

Over the next two years, the scientists will decide how to continue their research after the LHC. The FCC is not the only plan to be considered: another option is a large linear collider, known as Clic (compact linear collider).

The CDR envisages constructing a new circular tunnel beneath CERN and installing a new magnetically driven particle collider, equipped with detectors similar to those already existing at the LHC.

"The FCC's ultimate goal is to provide a 100km superconducting proton accelerator ring, with an energy of up to 100TeV, meaning an order of magnitude more powerful than the LHC," said CERN director for accelerators and technology Frédérick Bordry. ■

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COMMUNICATIONS

‘Mole’ could speed up fibre roll-out

Robots will be able to burrow without disturbing the ground above

HELEN KNIGHT REPORTS

Autonomous burrowing robots capable of digging beneath the ground without disturbing the soil above could dramatically improve the way fibre optic telecommunications cables are laid.

Researchers at the University of Leeds, led by Dr Raul Fuentes, are developing burrowing robots that can sense the behaviour of the ground around them, and the force they are applying to it, to allow them to move through the soil without disrupting anything above them.

The EPSRC-funded Mole project, which is supported by BT and includes civil engineering company Kier and the Universities of Birmingham and Sydney, could speed-up the roll-out of high-speed fibre to the home.

Installing fibre to individual homes is a slow and expensive process, according to Fuentes. “The current technology means it cannot be done quickly or cost-effectively enough,” he said.

“According to BT, something like this could potentially save £30m-£120m in installation costs, with the added benefit that we will be able to provide connectivity to homes much more quickly than would otherwise happen.”

As part of the £1.2m five-year project, Fuentes plans to develop a model that will merge geomechanics – the science of ground behaviour – with robotics.

The team will then develop a prototype burrowing robot, which at the end of the five years should be capable of laying down a fibre optic cable over a distance of around 10m at a BT-owned site.

An important element of the robot will be its ability to sense its interaction with the ground around it, said Fuentes.

“The critical thing is to make sure that these robots exert the minimum necessary force to move forwards and excavate, so that we can minimise disruption to the surrounding ground,” he said.

This is particularly important for shallow installations such as cables, which may be surrounded by pipes and other cables that cannot be disturbed, he added.

To this end, the researchers will develop a control algorithm, which will integrate sensor data on the condition and behaviour of the ground with that on the force being applied by the robot as it burrows.

As well as telecommunications cables, the robots could also be used to deploy sensors for ground characterisation, space exploration, agriculture, mining and disaster rescue. ■



Installing fibre to the home is a slow and expensive process

AEROSPACE

Aerostructure project aims to challenge industry norms

Research to focus on lightweight airframes

A new project led by the University of Southampton will explore the use of aerostructures and seek to highlight the limitations in current certification procedures.

Backed by an EPSRC grant worth £6.9m, the research will focus on more structurally efficient and lightweight airframes. In doing so, the team hopes to be able to challenge existing aerospace norms and seek step-changes that the regimented certification process may be preventing. By driving reduced weight, cost and development cycles, the researchers are aiming to lay the foundations for the aviation of the future, where fuel efficiency and electric/hybrid propulsion are expected to come to the fore.

“This funding is essential to enable continued growth of the UK aerospace industry and take economic benefits from the opportunities inherent in the move towards more sustainable aviation, as it fills a knowledge gap, where there is no equivalent capability in the UK or internationally,” said lead researcher Ole Thomsen, professor of structures and materials at the University of Southampton. AW

SPACE

The snowman in outer space

Images of most distant object ever visited

STUART NATHAN REPORTS



Nasa’s New Horizons probe has revealed that the most distant object visited by humanity, Ultima Thule, is shaped like a snowman.

Early on New Year’s Day, the New Horizons probe, which has already obtained the most detailed pictures yet of Pluto, continued its tour of the Kuiper Belt Objects (KBOs) at the fringes of the solar system by visiting Ultima Thule, which is four billion miles from Earth.

Ultima Thule orbits the sun at more than a billion miles beyond Pluto, and New Horizons returned a photograph to Earth taken from around 18,000 miles from the object.

About 21 miles long and 10 miles wide, it is dark red and consists of two roughly spherical lobes joined at a narrow neck. The mission team believe that Ultima Thule is a contact binary – two distinct objects that have gravitated towards each other and drifted together.

Launched in 2006, New Horizons has reached its location thanks to a gravitational slingshot manoeuvre around Jupiter in 2007. The probe is nuclear powered, running off a radioisotope thermoelectric generator (RTG) fuelled by plutonium-238 oxide. RTGs work by converting the temperature difference between the hot radioactive substance in the frigid external conditions into electricity and are employed in probes that cannot utilise solar energy.

The images were taken by the Long Range Reconnaissance Imager (LORRI), a digital camera built by the Johns Hopkins University Applied Physics Laboratory. New Horizons will continue to send back data, with transmissions taking six hours to reach Earth, for the next 20 months and is on a trajectory that will take it out of the solar system altogether. ■

ENERGY

Materials boost for electric vehicles

2D materials may catalyse performance of lithium-air batteries

STUART NATHAN REPORTS

Electron-transferring complexes may give electric vehicles the ability to extend their range to 400 or 500 miles per charge, claim researchers in the US.

Lithium-air batteries are considered a promising energy storage technology because they can store 10 times more energy than lithium-ion batteries and weigh less. However, their stability and efficiency fail to match expectations, so battery researchers are trying to find catalysts that can increase the rate of the chemical reactions inside them, which increases their ability to hold and discharge energy.

Among them are engineers at the University of Illinois at Chicago (UIC), who are working on 2D compounds of transition metals with non-metals.

In *Advanced Materials*, Amin Salehi-Khojin and colleagues from UIC's College of Engineering describe how transition metal dichalcogenides (TMDCs) enabled lithium-air batteries to hold 10 times more energy than batteries using traditional catalysts.

Lithium-air batteries use an anode made of pure lithium with external ambient air as the cathode, typically with an aqueous electrolyte. The catalyst is generally dissolved in the electrolyte, and gold and platinum are used conventionally. TMDCs, especially those with 2D shapes, have very high electronic conductivity and fast electron transfer and, according to Salehi-Khojin, are bi-functional, so they are active in charging and discharging the battery.

The Chicago team and collaborators used a battery with an ionic liquid electrolyte based on dimethyl sulphoxide (DMSO), which is commonly used as a solvent that can dissolve materials which contain either charged or uncharged components.

"The 2D TDMCs and the ionic liquid electrolyte that we used acts as a co-catalyst system that helps the electrons transfer faster, leading to faster charges and more efficient storage and discharge of energy," Salehi-Khojin said.

Salehi-Khojin's team synthesised 15 TMDCs, including vanadium telluride and diselenate, and molybdenum and niobium disulphides, and investigated their activity in an electrochemical system mimicking a lithium-air battery.

Leily Majidi, a graduate student in the UIC College of Engineering, said: "In their 2D form, these TMDCs have much better electronic properties and greater reactive surface area to participate in electrochemical reactions within a battery while their structure remains stable.

"Reaction rates are much higher with these materials compared with conventional catalysts." ■



Lithium-air batteries could greatly extend electric vehicle range

MEDICINE

Project aims to deliver pain-free microneedle contraception

Patches to improve access in poorer countries

Engineers and scientists at Cardiff University are working with partners to deliver microneedle technology that will provide contraception to women in the world's poorest countries.

Supported by the Bill & Melinda Gates Foundation, the consortium will focus on pre-clinical work to develop microneedle patches that have the potential to be administered painlessly and inconspicuously by the user within a few seconds.

Cardiff University's School of Engineering and School of Pharmacy and Pharmaceutical Sciences have secured funding for the project, which brings together partners from academia, NGOs, charitable bodies and NHS Trusts. Industry partner InnoCore Pharmaceuticals will utilise its biodegradable polymer platform to develop microneedles exhibiting the required mechanical properties for effective and painless puncturing of the skin, followed by contraception delivery for up to six months.

According to the university, socio-economic and cultural barriers are preventing women from obtaining contraception when they want to plan or prevent pregnancy. JF

ENERGY

Hitachi halts nuclear plans

UK power station projects put on hold

JASON FORD REPORTS



Plans to build nuclear power stations in the UK have suffered another setback after Hitachi announced it was suspending projects in Anglesey and Gloucestershire.

The announcement on January 17 followed speculation that Hitachi would put its nuclear development plans on hold in England and Wales after failing to negotiate a finance deal with the government.

Wylfa Newydd nuclear plant on Anglesey, North Wales, and a new power station at Oldbury in south Gloucestershire, were being developed by Horizon Nuclear Power, which was acquired by Hitachi in 2012. The company had planned to develop at least 5,800MW of new nuclear power across the sites.

Duncan Hawthorne, CEO of Horizon, said: "We have been in close discussions with the UK government, in co-operation with the government of Japan, on the financing and associated commercial arrangements for our project for some years now. I am very sorry to say that, despite the best efforts of everyone involved, we've not been able to reach an agreement to the satisfaction of all concerned.

"As a result we will be suspending the development of the Wylfa Newydd project, as well as work related to Oldbury, until a solution can be found. In the meantime, we will take steps to reduce our presence but keep the option to resume development in future."

Both sites would have created around 850 full-time positions and 9,000 jobs during peak construction.

In November, Toshiba wound up NuGen, the company set up to build a nuclear power station of up to 3.6GW capacity in Moorside, west Cumbria, at a cost of around £10bn. ■



How technology can close the skills gap

An important part of the strategy to increase the engineering talent pool will be to optimise technology, freeing up humans to do what they do best

New year, new me. This saying is one that needs to be applied to the manufacturing sector after the BCC Quarterly Economic Survey reported that the skills shortage in manufacturing is reaching critical levels.

The skills shortage is an ever-growing problem in the manufacturing sector, one which will prove detrimental if not addressed, and it is not an issue that can be resolved overnight. It is something, however, which can be fixed by combining technological developments with human insight. Using new technologies, alongside human soft skills, the manufacturing sector can recover from this shallow talent pool period.

Digital is our best friend

Digital disruption has massively changed the state of manufacturing, and technological advances over the past few years have been exponential. Contrary to popular opinion, however, this does not need to have a negative impact on job prospects. Instead, it has just changed the prerequisites for work.

The sector is undergoing a transformation – our Fit for Digital report showed that nine in 10 manufacturers believe the sector has already undergone digital disruption. A further 73 per cent said that technology lies at the heart of an organisation's ability to thrive.

Labour has long been a critical factor of production; however, we are increasingly seeing data as the lifeblood of the organisation to drive better decisions. New possibilities have arisen with the breakthrough of technologies such as AI, the Internet of Things and wearables, which are able to close the gap in supply and demand for a skilled workforce.

The question is, then: how can manufacturing keep up the pace of these new technologies without leaving the workforce behind?

Embracing change

Manufacturers must ensure their organisations are built in a way that allows them to embrace innovation. We found 52 per cent of organisations said that their businesses will not be the same by 2022. It is clear technology is here to stay; now it is time to implement it into business models.

One such set of technologies that will transform the industry is AI (in all its forms), which has the potential to streamline processes within organisations. From a manufacturing perspective, it can identify anomalies and decide what the next best course of action is to deal with these issues.

This is where the human element comes to the fore. Technology, sensors and industrial control systems, along with edge or cloud-based AI, is used to undertake administrative tasks such as monitoring machinery and equipment for potential issues. Once alerted to the problem, an engineer is needed. As such, technology does not replace the jobs, it just speeds up the process. It removes the mundane tasks and keeps individuals focused on where they add the greatest value. Furthermore, it can also identify future risks that may arise, saving manufacturers time and money. The introduction of these technologies also improves the efficiencies of services in manufacturing, increasing up-time, which will eventually close the gap between supply and demand for a skilled workforce.

A long-term solution?

In the long run, the need for skilled workers, with additional skills in analytics, AI and optimisation, cannot continue to go unaddressed. However, this needs to be resolved with a grassroots approach.

Educators need to work with industry partners, who are able to help bring more advanced technology into the classroom, to provide advice and examples of the skills employers are looking for. Most importantly, they need to provide opportunities for students to gain real-world experience and ensure that the manufacturing sector has a long-term pipeline of talent to help drive its future.

Moreover, for the sector to advance, there needs to be a change in approach, with a greater focus placed on the activity of those on the front line and how technology can be used to make their work 'frictionless'; i.e. making the right thing the easiest thing to do. There is already an array of talent out there; it's all about attracting them to manufacturing and realising how their skills can be applied. By creating a more innovative and technologically efficient system, the perception of the sector can be altered. In doing so, this will create a more dynamic workplace and help attract more talent to the sector.

What are the next steps?

Technology will naturally continue to play a big part in manufacturing. For businesses, the next step is ensuring that technology is used to handle more admin tasks, while continuing to invest in creativity.

It is important that as the sector changes, they also ensure they are accounting for the skills of tomorrow. In doing so, companies are able to create a more efficient system, where human input still allows manufacturers to have a clear view of the broader picture, alongside providing much-needed soft skills.

The impact of digital is inevitable and the manufacturing sector needs a strong, skilled workforce in order to feed its growth. ■

Graeme Wright is CTO for manufacturing, utilities and services, Fujitsu UK



Machines can do a lot of the mundane work in manufacturing, freeing up engineers for the more complex



Advancing where it counts

To give our customers vital advantages we never stop advancing our manufacturing. From the latest technology to new ways of working, we keep on making improvements. It's a critical part of how we give our customers what they want, more quickly and cost-effectively.

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Thehottopic



Where now for UK nuclear?

As Hitachi becomes the second firm in as many months to abandon its UK nuclear new-build plans, readers contemplated nuclear's future role in the energy mix

Responsibility and risk should lie with those who benefit from the investment. In this case it is Hitachi and UK(plc).

You cannot expect the developer to carry all the risk when compensation for the realisation of any problems only occurs decades down the line. Interest on any sums paid to cover unforeseen costs only makes the matter worse.

When it comes to big budgets, very few private enterprises have the staying power. The government must carry the risks.
Nath

Ignoring contractual costs, would it make sense to develop extensive and sophisticated renewable energy systems on the site? Even after meeting cost commitments, such an undertaking, coupled to UK university research, might provide a better, longer-term future for our children.
John Swallow

To my mind, this is another reason why the UK shouldn't put its strategic industries in the hands of foreign companies. Maybe this could be an opportunity to look at small modular reactors rather than these expensive mega reactors.
Another Steve

I am of the impression that the consortias that built the original nuclear power plants are now either defunct or were acquired by foreign-based multinationals. So are there any British-owned companies that still have the expertise to build the next generation of power stations? If there are none, we will have to continue relying upon foreign assistance.
Michael Breslin

We can save the cash that would have been ploughed into these mega nuclear projects and invest it into renewable energy technologies. Developments in these areas have progressed at a pace since the whole UK future nuclear program was planned. This abrupt cessation of the program has given us an ideal opportunity to reassess appropriate technologies for creating a new solid UK energy industry.
Sam Shields

Long-term high-cost projects for a country's infrastructure should certainly be a matter for national funding. The massive French programme over 40 years ago was such a case.

The need for base-load reliable power is made very clear in UK winter months when wind and solar are next to useless and more nuisance than benefit. Without the nuclear stations and old coal stations we would be having power cuts now.

In a short while, the UK will be dependent upon imported gas and our economy will be at the mercy of the volatility of the oil market.
Jack Broughton

Yet again investment in our core technology is sadly lacking. I am pretty sure the guys at Harwell all know very well how to build a big reactor. Can we take some of the Brexit savings and spend this on a new British power plant?
Steve

We need big nuclear if we're serious about getting clean energy on the grid in the near term. That said, the way the energy market works is completely inimical to big nuclear projects. We're going to have to do something different soon. Whether the solution is buying the reactors up-front and running them ourselves to make the money back or making the construction itself a state-run enterprise.
J Eyre

Surely, raising steam using old technology must now be laid to rest? It is expensive, extremely dangerous, as recent events have shown, and produces waste products we simply don't know what to do with. We're an island and, stating the obvious, we're surrounded by wet stuff that can't help being pulled and stretched twice daily by our biggest satellite, the moon. The free energy available here is immeasurable.
Ron Shilton



Thesecretengineer

Our anonymous blogger has a new job – and despite a positive start, managerial inconsistency is beginning to get irksome

I have now settled into my new life at work and, from what people have said to me "on the ground", all seems to be going well. I was a tad disappointed then when, via a circuitous route, I was informed that my work was considered to be a bit slow. As it happens, I have every reason to believe this was a bit of "Chinese Whispers" coupled to an early lack of speed due to learning the CAD system. However, as any I've worked with can tell you, I've never been the quickest to turn a job around so despite this it struck a bit hard and triggered a minor panic attack.

It's never a problem to have a "reality check" on how you approach work and generally I've found this particular issue isn't so bad. If you work at being quicker you just need to nudge up to "acceptable" without losing any other qualities (high quality draftsmanship/ meticulous maintenance of documents etc) and most folk are happy. Chuck in a willingness to pull long hours when needed and Bob's your mother's brother, as they say.

Of course, you have to be adaptable... It's the undeclared 180-degree U-turns that leave me on the back foot that gives me a real problem.

What was rather irksome in this case was that, when joining the company, I was very specifically told that the ethos was "I don't mind if it's late, so long as it's right". Of course, that's not carte-blanche to take forever over a job but it will – or at least should – colour the way you approach your work. Therefore, I've been picking up on errors in lookalike drawings used to create



new ones, considering better ways to lay them out and so on. I can say with confidence that what I have produced are a better set of drawings. What I'm worried about is that I have now been "marked down" for doing what I was specifically told to.

Of course, there's no point in spending much time worrying about it. You modify your approach and dive back in there. So, although I'm not improving the quality of the company's IP as much as I was – I am turning stuff around quicker – I shall continue with this until someone says something else and then once more modify my approach.

All engineering is compromise and I've never had a problem with adapting my work style to the particular requirements of a company, although I have worked with one or two people who appear to have a "my way or the highway" attitude – something that's always struck me as being rather arrogant and a little short-sighted. It's one thing to push for your own idea of the best way to do things on principle but it's another to completely go against what your boss thinks is required.

It's not just the generally nebulous area of the quality/time/resource triangle where the lack of straightforward direction is frustrating. I'm sure I cannot be the only who has had a conversation along the lines of:

General Managerial Type Bod: I'm not keen.
Design Eng: No problem, what would you like?
General Managerial Type Bod: I don't know, just not that.
Design Eng: Well, throw me a spratt at least. Which area of the design is giving you concern?
General Managerial Type Bod: I'm not sure...

And so on ad nauseum, or at least until you snap and staple his/her head to the desk. Then there's the world of pain that is the "moving goalpost", but that can wait until another time. Of course, you have to be adaptable, of course we are here to help others move towards an as yet undefined end point and – all joking aside – the general changes of mind or prevarications can be written off as part of the creative process. It's the undeclared 180-degree U-turns that leave me on the back foot that gives me a real problem. In these cases, a little bit of clarity and consistency would be greatly appreciated.

Inyouropinion

Readers responded to our article on the ITER nuclear fusion project

Very impressive... but can't help thinking it may have been built to inspire awe at the imposing size of the facility rather than focus on a more practical size for modular development. A small modular facility would promote a much more agile approach. It would facilitate rapid change and adaptation towards successful outcomes, without the slow bureaucratic processes involved when dealing with budgetary constraints.
Neil MacKinnon

I suspect that by the time ITER is really complete, and before DEMO is even really started on, someone out there will make a breakthrough on the smaller systems, and nuclear power will take a sharp left turn. Who can tell? I have been watching this nuclear fusion parade (charade) about 40 years now, and I really am having a difficulty seeing much in the way of real progress.
James Stewart

Fusion power will probably not arrive at commercial scale in time to address climate change without a sudden change of political will. However, I'd think of this as more of a long-term project for the species. Providing a solution to energy that should work for many millennia.
J Eyre

Immigration and engineering skills

I am an Englishman working in Germany, surrounded by colleagues of many nationalities. In my opinion, there is so much to learn from their skills, working practices and mentalities. I firmly believe that immigration is important.
Alec Thorne

We need UK-trained and overseas workers for our skilled jobs. The notion we should always recruit locally is an unnecessary form of parochialism. The bottom line is that we need immigration.
Desmond

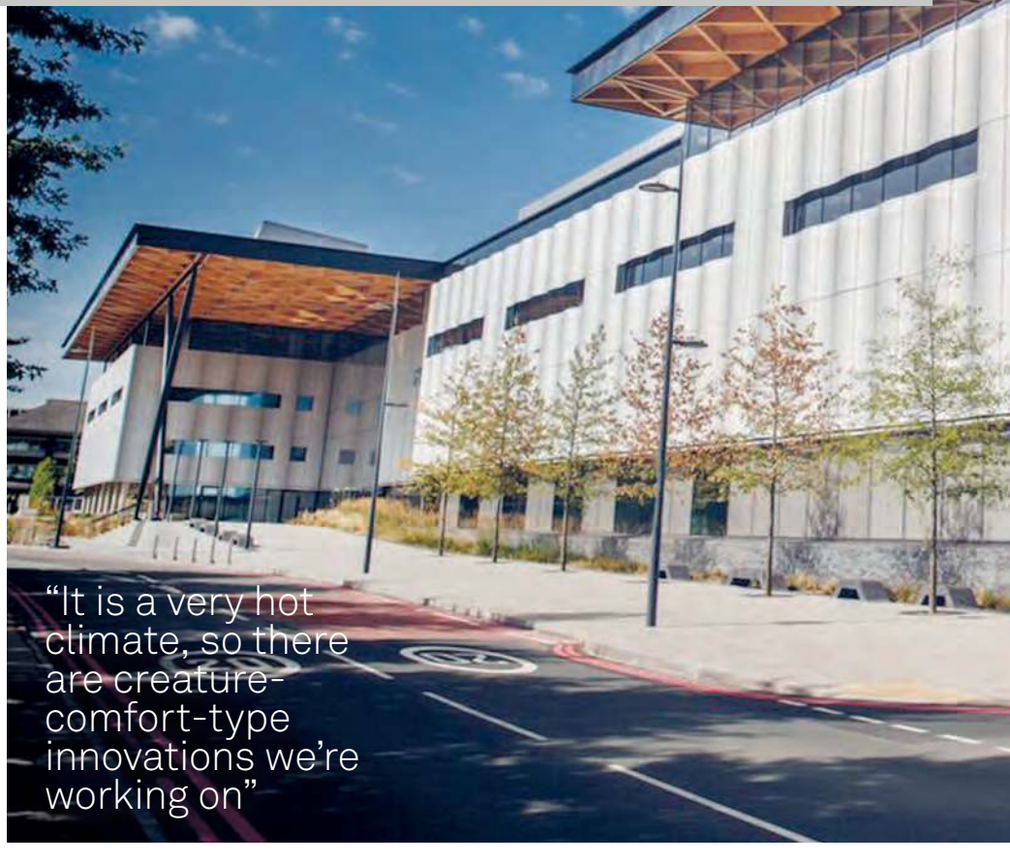
I'm very pro-movement of labour, but it shouldn't be manipulated as a race to the bottom, something that is missed at higher levels.
Chris

Join the debate theengineer.co.uk



Inside Tata's UK technology arm

Tata Motors' top UK engineer explains to Jon Excell how British expertise is driving innovation for the Indian car market



Fuelled by the spending power of its rapidly expanding middle class, the Indian automotive sector has changed beyond recognition in recent years to become one of the largest and fastest-growing markets on the planet.

And few firms have more direct experience of this transformation than the country's biggest and best-known car maker, Tata Motors, which – in a short space of time – has evolved from a maker of robust workhorses for a cost-conscious Indian market to a globally ambitious manufacturer of modern, high-tech, and – many would say – desirable vehicles.

Pulling off this game of technological catch-up, particularly at a time when the rest of the global automotive sector has been evolving so rapidly, has owed much to the efforts of engineers here in the UK, at Tata's Warwick University-based European Technical Centre (TMETC), a research division established in 2005 to enable the Indian manufacturer to tap into the region's world-leading expertise.

Just before Christmas, *The Engineer* visited TMETC at its new base within Warwick University's recently opened National Automotive Innovation Centre (NAIC) and heard from the group's head of engineering and technology, Mark Sealy, about how the Indian market's evolving appetites and expectations are driving the centre's work.

Sealy, who joined Tata just under two years ago from IMI's commercial vehicles division, explained that TMETC's focus in recent years has shifted from "getting the basics right" to addressing many of the hi-tech areas that dominate the rest of the car industry: from an insatiable demand for more efficient powertrains to electrification, connectivity, and even autonomy.

Much of the group's work in these areas is, he said, driven by the Indian government's fresh enthusiasm to ensure the country's cars meet the latest regulations. "We're right in the middle of trying to get to BS6 (the Euro 6 equivalent emissions level)," he said, "but unlike Europe where we went Euro 4, 5, 6 and spread out small cars, large cars, and heavy vehicles, India wants to go straight from 4 to 6 for every vehicle in the country simultaneously. It's an almighty challenge for us as we have probably the broadest range of vehicles in India."

A major area of focus therefore is chasing vehicle rapid efficiency gains in conventional powertrains and a key challenge here, said Sealy, is squaring efficiency improvements with India's increasing appetite for SUVs.

"All of these vehicle attributes go against efficiency because the vehicle becomes heavier and has worse aerodynamics, so we're putting a lot of work in to allow that trend towards SUVs but with no penalty to vehicle efficiency."

In the longer term, Sealy expects electrification to play a major role. And although the Indian government recently rowed back on its pledge to make 100 per cent of all new vehicles electric by 2030, a revised target of 30 per cent is still ambitious for a country with major infrastructure challenges and little domestic battery manufacturing expertise. Addressing these challenges is therefore a priority for TMETC, and electrification will be a major area of research at the group's new home in the NAIC, said Sealy.

He added that this work is also helping drive Tata's international ambitions, and confirmed that the firm is actively discussing bringing an electric version of its Nexon family SUV over to the UK.

An area that Sealy believes will have a more immediate impact on the Indian market is the rise of connectivity – a game-changing trend that uses communications technologies to enable vehicles to communicate with their users, other vehicles, and the roadside infrastructure.

"We think it will happen in India, possibly ahead of other countries simply because the Indian public are just so into their smartphones – the cost of mobile traffic is so low in India," he said. Related to this is the concept of so-called "shared" pay-to-use models, where rather than owning a vehicle outright, mobile technology and apps are used to summon up vehicles when they're required.



Whether it's enabling inhabitants of remote villages to access vehicles that they'd otherwise be unable to afford, or offering a compelling alternative to the challenge of owning – and parking – a car in a congested city, Sealy believes it is a model that will be particularly compelling for the Indian market.

Much of the company's expertise in these areas has been driven through its involvement in the UK Autodrive project – the UK's biggest ever trial of driverless and connected vehicles – where it worked with Ford and Jaguar Land Rover (JLR).

The project, which concluded in late 2018, saw real-world demonstrations of technologies on the streets of Coventry and Milton Keynes, and as part of this, Tata used a modified Hexa SUV to test a range of features including GLOSA (Green Light Optimal Speed Advisory) and EEBL (Electronic Emergency Brake Light). It also demonstrated how vehicles and infrastructure will work in tandem for a motoring network in the future.

01 TMETC's new base at the National Automotive Innovation Centre (NAIC) on the Warwick University campus

02 A modified Hexa SUV took part in UK Autodrive, the UK's largest trial of connected and driverless car technologies

However, whilst these kinds of technologies have obvious potential for the Indian market, Sealy said that it is harder to see how Autodrive's other area of focus – autonomy – could be easily applied to the chaos of India's roads. "There's a bit of doubt about its applicability to India because the driving is erratic, there's unexpected traffic and events which would be very hard to predict for a machine."

Although it could be argued, he agreed, that if you can crack autonomy in Delhi, you can crack it anywhere.

Beyond big global trends like electrification and driverless, Sealy explained that another important area of TMETC 's remit is to look at technologies and projects that address particular domestic challenges. "It is a very hot climate, vehicles often have a high passenger count, so there are creature comfort-type innovations we're working on," he said.

"Air movement around the interior space is an issue, as is reducing the solar load. We're also looking at road safety issues peculiar to the Indian market. If you take a German forward collision warning system and try to apply it in Mumbai or the suburbs of Delhi it doesn't work."

More generally, the pressure to innovate and to bring new technologies online for the Indian market is, he said, greater than it has ever been.

"When a new program starts we've got a list of innovations that are in the workshop and a target segment for that vehicle and we're starting to say, 'that therefore should be the platform' that drags that idea through. In the past, a lot of these ideas have been thrown out to keep the cost down –but we can't just carry on doing low cost."

The move to the new innovation centre, which brings together 1,000 designers, engineers and researchers from Tata, WMG and Jaguar Land Rover, is – said Sealy – expected to supercharge this process by encouraging greater levels of collaboration.

Whilst Tata owns Jaguar Land Rover, Sealy explained that collaboration between the two firms has been limited in the past, partly because there was little overlap in the vehicles that they produced.

However, as Tata's cars have become more sophisticated and JLR has become more cost-conscious this has begun to change, and the two companies have started to collaborate closely on key technology areas. "We're working on a composites project together," said Sealy, "and we've been working together in autonomy, digital, seat innovations, and tyre modelling. We have different problems but using the same tools."

Despite a growing appetite to tap into each other's experience, the two car makers have very different priorities however, something which is highlighted by their apparently differing attitudes to Brexit.

Whilst JLR has repeatedly – and with good reason given its dependence on pan-European supply chains – sounded some of UK industry's loudest warnings, Tata itself appears less concerned, said Sealy. "Tata is – I think – not that bothered about Brexit and in some respects it may help to drive a better unilateral relationship between the UK and India.

They have a fairly un-European perspective. I'm not surprised JLR is wading in to say it needs some kind of certainty. It would have a very big impact on JLR's ability to access supply chains in Europe and sell vehicles in Europe, but we are outside of all that." ■

AI helps to reshape

Andrew Wade **reports on the AI revolution changing the face of healthcare**

Slowly but surely, artificial intelligence is infiltrating almost every aspect of our lives. It is already busy in the background of many routine tasks, powering virtual assistants like Siri and Alexa, recommendations from Amazon and Netflix, and underpinning billions of Google searches each day. But as the technology matures, AI's impact will become more profound, and nowhere is that more apparent than in healthcare.

Healthcare's data-heavy nature makes it an ideal candidate for the application of AI across multiple disciplines, from diagnosis and pathology to drug discovery and epidemiology. At the same time, the sensitivity of medical data raises fundamental questions around privacy and security. This juxtaposition makes healthcare one of AI's most exciting frontiers and also potentially one of its most dangerous.

"You could look at almost any area of healthcare and see that advanced data science – if I could put it that way – has an enormous amount to offer," Sir Mark Walport, chief executive of UK Research and Innovation (UKRI), told *The Engineer*. "This technology has huge potential right across the world of healthcare."

As the former chief scientific adviser to the government and now the head of the UK's new umbrella R&D body, Professor Walport is uniquely placed to comment on the UK's AI healthcare policy. As part of the government's Industrial Strategy, five new AI research centres were announced in November last year, to be located in Leeds, Oxford, Coventry, Glasgow and London. Backed by a £50m investment and due to open in 2019, these centres will focus on the rapidly advancing area of image analysis.

"This is part of the Industrial Strategy Challenge Fund and it's about making sure we create the best opportunities, both in terms of improving healthcare and also ensuring that we grow a really important industry," said Walport. "And through our other programmes we're funding a great deal of research more broadly. But this (imaging) was a deliberately focused call in an area where there's obvious potential for transformation."

Roughly 90 per cent of all healthcare data comes from imaging technology, yet the vast majority of it goes unanalysed. The main areas of focus for the UK centres will be radiology – the science of medical imaging – and histopathology, which deals with changes in tissue caused by disease. Applying AI across these two disciplines could reshape medical diagnostics. According to Walport, the ultimate goal is to train AIs across multiple diseases so that they can suggest potential diagnoses from an X-ray, for example.

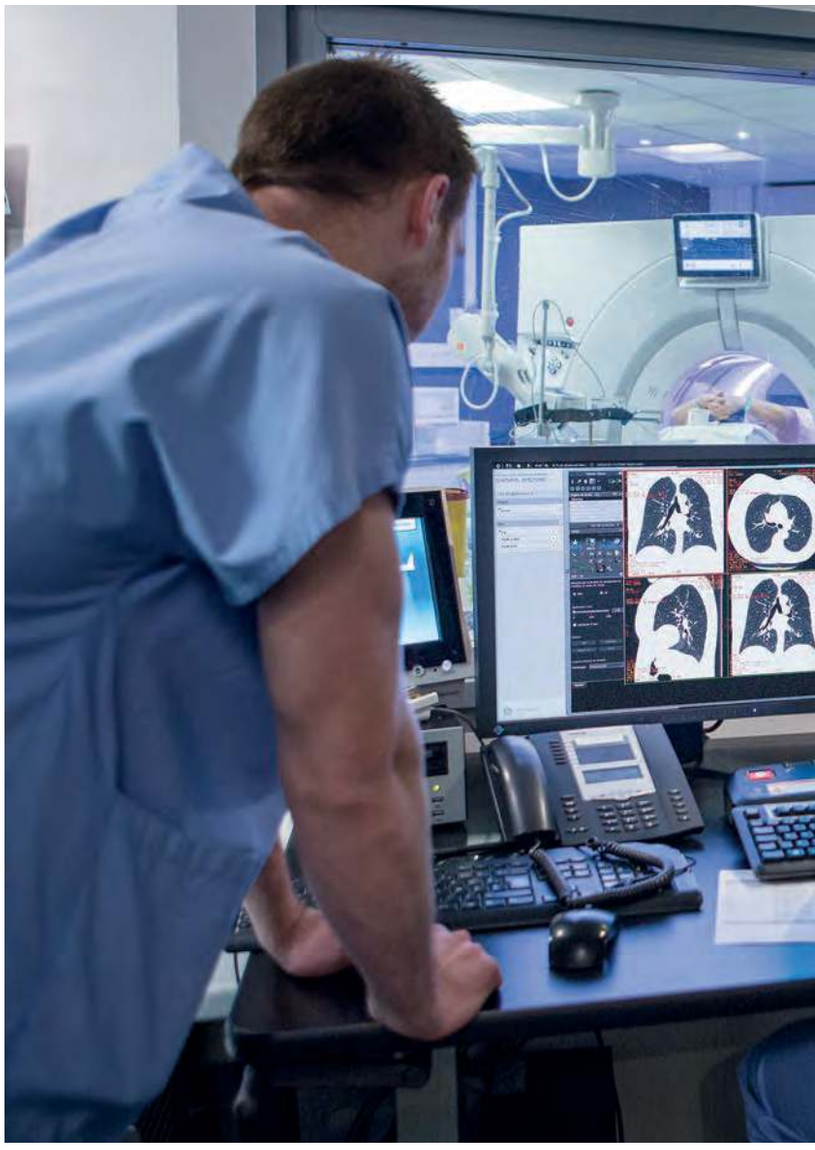
"A chest X-ray is a chest X-ray, as it were, and there are a whole range of diagnoses that can be made from any X-ray, which vary from infectious disease right through to cancer," he explained.

Walport stresses, however, that AIs will be assistive and won't replace medical professionals any time soon. "The potential here is to have a computer algorithm assisting humans in what are quite difficult diagnoses," he said.

"We've seen some quite prominent recent examples in the media, for example the work between Google DeepMind and London's Moorfields Hospital in the early diagnosis of macular degeneration using routinely collected images."

Founded in 2010 and acquired by Google in 2014, DeepMind is one of the world's leading AI companies, best known for its AlphaGo programme that toppled the world's best players at the strategy board game Go. Since 2016, its medical arm DeepMind Health has been working with Moorfields Eye Hospital, training software to diagnose a range of ocular conditions from digitised retinal scans. That work resulted in an AI system able to recommend the correct referral decision for over 50 eye diseases with 94 per cent accuracy, matching the performance of top medical experts.

The media reaction that followed was overwhelmingly positive, but in another NHS collaboration,





02

01 Medical imaging is one of the first major frontiers for AI in healthcare

02 Professor Sir Mark Walport, chief executive of UK Research & Innovation

medical diagnostics


01

DeepMind Health generated less favourable headlines. Working with the Royal Free Hospital, the company developed an app called Streams that brings patient information together in one place to provide better visibility on life-threatening conditions such as sepsis and kidney failure. The app has been hailed as a success, but the Royal Free was criticised by the Information Commissioner's Office (ICO) for the way in which the data of 1.6 million patients was shared with DeepMind.

In the wake of this, DeepMind made numerous changes, including the creation of an independent review board. However, in November 2018 it was announced that DeepMind Health would be fully incorporated into Google in California to allow Streams to be rolled out globally. This not only resulted in the scrapping of the review board, it reneged on a promise made by DeepMind that NHS data would never be connected to Google accounts or services.

DeepMind's pioneering work highlights what's possible for AI in healthcare, both good and bad. Its technology is already delivering impressive results, but its data policy and ever-closer union with Google give cause for concern. People may generally be happy for their data to be used constructively, but companies have a duty to be transparent on the extent of that use, as well as protect data from nefarious parties.

"When you ask people who are ill whether they want their data used for their benefit, there's not much doubt about the response," said Walport. "But equally, there is a responsibility to hold their data in a fashion that is confidential, that on the one hand allows the benefits to be delivered, but on the other hand protects against any potential risks."

> "This tech has huge potential right across the world of healthcare"
>
> Sir Mark Walport, UKRI

GE Healthcare is one of several prominent industry partners looking to harness data as part of the UK's new imaging project. It forms part of the Oxford-based group NCIMI (National Consortium of Intelligent Medical Imaging), which is aiming to employ AI for more personalised care, earlier diagnosis and targeted treatment.

"The initial tranche of project areas for us are in a couple of different modality areas," John Kalafut, imaging outcomes and solutions leader at GE Healthcare, told *The Engineer*. "One is molecular imaging – improving the quantitative reconstruction using deep learning methodology."

The other is radiography, or plain X-rays. With all the bells and whistles of modern technology, the humble X-ray still plays a fundamental role in medicine, used to detect everything from fractures to cancer. It is estimated that at any given time in the UK there are over 300,000 X-rays which have been waiting more than 30 days for analysis. NCIMI will see GE Healthcare and its partners looking to reduce that significantly.

"Obviously one of the challenges the NHS has is not enough radiologists or radiographers to read studies," Kalafut explained. "So we have some algorithms we're developing with other partners and we're going to adapt that and clinically validate that across this consortium."

In the fast-moving world of startups, different radiology techniques are also getting the AI treatment. London-based Lancor Scientific is behind a new type of diagnostic device that, combined with AI, could change the way that cancers are detected. Its underlying technology, known as Opto-magnetic Imaging Spectroscopy (OMIS), is based on Maxwell's equations in mathematics, which deal with electromagnetism. When light is shone onto human tissue, the magnetic component of the reflected light can determine how malignant it is.

"Our method of detecting cancer is based on an aspect of cancerous tissue, or cancerous proteins, that has been known for several decades in science, which is that the electromagnetic profile changes as new molecules begin to form," explained Aamir Butt, Lancor Scientific's founder and CEO.

Until now, the equipment required for this type of testing – magnetic and atomic force microscopes (MFMs and AFMs) – has been both huge and expensive, limiting its penetration. Lancor's Tumour Trace technology uses the same principle as these enormous machines, but employs light rather than radiation to detect electromagnetic changes. The device weighs about 5kg and a single test should cost no more than £10, making the technology much more widely accessible. During trials at Southend Hospital in 2018, Tumour Trace detected cervical cancer with more than 90 per cent accuracy. Using AI to remove biological noise from the signals, Butt believes this can be improved to 97 per cent, and that the device could eventually be used to screen for all





cancers. "Those trials are to do with cervical cancer, and we're also just in the final stages of setting up a cancer research laboratory on the invitation of the Austrian government in Graz," he said. "Because of that facility, by the end of 2019, we will have four more cancers enabled on the device."

Ordinarily, vast data sets are required to train neural networks, with brute force repetition refining the machine intelligence. Tumour Trace, however, relies on fundamental physical constants for its detection method, and requires much smaller pools of data than other diagnostic AIs as a result.

"When you train artificial intelligence algorithms you need to have tens, if not hundreds of thousands of samples," Butt explained. "But because our technology is based on an underlying signal based on fundamental physics, the number of samples we need is actually much lower."

The device is due to hit the market in 2019 and Lancor expects to produce more than 10,000 units over the next five years. Theoretically, that could provide in the region of 500,000 cancer screenings per day, a powerful weapon in the frontline battle against a disease that impacts so many. Where early diagnosis of cancer can dramatically improve survival rates, for some diseases – such as Alzheimer's – early detection is less about survival and more about understanding and management. Given the planet's ageing population and the fact that Alzheimer's has no known cure, the number of people with dementia is set to triple to 150 million by 2050. It has been described as a ticking time bomb for global health.

03 There is virtually no area of medicine that AI will not have some impact on

04 Around 90 per cent of all medical data comes from imaging technology

"This is, according to the WHO, the biggest healthcare challenge of the 21st century," Sina Habibi, founder and CEO of Cognetivity, told *The Engineer*. "One in two in wealthy countries and nine in 10 in developing countries never receive diagnosis."

According to Habibi, existing dementia testing is primitive, with doctors conducting simple Q&As about patient memory. MRIs and CT scans can help, but these are expensive and referrals often come back negative for dementia. Using AI, Cognetivity has developed a simple screen-based test that it believes could transform diagnosis of the disease.

"Since 1901 when Dr Alzheimer examined and characterised his first patients, the diagnosis process has not changed much," Habibi explained. "We believe that from the time the physio-chemistry of the disease starts, it takes 20-25 years until you have symptoms of memory loss to the level that triggers the full-on process of examination."

Cognetivity's test involves subjects being shown around 100 images in five minutes. These are flashed by for just 150 milliseconds, with subjects required to respond as quickly as possible whether they've seen an animal or not. Images vary in their complexity, some featuring more information than others, making it more difficult to detect animals with certainty.

"We've looked at something called visual cognition – how you perceive images," said Habibi. "When you look around your eyes capture information like a camera and your brain analyses the information inside those images. Your ability to understand what's inside the image and respond to it is affected by the disease."

The 100 responses provided over the course of a test are then compared with historical data, and this is where the AI component kicks in.

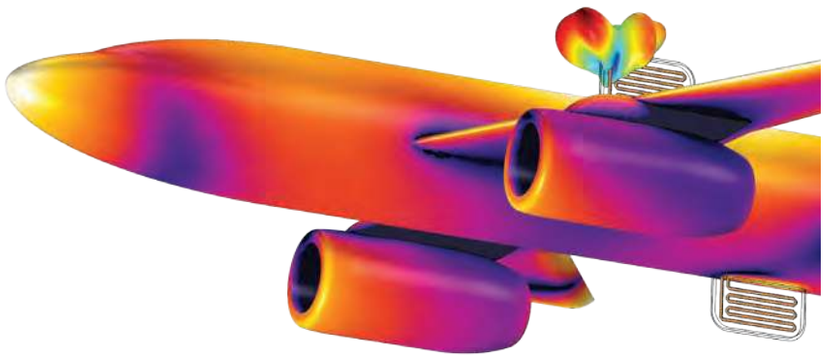
"We have trained our AI based on collecting data from healthy people and people with the condition, and we know if subjects have responded similarly to people with the condition or to healthier people," Habibi said. "Another aspect of the AI is we can link the test results with the physical status of the patient, link it with all the (personal) historical data of the patient: whether they've had a history of traumatic brain injuries or strokes etc."

The technology is currently being trialled at South London & Maudsley Hospital, with the study due to finish later this year. So far, the company's attention has focused on dementia almost exclusively, but Habibi believes visual cognition could also underpin AI testing for other neurological conditions.

"Our test, the way we look at it, is a platform technology," he said. "It's a new approach to assessing the brain, and by training the AI we will be able to be more specific to different conditions resulting in cognitive impairment. We will have studies lined up for concussion and other neurodegenerative diseases. There's huge potential, but we need to get clinical data, a trained AI and validate it."

Alzheimer's, eye disease, X-rays, cancer – it seems no area of medicine will go untouched by the power of AI. And as healthcare systems around the world creak under ever greater strains, machine intelligence may well hold the key to better human treatment. ■

Overcome antenna crosstalk issues with simulation.



Visualisation of the electric field norm and 3D far field due to a transmitting antenna. Antennas are intentionally large in this tutorial model.

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Race to save the Great Barrier Reef



Engineering a rescue for one of the world's iconic natural wonders

Stuart Nathan reports

The Great Barrier Reef is unquestionably a wonder of the world. The largest coral system on Earth, it consists of more than 2,900 individual reefs and stretches over 2,300km (1,400 miles). Famously visible from space, it represents one of the most biodiverse known habitats and is of huge importance to the Australian economy, both because of tourism and because it supports fisheries. Moreover, the reef is of huge cultural significance for many Pacific communities. And it is in trouble.

> "Even if successful, we will have a much less diverse reef"

The biggest threat to the reef is coral bleaching. This is caused by rising sea temperatures, and as a result of the complex nature of coral. Within the tissues of the millions of living creatures that comprise coral are microscopic, plant-like organisms called zooxanthellae, which capture sunlight, convert it to energy, and provide nutrients to the coral.

However, if sea temperatures rise, the coral expels the zooxanthellae and loses its colour. This doesn't kill the coral straight away, but bleached coral is effectively starving and, if conditions do not return to those hospitable to zooxanthellae, it will die. Researchers in Australia are now trying to find ways to help corals in the Great Barrier Reef resist higher temperatures without bleaching, which they hope will preserve this unique environment.

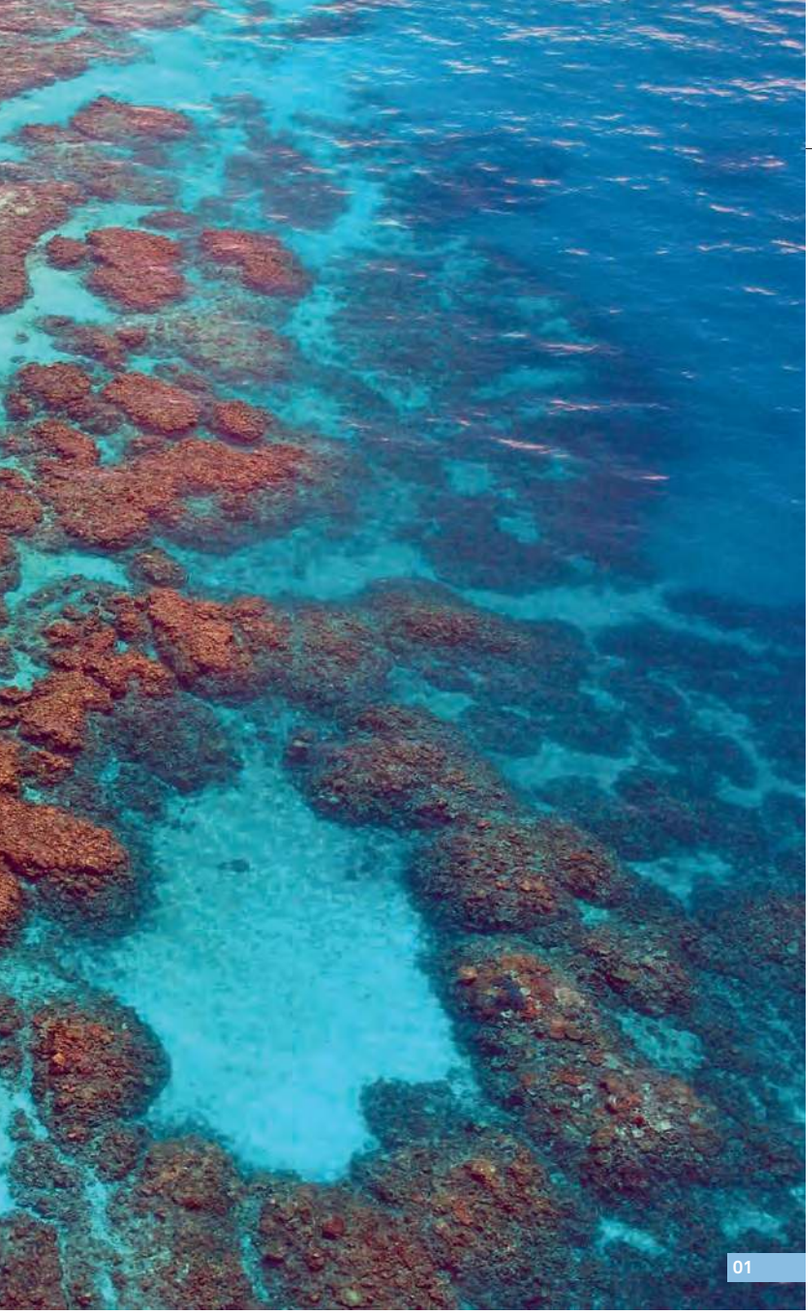
Although it's a world away from the factories, medicines and synthetic materials that characterise engineering in much of the world, this effort is nonetheless engineering of an important kind.

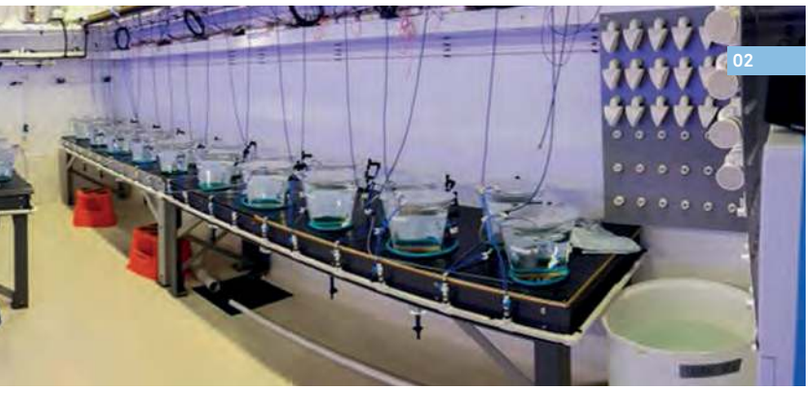
Coral bleaching is a natural event, and research indicates that bleaching has occurred many times during the reef's existence. But extreme heat waves in 2016 and 2017 affected up to two thirds of the reef, and current extreme temperatures are likely to have similar consequences. However, other reefs can withstand conditions in warmer waters: the Red Sea is consistently warmer than the seas around the Great Barrier Reef, for example.

Dutch researcher Madeleine van Oppen of the Australian Institute of Marine Sciences in Townsville, Queensland, visited London last year to talk about her work in engineering hardier coral. Van Oppen's work focuses on two techniques: assisted gene flow and assisted evolution. The first of these works by moving warmth-adapted corals to cooler parts of the reef; the northern extreme of the reef is routinely 1°C to 2°C warmer than the southern portion in summer. Corals are mobile in their larval form but, under normal conditions, larvae from the north do not travel south because the main ocean current that flows across the Pacific splits off the coast of northern Queensland, and flows are not favourable to north-south transfer. The researchers are experimenting with manually moving some of the northern corals south. If enough corals were moved, it could help heat-damaged reefs recover faster.



Assisted evolution is a somewhat more complex technique, which van Oppen described in a paper published in the Proceedings of the National Academy of Sciences in 2015 and in Nature Ecology and Evolution in 2017. "It's







artificial selection on steroids," she said. Targeting both the coral host and its symbiotic zooxanthellae, it takes several different tacks to improving their resistance to stress, in this case from heat.

One way to do this is by a technique called stress conditioning. This involves exposing coral to heat levels that approach those that will cause bleaching, and to investigate, firstly, whether the coral can adapt to this and, secondly, whether it can pass those adaptations to further generations. Evidence for this exists in some plants and animals, but it is not yet known whether coral can be stress-conditioned. Van Oppen and her colleagues are looking at this technique in the National Sea Simulator (SeaSim), a marine research aquarium in Townsville, which can store more than 3.5 million litres of seawater and can carry out spawning experiments on many reef organisms simultaneously and over several generations.

Another approach is more typical to genetic engineering, involving creating hybrids by bringing together compatible eggs and sperm from different coral species. This is known to occur naturally in some types of coral, increasing genetic diversity and producing novel genetic combinations that may be useful in selective breeding. "It's quite rare in nature, but not difficult to do under laboratory conditions," van Oppen said. Working at SeaSim, the researchers are looking to hybridise multiple pairs of coral species during their annual spawning (a major and predictable event) and grow their young under controlled conditions to select for climate resilience, then crossbreeding strains to produce desired results exactly the same way that conventional husbandry has worked for many centuries in agriculture. Hardy specimens could then be transferred to the reef itself.

> "The risk of doing nothing is just far too great"

Yet another approach is one that is sometimes used in humans to give health benefits: probiotics. These are live organisms, generally bacteria, which can confer beneficial effects if they establish colonies inside their hosts. Coral contains several potential habitats where probiotic colonies could be established, including the layer of mucus that coats its surface, digestive systems and even its mineral skeletons. Van Oppen and colleagues, including Katarina Damjanovic, are trying to develop probiotics that could either help coral tolerate the heat better, or help it recover faster from bleaching events by creating a more hospitable environment for the essential zooxanthellae. "One thing that probiotics could do is mop up oxygen radicals that occur in water and are damaging to the living coral tissue," van Oppen said. "One big advantage of this approach is that we could administer the probiotic anywhere on the reef."

Van Oppen is open about the potential for these techniques. "Our big hope is that it can buy us enough time to tackle the warming without the reef dying in the meantime. She also admits that, even if the technique was successful, it would change the Great Barrier Reef significantly. "At the moment we have a very diverse reef, with many different coral species," she said. "We are not going to be able to create successful strategies for all of those species, so even if successful, we will have a much less diverse reef. We simply don't know what the consequences of that for other life might be.

"If the reef rejects the results of our experiments, the effort will be wasted." However, she adds: "The risk of doing nothing is just far too great." ■

01 The Great Barrier Reef is one of the most biodiverse-known habitats

02 Rising sea temperatures are causing bleaching, and ultimately death, of corals

03 Inside Queensland's National Sea Simulator (SeaSim)

Innovating together



Why collaboration will be key to embracing technology

Dave Short, MSc, C.Eng, IntPE (UK), FRAeS, MIET, Technology Director, BAE Systems plc

In an ever-changing political climate, it seems to me that the only certainty about the future prospects for the UK's economy and industrial base is that there really are no certainties. What I am certain of, however, is that our manufacturing sector is well-positioned and ready to collaborate and take advantage of the potential that change offers.

In the past two decades, UK industry and much of our manufacturing sector has benefited from its own investments and deployment of high-end technology, as well as from collaborations with other organisations and government-sponsored programmes, such as the High Value Manufacturing Catapults and the Sector Deals created by the Industrial Strategy. As a result, the UK has been able to maintain its position and deliver some of the most advanced vehicles, aircraft, instruments, high-quality clothing and components that are the envy of the world. "Made in Britain" is still a prestigious tag and proof of a very well-made product. The importance of British manufacturing to our economy is clear from the statistics – with 45 per cent of our exports derived from the sector*.

Having worked in the military aircraft sector for more than 30 years, I have seen at first hand the enormity of the industrial ecosystem and collaborative effort required to manufacture and export goods. For BAE Systems alone, this means a £4bn annual spend with thousands of UK suppliers, and training 2,000 young people in engineering and manufacturing environments. The extent of the economic benefits cannot be underestimated, with BAE Systems making an annual £11bn contribution to UK GDP and delivering a multiplier effect of 3.8 jobs in the UK for every job at the company. To put some further context to this, by 2013 the Hawk programme through worldwide exports, had generated a return of £11.5bn for the UK from an initial government investment of £900m.

None of this is achieved in isolation – the collaborative effort with our supply chain is absolutely the key. But constant change and improvement through technological advancement is the order of the day here, as all customers, whether in the commercial or military sector, require higher-performing and more cost-effective and efficient products. In the past decade, I have seen industry and academia alike truly embracing the concept of "open innovation" and technology – in part, driven by more limited resources, but also as a result of the extraordinary pace of technological development underpinned by internet communications and the need to maintain a competitive edge and encourage investment. Gone are the days of "pure research" by universities and this has been replaced by a desire to collaborate and exploit technologies for mutual gain.

I see many examples of this in the manufacturing sector – not least the partnerships between BAE Systems, SMEs and universities to embrace and deploy digital manufacturing techniques to create the factories of the future. Other significant partnerships for us include work with a number of strategically important universities for our business – this includes a project with Cranfield University to develop additive layer manufacturing on a large scale and projects with Manchester University and the Advanced Manufacturing Centre in Sheffield to investigate cobotics and how humans and machines can work together seamlessly in military aircraft manufacture. Increasingly, we are embracing the use of virtual reality techniques to assess spatial clearances, for example in the manufacture of warships and submarines. With expert SMEs we are also exploring advanced layer manufacturing in our maritime and munitions businesses, as well as investigating how acoustic mixing and ultrasound imaging can support our manufacturing processes.

Clearly, continued investment in skills must be an important part of this picture, particularly as the types of roles in manufacturing will change and we will need to train and re-skill people. Traditionally, apprenticeships have been a natural feed for manufacturing roles and here the renewed interest and collaborative work by government, industry and education to change the perception of apprenticeships is welcomed, as is the desire to apply standards across apprenticeships as a measure of quality. Indeed, 86 per cent of manufacturers say they have a responsibility to get involved in schools and training to shape the future workforce, and 71 per cent believe apprenticeships are developing into a proper alternative to higher education for school leavers*.

At BAE Systems, we have always found that employee involvement and empowerment is critical, not just to the adoption of new manufacturing techniques but also to productivity levels. Deploying employees' ideas for change and improving production is not only motivating for workers but results in working environments that are more productive. We are sharing our experience of this with other companies through a programme called Productivity Through People, which is delivered by the government and industry-sponsored organisation Be the Business, together with the universities of Lancaster, Aston, Bath and Strathclyde – with the University of Swansea soon to join the fold. The programme has been designed specifically for senior managers in SMEs and focuses on developing leaders, nurturing talent and empowering employees. Some 2,000 SME business leaders have signed up to take part in 2019. In addition, BAE Systems' senior managers are directly mentoring 200 leaders in SMEs as part of the accompanying Mentoring for Growth programme.

To conclude, in spite of huge political uncertainty, I believe that the UK manufacturing sector is in good shape to weather what storms may come. More than ever before, manufacturers are motivated to embrace technology and invest in skills for the future. The resilience and willingness of the sector to collaborate and share best practice can only be to our nation's long-term advantage. ■

*figures from The Annual Manufacturing Report 2018



Roundtable report: Exploring the factory of the future

A panel of experts reflect on the challenges and opportunities presented by digital manufacturing technologies. Stuart Nathan and Jon Excell report

From cobots to AI, and additive manufacturing to AR, a host of emerging digital technologies promise to make manufacturers more nimble, productive and efficient.

But in such a rapidly changing landscape, how can engineering firms ensure they are making the best possible use of the available technologies? And what lessons can be learned from companies that are already deploying these systems?

Until recently, it's not been easy to answer these questions. While industry leaders and government-led panels have repeatedly made the high-level strategic case for the productivity-boosting benefits of "digital manufacturing", it has been difficult for the rest of the manufacturing sector to grasp the benefits.

But this is beginning to change. Today, there are numerous tangible examples of technologies that were at the fringes less than a decade ago now playing a key role in manufacturing operations across the industry.

The Engineer, in partnership with BAE Systems, brought together a panel of experts to reflect on this changing landscape, to examine the benefits and challenges of adopting digital manufacturing technologies and to look at how UK industry might accelerate its digital transformation.

Over the following pages, we report on some of the key themes arising from this discussion.

As you'll learn, there are clearly some major challenges ahead – from the requirement to encourage greater cross-sector collaboration to an urgent requirement for entirely new skills.

But encouragingly, there's also a growing understanding of what industry is doing right and how it can rise to these challenges. ■

BAE/The Engineer Roundtable: The Panellists



Sophie Jones
General manager, Added Scientific



Craig Turnbull
Director, Electroimpact UK



Colin Sirett
CEO, AMRC



Paul Perera
VP technology, GKN Aerospace



Jeremy Hadall
Chief engineer, Intelligent Automation, MTC



Simon Keogh
General manager, Digital Factory, Siemens



Mike Wilson
Business development manager, UK and Ireland, ABB Robotics



Doug Wolff
Technology manager, Epic Games



Dr Lina Huertas
Head of strategy for digital manufacturing, MTC



Andy Wright
Strategic technology director, BAE Systems



Julia Sutcliffe
Chief technologist, Air, BAE Systems

The state of the nation



While awareness and deployment of digital technologies is growing across the industry, our panel agreed that there's a long way to go. And although many of industry's big hitters are enthusiastic converts, driving uptake further down the supply chain is a key challenge.

"Unless we start embracing the rest of that learning with the supply chain, it doesn't go far enough to have an impact," said GKN's Paul Perera, adding that firms such as his have a role to play as technology evangelists. "We have amazing capabilities at GKN. But nobody knows what we do. We've got hidden capability sitting in the UK that could be a case study for others to use. I think the onus is on us to educate."

ABB's Mike Wilson – someone on the front line of encouraging the uptake of advanced manufacturing technologies – believes that this is easier said than done. "We do have some very strong industry sectors in the UK and they are certainly developing digital capability and industry 4.0," he said, "but if you look at the vast majority of UK manufacturing, it hasn't even done 'Industry 3' yet. The challenge is, how do we get them up the scale?"

Wilson added that he believes the culture of UK industry needs to change from one where manufacturers are "proud of keeping old machines running" to one more like Germany where "they're proud that they bought new ones".

AMRC chief executive Colin Sirett agreed that the UK was lagging behind in terms of robot adoption, but pointed to a growing trust in digital techniques: "We always used to have a standing joke in Airbus that you knew when an aircraft was ready to fly when the amount of paperwork weighed more than the aircraft. We're kind of getting away from that now and we're seeing that acceptance of, 'Yes, we can trust digital in this environment'."

Panellists praised the role government has played here. Describing the industrial strategy as "a breath of fresh air", Sirett pointed to Catapult Centres as a rare example of a government initiative with legs. "Ten years for an initiative out of government is almost unheard of," he remarked. Perera was similarly enthusiastic, hailing government's involvement in the Aerospace Technology Institute (ATI). "We think it's the most rich environment the UK has ever had to develop the technologies that we're talking about," he said.

> "I think the onus is on us to educate"
>
> Paul Perera

These comments were echoed by BAE's Andy Wright, who commended "the foresight within government" and said that a focus on tapping into the UK's university sector coupled with the work of groups like the catapults, was helping the UK to develop and extract value from technology far more rapidly than in the past.

Epic Games' Doug Wolff – who is helping manufacturers, including GKN, exploit gaming technology – said the biggest impact of digital technology on manufacturing was yet to be felt. "Manufacturing has been isolated a little bit from disruption," he said. "[It is] a little bit insulated because you have to eventually make a thing. You can't just do it digitally from your bedroom and become a worldwide supplier like you can for software. But with emergence of manufacturing technologies that are becoming more disruptable, the model has the chance to be very greatly shaken up in the same way that pure digital industries have been."

Why embrace digital?



Sophie Jones, general manager of Added Scientific

Given the sometimes confusing plethora of digital technologies available, and the competing – and even contradictory – claims about their effectiveness, it can be difficult to keep in sight the reasons for using them. The roundtable panellists had a variety of points of view on this, mainly foregrounding the abilities that technologies give for keeping the performance of factories simple to observe, and keeping in sight the improvements they can bring to the final product.

For some, investment is not justified unless its advantages can be quantified. MTC's digital strategy lead, Dr Lina Huertas, said some examples from around the world suggest that investment in technology can improve productivity by up to 30 per cent, as well as generate "hundreds of thousands of jobs".

Paul Perera agreed and said that investment in technology is a matter of urgency if the UK is to compete on the world stage, particularly for the country's SME base. "We've got competitors in Korea who are buying robots at the rate of 10 or 20 times what we are in the UK, if not more," he said. "If we don't accelerate the use of digital, some SMEs will be out of business, because some countries around the world are taking their SMEs further and faster."

For BAE Systems, digitalisation allows the advantages of other technologies to be unlocked. "AI will enable us to use machine optimisation and design, give us the ability to think about the internet of things and get sensing into products and therefore design digital twins and use those the right way," said BAE's strategic technology director Andy Wright.

Meanwhile, Sophie Jones – general manager of additive manufacturing firm Added Scientific – put the advantages into a broader context, and said investment in manufacturing technology will be key to developing the Tomorrow's World type of innovations that will open up new markets for the UK and shape society in the future. "I don't think we're going to get to the products unless we develop the manufacturing technology," she said. "For me, the benefit is not in manufacturing technologies, it's in the completely overhauled healthcare system and the completely overhauled positioning systems – and helping the UK assume a leading position in developing and delivering those – that I see as the benefit."

Case study: From tier ones to SMEs



Industry 4.0 tech can be applied to legacy equipment

Engineers at BAE's Samlesbury site are trialling a smart cobotics workstation developed in collaboration with researchers from AMRC's Factory 2050.

The technology allows workers to make strategic decisions while delegating repetitive, machine-driven tasks that require consistency to the cobotic arm.

As well as a so-called "skills passport" that recognises operators and automatically loads optimised individual profiles using wireless technology, the smart workstation also features light-assisted assembly, which uses "pick by light" technology, prompting the user towards the correct components or consumables during the manufacturing process.

Dave Holmes, manufacturing director at BAE Systems' Air business, said: "Cobotics is the next natural step in developing manufacturing technology that will allow for a blending of skilled roles. We envisage that people will make larger, more strategic decisions while delegating the repetitive and intricate aspects of production to a robot."

In an illustration of how future factory technologies aren't just for the big players, AMRC has also been working with Tinsley Bridge, a Sheffield SME, on the development of an Industry 4.0 demonstrator that can be retrofitted to existing manufacturing equipment.

"Using edge computing devices retrofitted to the company's CNC machines, we have collected power consumption data during the production of automotive suspension components," explained Rikki Coles, AI project engineer for AMRC's Integrated Manufacturing Group at Factory 2050. "It isn't a complicated parameter to measure on a CNC machine, but using AI and machine learning, we can actually do a lot with such simple data."

The director of engineering at Tinsley Bridge, Russell Crow, said: "Interrogating our machine utilisation rates means we have better visibility of what was being manufactured and when, and the ability to assess if we are scheduling effectively. This data will allow us to look at boosting our productivity on the shop floor.

"Rather than investing in significant cost and time for new digitally integrated smart machining centres, we were able to work with the AMRC to retrofit our existing capabilities to achieve the same results."

Engaging SMEs

One recurring issue with UK industry is that the smaller companies who make up the bulk of the sector tend to be slower in introducing new technologies than larger companies, even though they tend to be the suppliers on whom the large companies depend.

This is certainly an issue with digital technologies, with, for example, robots being far more prevalent at the top end of the industry. "You see the top one or two per cent of companies are absolutely all over this," noted the MTC's Jeremy Hadall. "They understand digital, they understand what it's going to do for them and their supply chain and they're fully on board and very supportive. But you start going down – across multiple sectors – and it just disappears."

The problem, he surmised, is partly one of inertia: companies don't have the time, they trust the technologies that they have used for some time, and are put off by the cost. "They can't see the route to investment," he said. "They can't make the business case. It's a cultural issue, a financial issue, a skills issue."

One way this culture could be changed, said some panellists, is for companies to ensure they're employing technology champions, people who have the understanding and skills to articulate the benefits of technology to their colleagues. "If you don't have champions inside an organisation that can take technology and drive it, then it's not going to work," said Dr Lina Huertas.

Major projects that engage the supply chain can also be an important way for tier one organisations to spread the word about the potential of new technologies, Paul Perera said. "We need to give them the opportunities and the projects to work on, and I think BAE Systems has got an opportunity with Tempest to get that supply chain engaged in a very different way so I'm really looking forward to that collaboration," he said.

Digital technologies also bring an opportunity to change the business model, a situation that the MTC has seen in its clients. "We have an SME in the South East – they do general manufacturing for bespoke parts, but they've completely changed their business model," said Huertas. "They're bringing people they've found from various central Jobcentres to give work experiences to the long-term unemployed, they've developed apprentices, they've developed people inside, and they have enormous amounts of talent. They are willing to take risks in terms of how they develop their internal systems."

One way this has manifested is in a new procurement system. "At some point they said, 'well you guys are going to create your new system yourselves'," she said. "They created the code, and now they develop software for the company. They kept the whole talent well-progressing in technology."





Human skills go hand in hand with advanced technology at Samlesbury

The cost of digital

A major barrier to adoption is the perceived high cost of investing in digital, said our panel. "The biggest problem with any of these advanced systems is money," claimed Craig Turnbull, the lone SME voice on the panel. He added that the main argument often given for investing – that it will lead to payback in the future – often doesn't resonate with many. "I don't feel this is true for an SME," he said. "I don't feel investing millions and millions of dollars in a piece of equipment, because one of the large primes thinks it's a good idea, is going to take me on a jet."

Dr Lina Huertas agreed that this is a concern, but said that cost is beginning to come down as business models change. "We work for SMEs that are now using certain types of technologies that they couldn't use before because the business model of that technology provider has changed so they can now afford it," she said. "They pay for it for the week that they need to develop their product."

According to Paul Perera, GKN's work with Epic Games is a good illustration of how digital platforms don't have to cost the earth. "New platforms are available to us to pick off the shelf," he said. "In fact, to start with, most of our development was done for free, then we ended up buying a couple of licences and we're now building our complete capability set for our skills and development of our teams around digital manufacturing."

Taking this a step further, Colin Sirett said the best way to remove the cost barrier is to make the technology free and accessible, rather like a mobile phone app. "Whatever system we end up with in the future, it's got to be almost agnostic to the technology; it's got to be a real 'Android' solution," he said. "As soon as we start putting barriers up, that's then going to prohibit



Jets guard the entrance to BAE's Samlesbury site – home to its F-35 machining and assembly operations





Epic Games' Doug Wolff, left, and Electroimpact MD Craig Turnbull

the deployment and exploitation of the capability. The challenge for us and the challenge for the assistance providers is that the app has to be free. That's why we've got to get our minds around that the future industrial supply chain is digitised and enabled by free commercial products."

As a supplier, Siemens' Simon Keogh was understandably lukewarm on the prospect of free digital tools, but agreed with Huertas that the emergence of new business models is helping to open up technologies to a wider user base. "There are certainly new business models that are enabled by digital technology and we're seeing that now in things like licensing and software solutions. We're also seeing that within the supply chain itself, and the way in which OEMs, for instance, that are supplying specific machinery, are now actually not there to sell those machines but they're there to lease them at least on a pay-per-pack or pay-per-production of a single unit."

Skills



Dr Lina Huertas says training up existing staff is vital

Throughout the discussion, the issue of skills was a recurring theme and, for Jeremy Hadall, this was the overriding factor in spreading the implementation of digital technologies.

Integration is a challenge, he said, but "the bigger challenge is just the skills to do it, both in the end users – because a lot of these companies have never done it, they don't have clue how to start – and secondly in the supply chain".

GKN's Paul Perera agreed that it is the number one issue and stressed that companies need to work together to address it. "We actually need to develop those skills ourselves and in conjunction with others because we're all after the same people," he said.

BAE Systems has invested heavily in ensuring that it has a pipeline of skilled people, Andy Wright said. "We have the new ASK – the academy for skills and knowledge centre. That's £15.9m worth of investment, to be sure that we can develop the skills and capability within our people for the future. Training our apprentices and lifelong training of our staff to keep them current with technology."

Dr Lina Huertas agreed that, while ensuring a future pipeline of talent is vital, training up existing staff is also important. "We need to look at upskilling because, if you want to have an impact in the next three years, we can't wait until the youngsters have come through," she said. Another key element, she added, is ensuring that leadership teams have the right skills to embrace change. "It's also about leadership skills and introducing that disruptive spirit into leadership skills to find the people who are going to be the change makers in manufacturing and drive new technologies and a different way of doing things," she said.

Picking up on the apprenticeship theme, Colin Sirett said that AMRC's experience in this area is a neat illustration of how apprentices can help meet future factory skills requirements. The AMRC training centre – which was established in 2014 – has, he said, already established a pipeline of young engineers and technicians who are feeding fresh ideas into the region's SMEs. "Thankfully, those SME companies don't have an ego big enough that rejects it," he said. "They're taking that advice from a youngster. And it absolutely works."

While industry clearly needs to get to grips with changing skills demands, Doug Wolff suggested that digital skills are not the barrier they once were. "I remember in school and through university, if I wanted to do put in an external system like a robot, I had to go to the lab to do it. Now, not only is the barrier to entry lower with the tools you're able to get for free, but you can make very impressive things very quickly." He added that industry needs to get used to viewing digital as a core competency rather than a separate discipline. "One of the things that frustrates me the most is that people see digital as its own thing, and think they need to go to computer science graduates in order to get our digital skills," he said.

Expanding on this point, Sirett said that many of the young engineers he sees coming through are natural digitally oriented in a way that older engineers simply aren't. "The lad that pulled together some of the first software that drives the smart bench was an intern," he said. "We gave him an environment where he basically couldn't wish for any more toys than he could lay his hands on. And he just went wild. And the outputs were phenomenal. Is there a skills gap? My view is that it's softening. I don't think it's a skills gap. There are different skills in the same way you'd have different traditional skills that you'd buy into a company. We would probably go to a completely different demographic for a lot of the digital skills now."

Cross-sector collaboration

With the UK's digital manufacturing landscape best described as patchy, our panel agreed that cross-sector collaboration will be key to encouraging more widespread uptake.

BAE's Julia Sutcliffe said there is a keen awareness of this in the aerospace sector. "One thing that is widely recognised is the vast amount of investment that's going into things like digital technologies outside of the defence aerospace sector. It's colossal globally. So without doubt, there is an incentive to ensure that we understand how and where it might fit," she said.

In order to achieve the knowledge-sharing required, AMRC's Colin Sirett said that industry needs to be proactive about creating environments where different sectors come together. He pointed to a recent digital forum convened by the AMRC, involving JCB, Jaguar Land Rover, Rolls-Royce, Marshall Aerospace and Defence Group, and Airbus. He said: "Out of that roundtable, there have been so many offshoots into different areas, where people have said, 'Wow, I didn't realise that was how you approach things.' If you put the different sectors together, they thrive."

Paul Perera cited a recent visit to a medical company as evidence of the value of looking to other sectors. "I looked inside the factory windows and there were 150 additive machines spread out in front of me. I've seen nothing of that scale in aerospace. We're looking at another industry with the scaling capability that we can only imagine. We need to excite our supply chain about the possibility of using this technology," he said.

Perhaps one of the keys to enabling this common understanding lies with the suppliers. "We can certainly help, because we are connected with all these different sectors and we're aware of what's going on," said ABB's Mike Wilson. However, he warned that organisations' reluctance to discuss areas of competitive advantage can make this difficult. "There are sometimes challenges because companies think, 'we develop this and we don't want anyone else to have it' and so we can't spread the gospel as much as we'd like."



Inside Samlesbury's F-35 machining facility

Wilson stressed that it is important for bigger businesses to take the lead and work harder to spread the message down through the supply chains. "Without the whole environment collaborating on it, we still end up with these pockets of different groups of people that are keen, talking to each other and not making much of a concrete difference," he said.

Simon Keogh agreed and added that, with the UK's digital expertise dispersed across pockets in different sectors, suppliers have a vital role to play. "There are really great examples where people are using digitalisation, but it's so diverse," he said. "They are just pockets here and pockets there. Right now, we're finding that naturally leads to trying to use references that are outside of one industry for another industry."

Sophie Jones said by looking further afield, manufacturing businesses can help solve challenges in other sectors and open up new markets. "One of the things we've tried to do as a business is look at industries that aren't typically involved in additive manufacturing, because we think there's enough attention on aerospace and enough potential in automotive," she said. An example of this, she said, is her firm's work in the quantum sensing field. "We went to them and said, 'We can use AM to make your components better', and everybody we spoke to said, 'Not a chance. You can't put AM components under ultra-high vacuum conditions and get them to perform'. So, we did exactly what they said we couldn't do, and we opened up avenues within that industry that were categorically closed off to us. I think that's a really interesting space to play in: working with people who typically you wouldn't talk to." ■

Case study: In the wings

GKN is to open a new Global Technology Centre (GTC) in Bristol in 2020, where it will make concrete its commitment to digital manufacturing technologies. Costing £32m, the 10,000m² facility will serve as a base for GKN Aerospace's technology partnership in the Airbus Wing of Tomorrow programme. Its 300 engineers will focus on additive manufacturing, advanced composites, assembly and Industry 4.0 processes.

The centre will include collaborative space for R&D with universities, the UK Catapult network, and GKN Aerospace's UK supply chain. Chief executive Hans Büthker said: "The GTC will ensure we continue to develop new technologies that deliver for our customers, making aircraft more sustainable and economical."

Announcing the opening, the secretary of state for business, energy and industrial strategy, Greg Clark, said: "As the [aerospace] sector moves towards a cleaner, greener and more efficient future, we are partnering with industry through our modern Industrial Strategy and new Aerospace Sector Deal to ensure we have the skills, innovation and supply chain to continue our world leadership in aviation." Among the GTC collaborators is Additive Industries, the additive manufacturing hardware vendor, which is hoping to accelerate industrialisation of 3D-printed aerospace applications.

GKN has already found advantages with additive manufacturing through partnership with Stratasys, via which it is producing tooling, jigs and fixtures using the fused deposition modelling (FDM) technique. The company invested in an F900 FDM machine, with which it prints parts from Ultem 1010 (polyetherimide) thermoplastic resin. It takes around three hours to produce a part.

"This saves critical production time and, by printing in engineering-grade thermoplastic, we can produce 3D-printed tools with repeatable, predictable quality every time," said additive manufacturing centre manager Tim Hope. "All the while matching the quality of traditionally produced tools and reducing the costs and concessions compared to equivalent metallic tooling."

Additive techniques will be further used in the Prometheus programme, which will see the manufacture of a demonstrator for a low-cost reusable rocket engine using methane propellant, with the turbines generating power for the methane fuel system.

Manufacturing will take place at GKN Aerospace's engine systems centre of excellence in Trollhättan, Sweden, with ArianeGroup the prime contractor.



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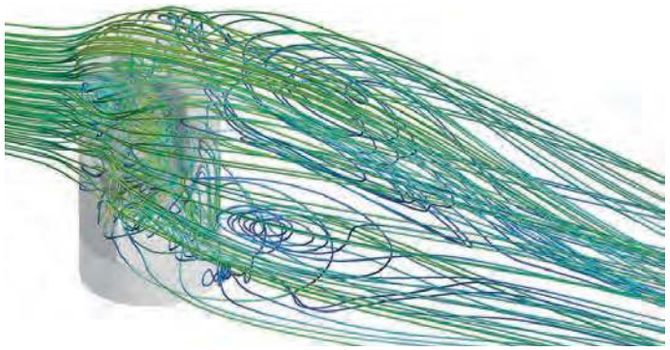


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Hydrogen in the home – looking at the logistics



Stephen Livermore and Ailidh McGilp **from engineering consultancy Frazer-Nash explore the challenges of a nationwide hydrogen gas conversion**

Engineering consultancy Frazer-Nash has been investigating the logistical challenges of undertaking a nationwide 100 per cent hydrogen gas conversion. In this article, *The Engineer* looks at the lessons to be learned from the 1970s 'town gas' conversion.

Generating the heat required by the UK's homes, businesses and industry is the country's single biggest source of carbon emissions. In 2017, heat accounted for 37 per cent of the total carbon and the UK government is considering a range of options to reduce this liability. One possibility, which allows significant re-use of the existing asset base, is to undertake a nationwide conversion of the gas grid to 100 per cent hydrogen, which has zero emissions at the point of end-use. Although a formidable undertaking, a conversion at this scale has a precedent – in the 1970s the UK converted from locally manufactured town gas, which contained 50 per cent hydrogen, to the newly-discovered North Sea natural gas.

Appliances and domestic modifications

The town gas conversion involved adapting or replacing approximately 40 million appliances over a period of around 10 years. Compared to town gas, natural gas required more than twice as much air for combustion, and switching the gases without converting the appliances would have resulted in large, sooty flames that were neither efficient, nor desirable for cooking and heating. A key aspect of the town gas conversion was to increase domestic gas pressure from 4 millibar (mbar) to 20 mbar. While relatively minor changes to the burner injector and ports were required for natural gas, unless the existing pipework or gas fittings were found to be unsafe, the domestic pipework itself did not need to be changed.

The position for a contemporary equivalent is more complex. To enable a 100 per cent hydrogen conversion, it would be essential to remove the pre-mixing of hydrogen and air prior to the point of combustion for hobs, ovens and fires as hydrogen has a significantly faster flame speed than natural gas and is likely to burn at a hotter temperature. Modern boilers, which contain fans to actively mix the fuel gas with air prior to the combustion zone – and hence develop a flammable volume behind the burner surface – would also need special consideration. Hydrogen appliances are being developed as part of the Hy4Heat Programme being run by the Department for Business, Energy and Industrial Strategy (BEIS), but at this stage there are no plans to reduce the supply pressure back to that used with town gas.

In the town gas conversion, the emphasis was on adapting, rather than replacing appliances. A designated body was formed to develop conversion kits for in-situ domestic conversions, and to undertake more complex appliance conversions off-site. The diversity and complexity of modern gas appliances means that, though adaption may be possible in some cases, appliances are most likely to require replacement. To ease the burden of the conversion, one option is to develop 'Hydrogen-Ready' appliances, which have been developed for hydrogen but temporarily back-fitted to run on natural gas. These could be installed as part of the replacement cycle of gas appliances, so that minimal work is required at changeover. This is analogous to development of the high definition (HD)-ready televisions which were 'back-compatible' with standard definition television signals prior to the HD roll-out.

Copper piping for domestic gas distribution was introduced in the 1960s and before this, lead and steel were predominantly used. There has been no legal obligation to remove old pipework unless a fault is discovered, and so many UK homes still have these legacy materials. Modern pipework is typically soldered copper – although steel is becoming more popular as, while it is more labour-intensive to join, it is significantly cheaper. Medium-Density Polyethylene (MDPE) is also cheaper than copper and used in the gas distribution network, but is not currently permitted for use in domestic gas



Hydrogen appliances are being developed as part of the Hy4Heat Programme

applications due to fire safety concerns. It is likely that copper would be a suitable material for hydrogen in low-pressure domestic gas systems, although there are concerns over the type of joints used and some form of gas tightness tests would need to be undertaken during the domestic surveys.

Delivery of the conversion

The town gas conversion required the creation of dedicated regional task forces of conversion engineers, organised by the centralised, publicly funded Gas Council. Since then the Gas Safe Register has been developed to regulate domestic natural gas work, with approximately 130,000 individual engineers, of whom 80 per cent are qualified to work on domestic gas systems. The register ensures that the list of competent and qualified engineers is accurate and up-to-date, inspects the work of Gas Safe engineers, investigates reports of malpractice, and conducts gas safety public awareness campaigns. The structure and rigour of the Gas Safe qualification would be an appropriate starting point for developing a workforce for a hydrogen conversion.

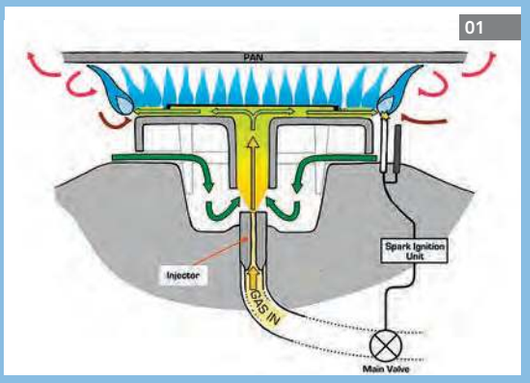
As of 2017, there were approximately 21.2 million boilers, 12.7 million hobs and ovens, and 10.4 million gas fires in the UK. This is actually similar to the total number of appliances converted in the town gas conversion, although gas cookers and fires were more prevalent than central heating boilers in the 1970s. Interestingly, the total number of gas appliances is similar, despite there now being considerably more dwellings than in the 1970s.

Life's a gas How it works

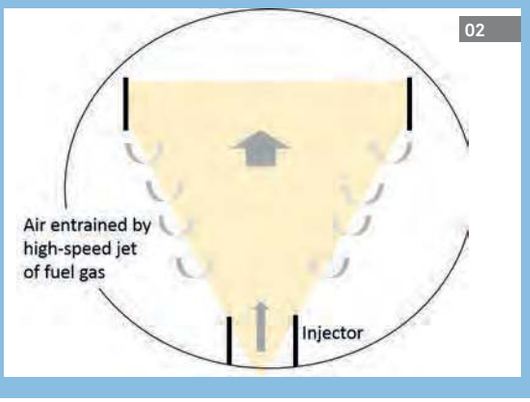
In a domestic hob, the fuel gas is injected out of a nozzle where it entrains ambient air (primary airflow). This mixture then flows up into the burner and out of the ports where it is ignited. Combustion at the burner surface relies on the speed of the gas mixture being equal to the flame speed. The town gas to natural gas conversion required two key changes:

- **Increased gas supply pressure, but reduced nozzle size (injector). This provided a reduced total flow of fuel gas, but increased its speed so that it entrained more surrounding air.**
- **Increased area of burner ports, to reduce speed and rematch gas speed to the new lower flame speed.**

As town gas contained 50 per cent hydrogen, some aspects of the town gas appliances may be applicable to 100 per cent hydrogen. However, with 100 per cent hydrogen it is likely be necessary to completely remove the pre-mixing, and only to bring the fuel gas and air into contact at the point of combustion.



01 Gas supply pressure was increased, but the injector size was reduced



02 The area of burner ports was increased, to rematch gas to flame speed

Hydrogen conversion timescales depend upon the type of appliance, but it is anticipated that a boiler conversion would take approximately one day whilst simpler hobs, ovens and fires would each take around half a day. Combining these appliance estimates with an average of half a day per property for pipework updates, and allowing for three home surveys a day, a nationwide conversion could potentially be undertaken in as little as four years, if a dedicated conversion team is developed, or in around 16 years if the existing Gas Safe workforce is used. This is roughly the same total time frame as the town gas conversion. While aspects of the domestic gas system have changed substantially since the 1970s – not least the privatisation of the gas transmission and distribution system, the complexity and diversity of appliances and the alternative electrical options available to consumers – the fact that a nationwide conversion has been achieved previously does show that a conversion to 100 per cent hydrogen is in the realms of the possible. ■

■ **Stephen Livermore is a chartered Mechanical Engineer and Ailidh McGilp is a chartered physicist.**

Honda NSX: Still miles ahead?

Three decades on from its launch, can the original Honda NSX really live up to its reputation? *The Engineer* drives an icon, writes Chris Pickering



Legend of the road: The Honda NSX still manages to impress, 30 years later

The legend of the original Honda NSX precedes it. An automotive icon built by a mainstream Japanese manufacturer to take on the European supercar elite. It was famous for its ruthless application of technology at a time when most supercar makers were still rooted in the dark ages. Suddenly you could buy a mid-engined rocket ship that wouldn't steam up, break down or allow entire families to shelter in its panel gaps.

Honda had always been an innovative manufacturer. Its first car, the S500 of 1963, featured a tiny 531cc four-cylinder double overhead engine that revved to over 9,000rpm. By the 1980s it was a global player with a reputation for building clever, if somewhat bland, saloons. On the racetrack, meanwhile, Honda was at the height of its powers. Every single Formula 1 World Constructors' title winner from 1986 to 1991 used a Honda engine. At the same time, a certain Ayrton Senna – who picked up all three of his world titles with Honda – was enlisted to help with the work on the new NSX.

Over 400 patents were filed during the course of the car's development. It is perhaps best remembered for being the first car in the world to use an all-aluminium monocoque construction. Steel was apparently considered, but the extra weight would have required a larger, more powerful engine to achieve the desired performance targets – particularly with all the mod cons onboard that the Honda's more traditional competitors generally lacked, such as ABS brakes, power steering and air conditioning.

In the end, five different aluminium alloys were incorporated into the design. A whole new forming process had to be developed for the sills, because – unlike steel – the aluminium wasn't suitable for deep drawn pressing. Instead, the material was heated to 600 degrees, poured into dies, and extruded while it was being drawn. Honda calculated that this approach would save nearly 200kg compared to a steel-bodied car.

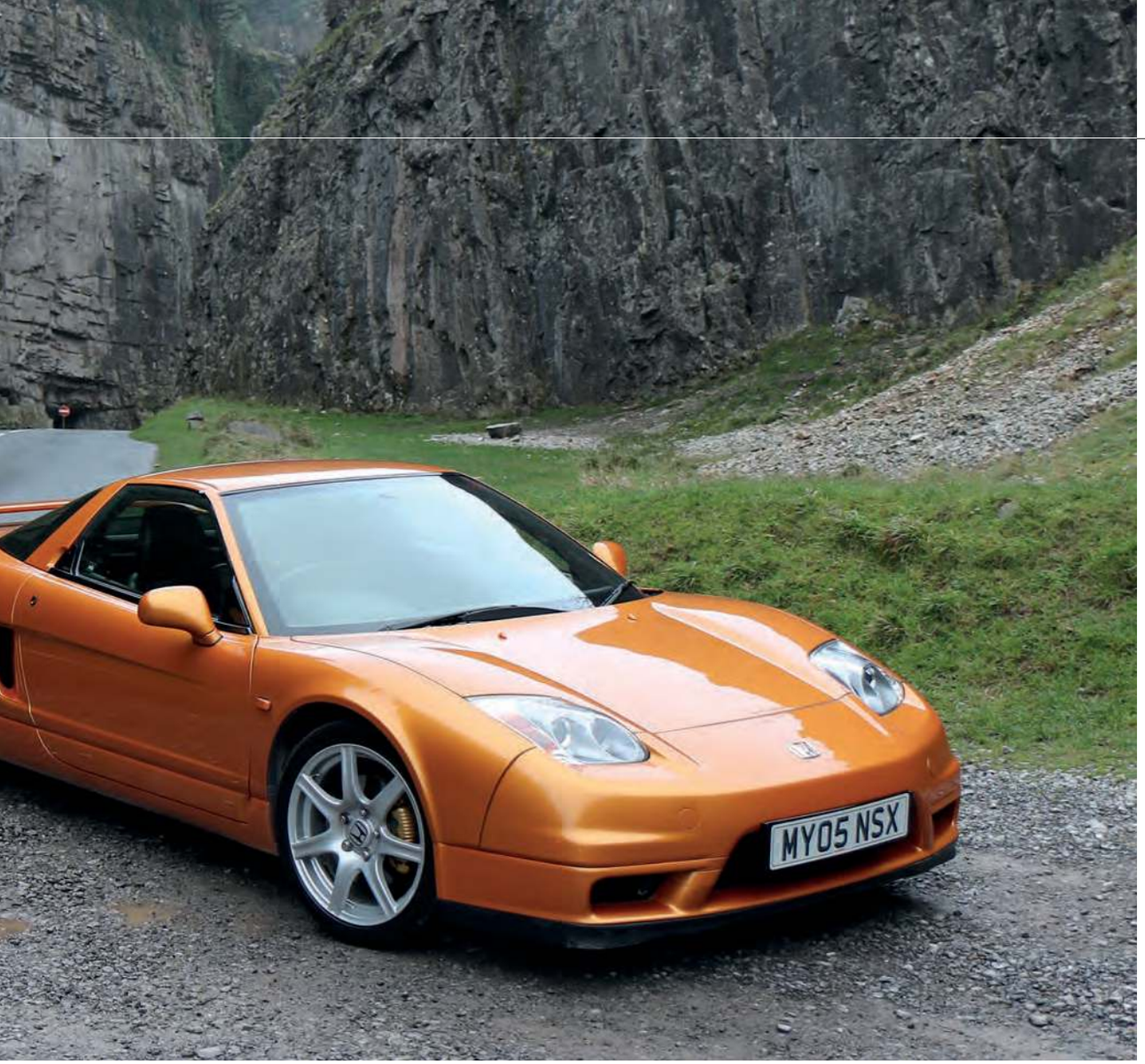
Long before it was fashionable to do so, Honda had set up a small R&D centre at the Nürburgring and began testing on the legendarily punishing 15.2-mile German circuit. However, much of the work was carried out closer to home at the Suzuka circuit in Japan, and it's here that Senna enters the equation. He test drove the prototype NSX in February 1989 and complained that the chassis "felt fragile" and lacked stiffness.

As a direct result of this feedback, the engineers returned to the finite element models that they were running on Honda's Cray supercomputer. By the time the production version broke cover later that year they had managed to increase the torsional rigidity by an impressive 50 per cent. This reputedly gave the NSX the highest torsional rigidity of any car on sale at the time. More importantly, it meant that the vehicle dynamics engineers had a uniquely stable platform on which to practise their art.

Other significant innovations can be found right throughout the design. The NSX was the first production car to use titanium connecting rods; it was one of the earliest applications of Honda's VTEC variable cam timing and lift system; it featured independent four-channel ABS braking; and from 1995 it became the first Honda to use fly-by-wire throttle control.







01 This sensible supercar impresses on first viewing

02 The 3.2-litre V6 VTEC engine sounds quiet at first

03 The NSX is a smooth ride with excellent suspension

04 The interior is perhaps a little too plastic-looking





All this meant the NSX was not just every bit as fast as the Ferrari 348 that Honda had benchmarked it against, but also a great deal more usable day-to-day. So usable, in fact, that it has gained a bit of a reputation as the sensible supercar – enough to make me question whether the car you see here will live up to its iconic reputation or whether it will all turn out to be a little bit too competent.

First impressions are positive. It may not be as svelte as a Ferrari or as sinuous as a Lamborghini, but this immaculate 2005 example from Honda UK's heritage fleet certainly looks the part. The interior is somewhat less inspiring to behold, with swathes of black plastic and a faint whiff of 1990s minicab, but the driving position is spot on and everything feels just right from the moment you sink into the low-mounted seat.

The 3.2-litre V6 sounds relatively muted initially. Its 276bhp output also seems fairly modest by today's standards (for comparison, the current Honda Civic Type R squeezes 316bhp from a 2-litre inline four). However, once you get the chance to open it up the VTEC engine comes alive. It's not as frantic as the high-revving four-cylinder engines in the Honda Integra Type R or the S2000 of the same era; instead, there's a creamy, linear spread of torque all the way up to the 8,000rpm red line, accompanied by an addictive bark from the intake system. The six-speed manual gearbox found on this last-of-the-line example is a wonderfully tactile experience too.

The thing that really strikes you about the NSX, though, is its balance and poise. The steering response is more measured than that of the hyper-sensitive racks found in a lot of modern supercars, but it is unflinchingly linear and brimming with feedback – something that's particularly impressive when you consider that it's one of the earliest examples of electric power assistance. The suspension too is beautifully composed, combining a supple ride with excellent body control.

Of course, the fact that it's a technically accomplished car doesn't come as any great surprise, given the NSX's reputation. What's really impressive is the way it makes you feel. So predictable are its responses that after the first few corners you seem to know exactly what the car is going to do. That gives the NSX a sort of instant familiarity; as if you've been driving it for years. No other car I can think of feels quite so much like it's on your side.

Cost-cutter

Software calculates cost impact of design decisions early in the development process

Supplier: aPriori

Manufacturing businesses across all sectors face a growing challenge to reduce costs and bring products to market more quickly. And an innovative software tool that helps engineers calculate the cost implications of early stage design decisions on the fly is helping a growing number of users achieve exactly that.

Developed by US software firm aPriori, the software – also called aPriori – works by introducing considerations over manufacturability far earlier in the product development process than is often the case. Existing users span a range of sectors and include Alstom, Ford, Whirlpool, Honeywell, Boeing, HP, and Cisco.

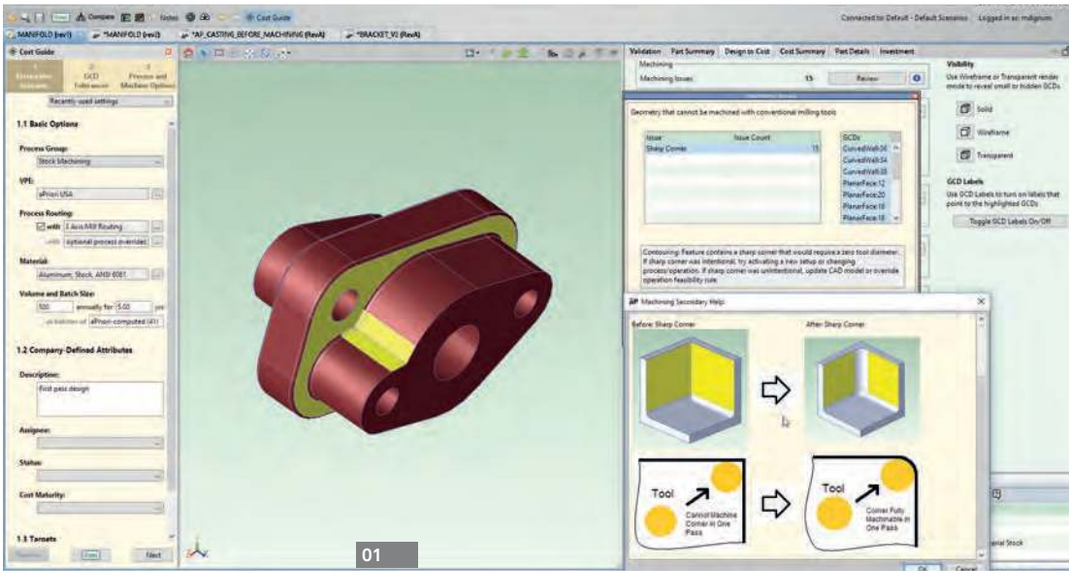
Integrating smoothly with any CAD package, the software ticks away in the background as the designer makes changes, and provides instant feedback on how these decisions are likely to affect the end cost, as well as guidance and suggestions on changes that the designer might like to make to bring the cost down.

aPriori sales director James Dainty explained that the software begins its work by analysing the geometry of a 3D CAD model. "If it's looking at a casting it will look for wall thicknesses, voids, holes, and what might be machined features," he said. "If it's a sheet metal part it will looking for how many bends there are going to be and things like that. If there are tolerances applied it will also look at the tolerance and surface finish information."

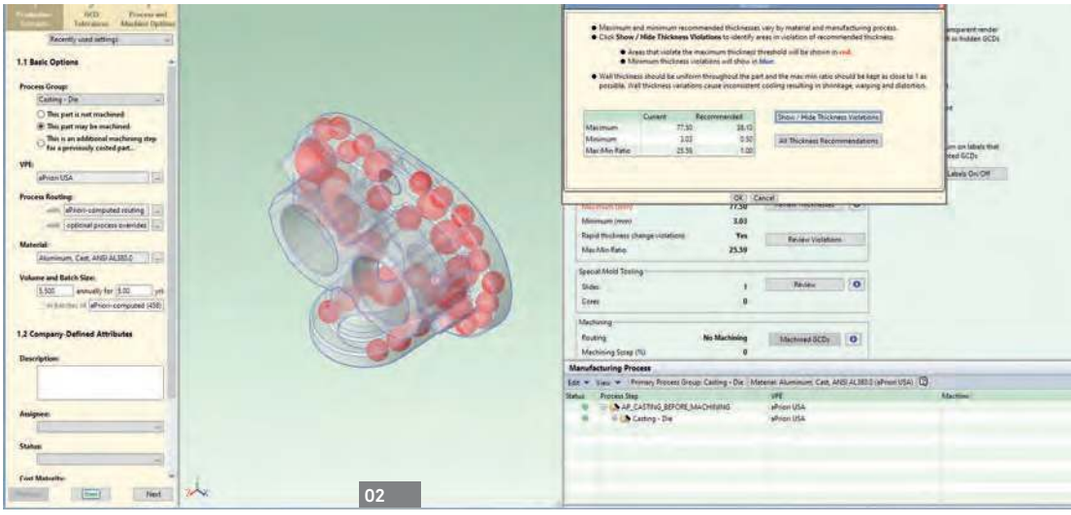
Having analysed this information it will then consider the manufacturing processes that could be used. "If it's a casting it will think, am I going to die cast it or sand cast it?" added Dainty. "If it's got to have secondary machining will it use a 3-axis mill with multiple set-ups, or a 5-axis mill with a single set-up? If it's plastic what is the optimal machine it would go on?"

Throughout this process the tool also factors in up-to-date information on the labour and material rates in multiple regions around the world (as well as packaging and logistics costs) in order to calculate the real cost implications of these early stage design decisions.

Guy Langley VP, EMEA for the firm, said that the software enables businesses to take a fundamentally different approach to cost reduction. "There's not been a great deal of pressure on the design engineer from the perspective of cost," he told *The Engineer*. "It's all been fit, form and function – now we're starting to see a lot of organisations where the business is turning to engineering and saying you need take cost out – because if you take cost out early in the cycle it has a bigger impact than having to manage it out later on."



01



02

As well as enabling early visibility of cost, the software also helps companies analyse a multitude of design alternatives – potentially as many as 1,000 – for the cheapest fit, form and function.

Despite an inevitable perception that tools like this are giving design engineers even more to do, Langley said that the reaction from users has been broadly positive. "You get engineers turning around saying 'hang on a minute, you want us to design it, analyse it, you want us to use all these other simulation tools and you want us to cost it as well?', but once they start using it and realise it's not going to be a huge overhead a lot of them are very positive." He added that this is particularly true of younger engineers, who are typically quicker to embrace change and often keen to learn more about the manufacturing process. What is more, he added, there is a strong argument that the tool actually simplifies the design process by reducing the amount of "thrashing" to and fro in an effort to bring down the cost.

The savings that can be enabled by the technology are potentially huge, claimed Langley. "If you work well, within the first year you'll start seeing benefits.

One customer that's been using the product for five years is getting a nine to one return on investment. If it works well you're going to pay for it within the first year." ■

01 The software initially analyses CAD models

02 After CAD analysis, aPriori considers the manufacturing process to be used



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Messe Düsseldorf

Out with the old cars, in with the new electrically assisted motors

With the phasing out of petrol and diesel cars by 2040, battery power and digital connection seem to be the way forward Supplier: Schaeffler

The clock might be ticking on diesel and petrol-powered cars but statistics show that the car is the most popular mode of personal transport in Britain.

In 2017 alone, passenger cars accounted for 254 billion miles of travel in Britain, which was an increase of one per cent compared to 2016. Overall greenhouse gas emissions from cars fell but plans are in place to phase them out entirely with the withdrawal of new petrol and diesel cars by 2040. This doesn't mean the end of cars, but it does have OEMs and others looking seriously at how they can best serve a market that values environmental stewardship and the freedom afforded by personal mobility.



Among them are Bio-Hybrid GmbH, a Schaeffler Group company that used this year's CES show in Las Vegas to debut cargo and passenger versions of its four-wheeled, electrically assisted vehicle. "The world premiere of the two near-production prototypes at CES marks the next step on the road to the planned market launch in 2020," said Professor Peter Gutzmer, deputy CEO and chief technology officer of Schaeffler.

The vehicle's electric traction motor assists the operator – as in the case of a pedelec – up to a speed of 25km/h. Both versions have two 250W motors and accommodate a 48V battery, which has a capacity of 1.2kWh, or 2.4kWh if a second battery is fitted. In both modes, the vehicle has a range of around 50km, doubling to 100km with the second battery installed.

Bio-Hybrid adds that WiFi, GPS, Bluetooth and 4G make the vehicle "a full-fledged element in digital and connected cities". A smart operating concept is claimed to ensure "maximum riding pleasure, high safety and easy control".

Bio-Hybrid only requires a third of the parking space of a small car and can be operated in most countries without a licence and vehicle registration. ■

Siemens helps glassmaker to keep fires burning brightly

Float Line 2 can operate 'with confidence' Supplier: Siemens

Glassmaker Pilkington has partnered with Siemens to retrofit an entire production line at one of its plants in Germany.

The 'Float Two' line at Pilkington's Weiherhammer factory had been in operation 365 days a year for a decade, manufacturing a remarkable volume of material.

With up to 810 tonnes of glass daily, the line has produced the equivalent of a 3.5m wide glass sheet about 75,000km long – enough to orbit the Earth twice.

In light of this heavy workload and recognition that spare parts were increasingly hard to locate, the line was scheduled for a retrofit. As part of the upgrade, the process control system was replaced with a state-of-the-art solution from Siemens which had already been tested and approved in a factory acceptance test in Karlsruhe. The massive project was completed in 100 days, minimising production downtime.



"By upgrading to a PCS 7 process control system, we now have a future-oriented investment in place on Float Line 2 which we can operate with complete confidence," said Pilkington plant director Reinhold Gietl.

Siemens claims that the new decentralised control system guarantees a high-quality production process, as the PCS 7 process control system monitors precise maintenance of all variables during glass production. Intelligent controls also contribute to energy savings and to minimising exhaust emissions.

"Our central engineering department at Pilkington worked closely with the Siemens specialists and colleagues from the plant at Weiherhammer during the control system upgrade," said Gietl. "The combination of automation and project management specialists worked perfectly. It is only through years of intense and proven collaboration with Siemens that we were able to complete a project of this complexity without any problems in such a short period of time." ■

IN THE HIGH COURT OF JUSTICE **No. CR-2018-009151**
BUSINESS AND PROPERTY COURTS OF ENGLAND AND WALES
INSOLVENCY AND COMPANIES LIST (ChD)

IN THE MATTER OF
ROYAL & SUN ALLIANCE INSURANCE PLC
- and -
IN THE MATTER OF
THE MARINE INSURANCE COMPANY LIMITED
- and -
IN THE MATTER OF
MERCANTILE INDEMNITY COMPANY LIMITED
- and -
IN THE MATTER OF
THE FINANCIAL SERVICES AND MARKETS ACT 2000

Notice is hereby given that on 17 January 2019 an Application was made under section 107 of the Financial Services and Markets Act 2000 (the "**Act**") in the High Court of Justice of England and Wales by the above-named Royal & Sun Alliance Insurance plc ("**RSAI**") and The Marine Insurance Company Limited ("**MIC**") (together the "**Transferors**") and Mercantile Indemnity Company Limited (the "**Transferee**") for Orders:

(1) Under section 111 of the Act sanctioning a scheme (the "**Scheme**") for:

(a) the transfer to the Transferee of certain direct and reinsurance business of the Transferors, namely certain UK-based commercial general insurance business; and

(b) the making of ancillary provisions under section 112 of the Act for implementing the Scheme.

The following documents are available and may be obtained by any person free of charge by downloading them from the website (www.rsagroup.com/RSATransfers) or by making a request by email to RSATransfers@equiniti.com, or in writing at RSA Insurance Group, 20 Fenchurch Street, London EC3M 3AU (Attention: Jonathan Colson) or by calling the Scheme helpline on +44 121 415 0966 at any time until the making of an order sanctioning the Scheme:

- a copy of the Scheme document;
- a copy of the report on the terms of the Scheme prepared by an independent expert in accordance with Section 109 of the Act;
- a communications pack, which includes a statement setting out the terms of the Scheme and a summary of the independent expert's report.

Anyone who has any questions regarding the proposed Scheme or would like further information should contact us using the above details.

The specific nature of the transferred business differs between RSAI and MIC, but in both cases constitutes part of their respective commercial general insurance businesses.

It is intended that the Scheme will transfer from RSAI to the Transferee certain commercial general insurance policies that include liability cover and that were either: (i) written by or on behalf of RSAI prior to 2006, or (ii) written by or on behalf of another insurer prior to 2006 and transferred to RSAI prior to 7 February 2017. Policies that relate exclusively to marine or motor liabilities, or were underwritten by a branch or agency incorporated or domiciled outside the UK are excluded from the Scheme, as are certain other specifically excluded policies.

It is intended that the Scheme will transfer from MIC to the Transferee the following categories of commercial general insurance policies that were either written: (i) by or on behalf of MIC, or (ii) written by or on behalf of another insurer and transferred to MIC prior to 7 February 2017:

(A) all marine energy policies written prior to 2004;

(B) all other marine policies written prior to 1997; and

(C) all aviation policies written prior to 2009.

The Scheme will also transfer various business contracts from each of RSAI and MIC to the Transferee, including all or part of certain outwards reinsurance contracts. The business of the Transferors, comprising policies and business contracts, and associated assets and liabilities, that is to be transferred to the Transferee by the Scheme forms the "**Transferred Business**".

The Scheme will transfer the Transferors' rights and obligations under the commercial general insurance policies forming part of the Transferred Business (referred to as the "**Transferred Policies**") without alteration to Mercantile. The holders of the Transferred Policies (and any persons entitled to beneficial rights under such Transferred Policies) will, with effect from 00.01 BST on 1 July 2019 (or at such other later time and/or such other date as the Transferors and Transferee may agree) (the "**Effective Date**"), become entitled, to the exclusion of any rights which they may have had against the Transferors under a Transferred Policy, to the same rights against the Transferee. Similarly, the holders of the Transferred Policies shall be liable to account to the Transferee for any further or additional premiums or other sums attributable or referable thereto, as and when they become due and payable. Responsibility for handling all claims under the Transferred Policies, which are currently being handled by, or on behalf of, the Transferors will transfer to the Transferee. The Transferee shall be entitled to any and all defences, claims, counterclaims and rights of set-off under the Transferred Policies, which would have been available to the Transferors prior to the Effective Date.

Subject to certain exclusions, at and with effect from the Effective Date, all assets and liabilities that are comprised in, arising from or in connection with the Transferred Business shall transfer to the Transferee. Various business contracts will also transfer so that they will become agreements between the Transferee and the relevant third party. The Scheme will be valid and binding on counterparties to such contracts notwithstanding any restriction on transfer or assignment contained in any such contract.

The Application is due to be heard at the High Court of Justice of England and Wales (High Court), 7 Rolls Buildings, Fetter Lane, London, EC4A 1NL on 13 June 2019. Any person who considers that he or she may be adversely affected by the Scheme has the right to make representations and/or to appear at the Court hearing. It is requested that any person intending to make representations (either in writing or by telephone) and/or appear at the hearing (either in person or using legal representation), please contact RSA on +44 121 415 0966 or in writing at the email address below as soon as possible and before 13 June 2019 to set out the nature of their representations. This will enable the Transferors and the Transferee to provide notification of any changes to the hearing and, where possible, to address any concerns raised in advance of the hearing. If the requested notice is not given, attendance at the Court hearing, either in person or using legal representation, will still be permitted.

Jonathan Colson
RSA Insurance Group
20 Fenchurch Street, London EC3M 3AU
RSATransfers@equiniti.com

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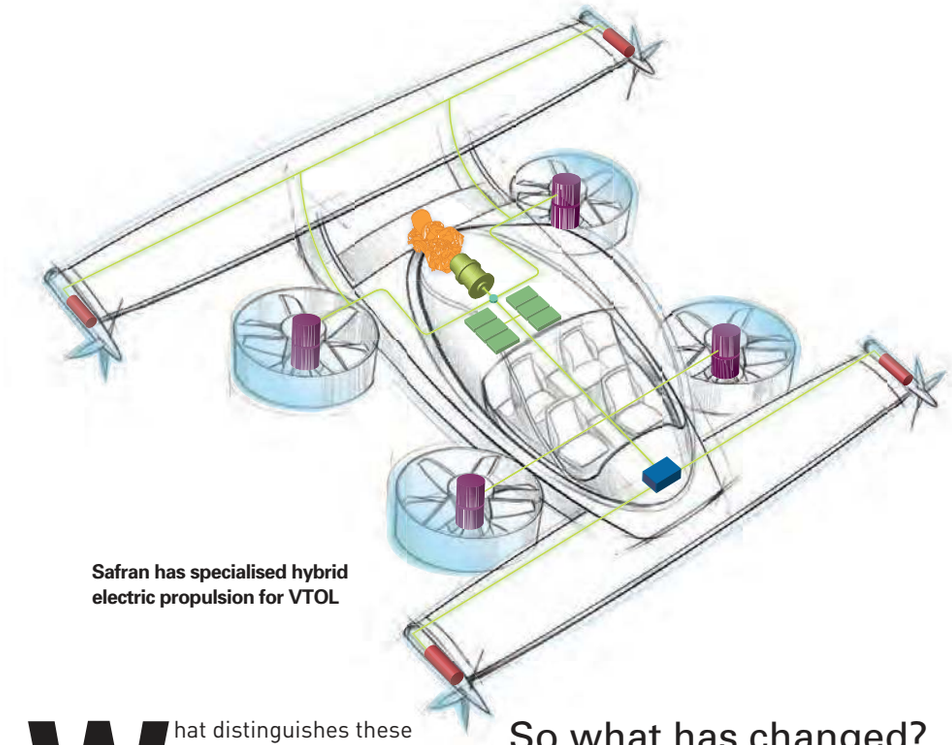
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VTOL: Safran tak

VTOL – Vertical Takeoff and Landing – may be the next revolution of aerospace and now mainly refers to helicopter type drones.



Safran has specialised hybrid electric propulsion for VTOL

What distinguishes these platforms from previous VTOL iterations is their propulsion system, either all-electric or hybrid electric. Safran is rising to this challenge – vertically! – to specialise in hybrid electric propulsion systems, spelling out the future of air transport. These new VTOL aircraft will first carry cargo, and eventually people.

"Remember that the first VTOLs were helicopters", notes Hervé Blanc, Vice President of Power division at Safran Electrical & Power. "Historically, this type of aircraft has been used for military applications."

So what has changed?

Helicopters are limited when flying over inhabited areas, mainly because they're noisy. One way of addressing this problem is a distributed electric propulsion system, involving a large number of rotors. "We have been working on it with our sister companies and have developed a smart electrical propulsion system, i.e. a full electrical channel, based on a power management system and on a smart generator and electric motor," says Naveed Sheikh, R&T UK Program Manager at the Power division of Safran Electrical & Power. "This solution aims at overcoming challenges on noise, size, cost, and emissions".

VTOL aircraft are seen as safer, quieter and less expensive than helicopters, with the added ability to take off and land autonomously within small areas. That makes them ideal for quick container carriage, medical evacuation, urban logistics, etc. However, we have to wait for changes in air traffic regulations before we see VTOLs being used as air taxis.

The Safran Challenge

Safran is forging a position in this emerging market in partnership with major international airframe manufacturers, to supply hybrid VTOL propulsion systems.

Safran's road map aims for initial demonstrations to start in 2020, and for these technologies to hit the market by 2025. ■



Inspection of an advanced generator

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es off!

Safran Electrical & Power propelling the future

The vision of Safran Electrical & Power is to deliver to the market smarter electrical solutions for a better flight. The first step is to develop and optimize a complete hybrid electrical system, notably for VTOLs and the company has launched a new range of electric motors called ENGINeUS.



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The Pitstone site, powering aircraft systems



The Pitstone plant hosts 500 employees

At the foot of the Chiltern Hills, only 40 miles from London, the Pitstone site is an R&D and manufacturing facility with 500 employees. Part of the Power division within Safran Electrical & Power, Pitstone products provide the electrical energy to power aircraft systems. The plant designs, manufactures, assembles and repairs main and auxiliary generators, as well as electrical distribution systems and the ENGINeUS electric motors.

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- **Program managers**
- **Quality assurance engineers**
- **Business support & product support engineers**

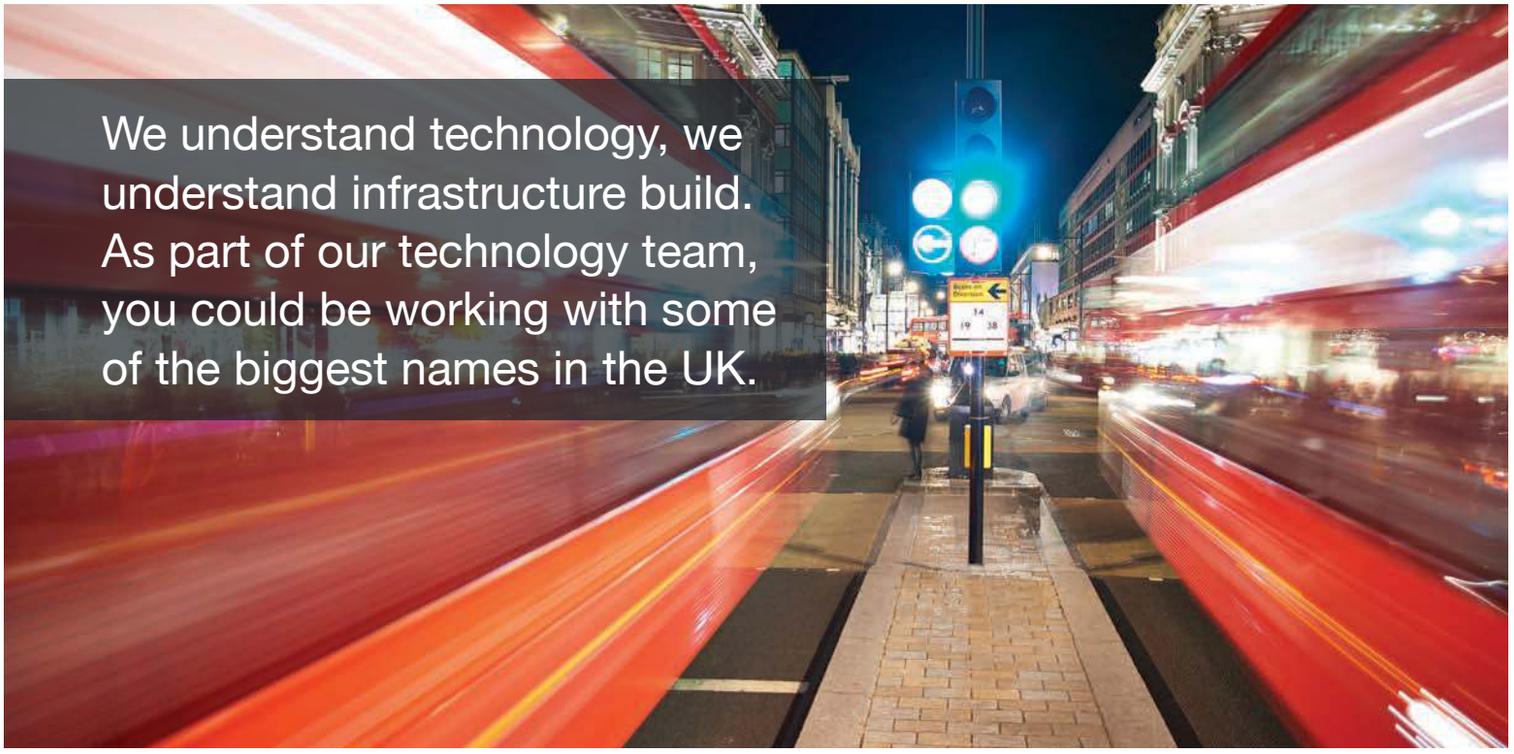
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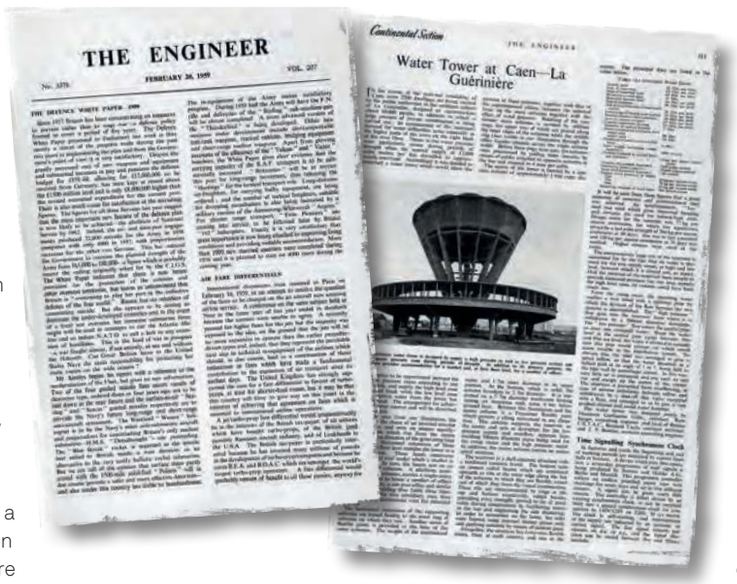
Form and function

How *The Engineer* reported on Caen's brutalist building

Three quarters of Caen was destroyed during the latter stages of the Second World War, and a feature of its reconstruction is arguably as brutal as the bombardment that flattened the Normandy city.

Resembling a giant shuttlecock at rest in a concrete ring, the water tower at Caen-La Guérinière counts renowned brutalist architect Guillaume Gillet as one of its designers, and is one of a long list of buildings that were built for the same utility and aesthetics as well as functionality.

In fact, the water tower was built to accommodate subsidiary functions such as a sub-post office, shops, and several offices, in addition to providing a high and low-pressure system that would operate during periods of drought.


THE ENGINEER

FEBRUARY 28, 1958

Continental Section

Water Tower at Caen—La Guérinière

Our correspondent reported that 2,200 dwellings were being built by local authorities in the southern suburb of La Guérinière to accommodate approximately 10,000 people. Construction by private companies was also taking place, and the increase in demand for water created difficulties in supplying higher parts of the town on the right bank of the Orne river.

The Engineer noted that drops in water pressure were severe during periods of drought, when the normal supply of 12,000 cubic metres per day decreased to approximately a third of that.

"Accordingly, it was decided to construct a water tower which would allow the available supplies to be apportioned between the high and low-pressure zones according to any desired schedule," our correspondent wrote, "and supply the high-level zone at an increased head, while the low-level zone would also receive water from the tower but with a lesser head."

The total weight of the building – including water – amounted to approximately 5,000 tonnes, and ground pressure at the central footing was estimated at 10kg/cm2.

The comparatively large size of the reservoir was accounted for by the fact that its water was destined for the two supply zones. From the rising main, incoming water reached a weir fitted with a splitting plate to divide the flow between the two systems.

The high-pressure flow, according to *The Engineer*, went into the reservoir, from where it was withdrawn by a 500mm diameter downpipe. The low-pressure flow entered the central pipe, along with any overspill water. Since the water level in the central pipe varied between "30m and 49m sea level", the water – if allowed to cascade into this pipe – would entrain air, which could disrupt the distribution system.

"To obviate this, the inlet was arranged to give a spiral inflow, so that the water descends in a helical path at an angle of one in five, being held to the pipe wall by centrifugal action," our correspondent said. "In this way, very little air is entrapped and any such air can rise and escape up the centre of the vortex. The reservoir is prevented from overflowing, in case of serious unbalance between inflow and withdrawal, by a shut-off disc valve equipped with a float and arranged so as to give a gradual closure and avoid water hammer."

As well as function, this publication paid attention to the tower's construction, describing the reservoir more formally as "an inverted circular truncated cone", which was designed to rest on 16 equally spaced columns rising from the centre foundation in the direction of the generating lines of the cone.

Horizontal extensions of these columns at first-floor level stabilised the tower vertically, supporting the conical roof under which the market was to be installed.

"In turn, the beams rest on an elliptical ring of columns," *The Engineer* wrote. "A platform, cantilevered from the columns, carries a single-storey structure which is intended to house a number of offices of the municipality, a sub-post office and similar facilities.

"The building thus fulfils three functions, of which the two subsidiary ones have been ingeniously harmonised with the principal objective."

Readers' concerns about stability were allayed with remarks on the building's construction. For example, the horizontal extensions of the supporting columns were observed as being joined flexibly to the outer ring of columns on which they rested.

"Another series of flexible joints is provided at the base of the outer columns," noted our correspondent. "The weight of the cantilevered portion of these columns, together with that of the superimposed offices, balances the outward force on the main columns together with the effect of wind pressure.

"Buckling of the very slender main columns is resisted by stiffener rings, the upper two of which are placed along the inner edges of the columns while the middle ring extends across the whole column width." **JF**

Word of the issue

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

When it comes to the engine, particularly the internal combustion engine, the clutch must be one of the most oft-cited parts. Yet the technology, first used on motor vehicles in 1899, had already proven useful for mill works a century earlier. It took the sense of 'clutch' as in meaning to 'seize, grasp' as this is ostensibly what it does. Today 'clutch' in the 'grasp' sense is used almost exclusively as a verb. Yet it had been a noun from the early 16th century, invariably used in speaking of cruelty.

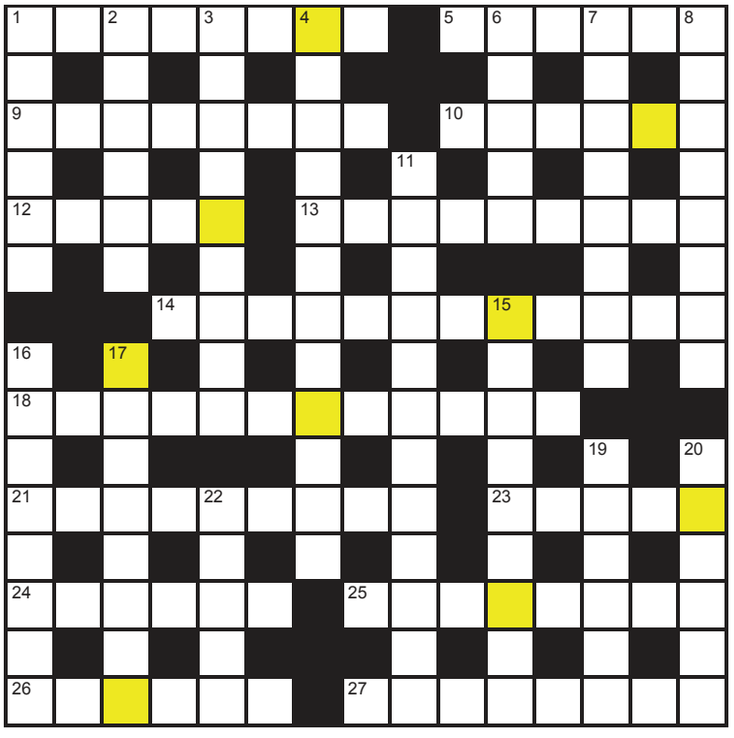
We can trace 'clutch' back to Old English clyccan, used to mean 'bring together', 'bend fingers', 'clench'. This is related to words in other Germanic languages with similar concepts; such as Swedish klyka 'clamp, fork', and Middle English cloke 'a claw' – the latter leading to the English sense of 'hold tightly or closely'.

Oddly, a 'clutch of eggs' has a different origin. It is a southern England version of the northern 'cleck', itself from Middle English clekken 'to hatch, give birth'.

Bigpicture



Efforts toward on-demand autonomous air transportation have taken off in Manassas, Virginia where Boeing has completed the first test flight of its autonomous passenger air vehicle (PAV). The electric vertical take-off and landing (eVTOL) aircraft completed a controlled take-off, hover and landing during the flight.



Prize crossword

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

Across

1 Distance travelled per unit time (8)
5 Framework of metal bars (6)
9 Pretentious talk (8)
10 Production of a certain amount (6)
12 Cause to become loose (5)
13 Organic process of releasing some substance (9)
14 Underground water source (8,4)
18 Government workers (5,7)
21 Concise reference book on a location (4,5)
23 Extract metals by heating (5)
24 Sharp pointed implement (6)
25 Uprising by Palestinian Arabs (8)
26 Make certain of (6)
27 Language of modern Iraq (8)

Down

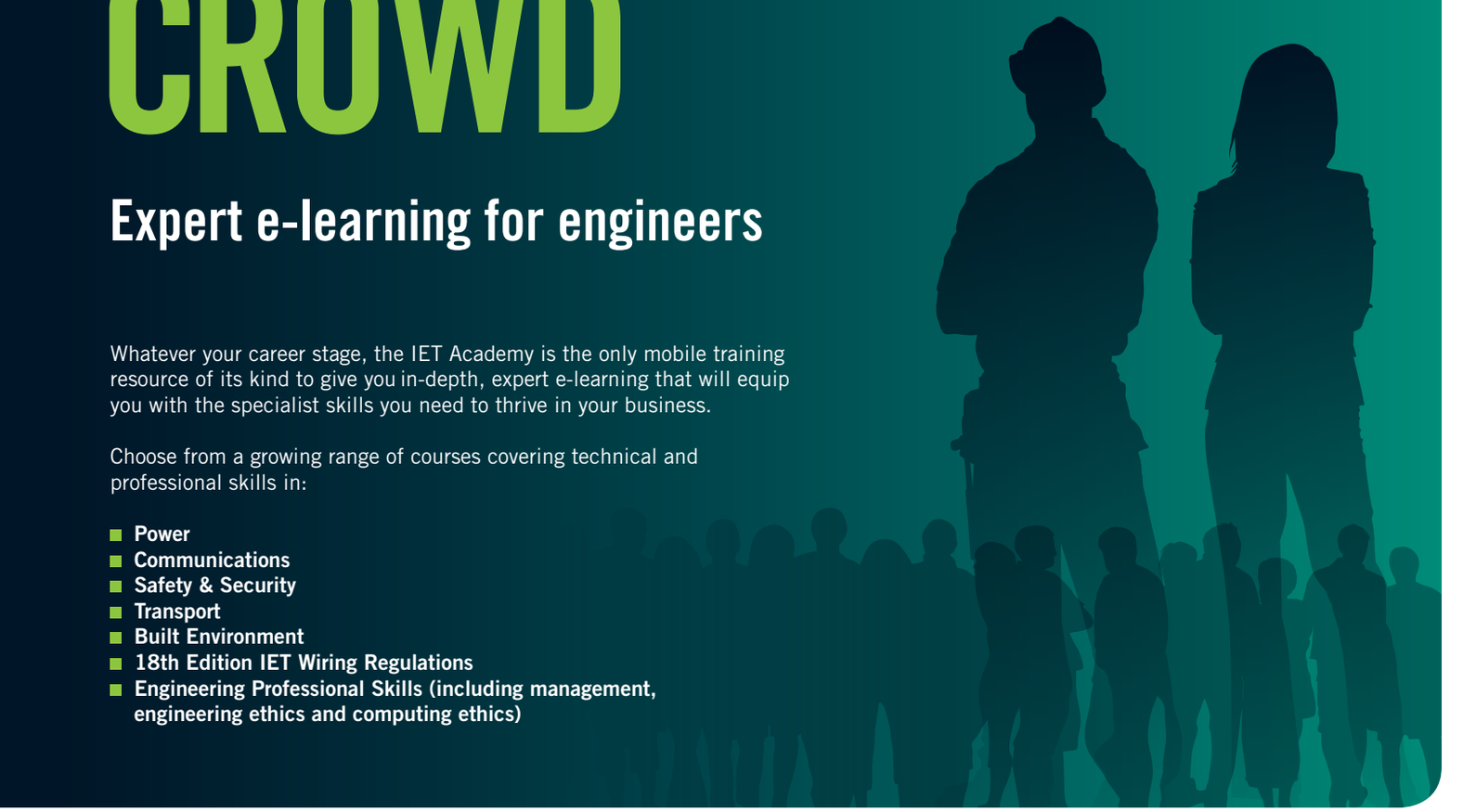
1 Region that is devoid of matter (6)
2 Rough shelter against a wall (4-2)
3 Large and important church (9)
4 Act of changing something from one form to another (12)
6 Employ again after processing (5)
7 Twisted toward one direction (8)
8 Twist together into a confusing mass (8)
11 Abilities that have been acquired by training (12)
15 Anything indispensable (9)
16 Collect discarded material (8)
17 Positive feeling of wanting to push ahead (8)
19 Native of the Himalayas (6)
20 Test the limits of (6)
22 Thin polyester film (5)

January's highlighted solution: **Corrosion**. Winner: **Angelina Acaster**

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