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## Safer connection

Reducing security risks of the Internet of Things



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## our opinion

# Internet of risks



Not so long ago, one of the most regularly touted examples of the game-changing benefits of connectivity was the internet fridge.

It's probably fair to say that while it remains the stalwart of many a "smart home of the future" vision, the chiller that knows when you're about to run out of cheese hasn't exactly set the world on fire.

It's probably also fair to say, however, that connectivity has become one of the most transformative technology trends of our time.

The so-called Internet of Things – where almost any physical system you care to mention can wirelessly connect to a network and exchange data – is underpinning game-changing advances in practically any sector or discipline you can think of.

From the rise of smarter – ultimately autonomous – vehicles that are able to communicate with other vehicles and infrastructure to make more sense of the environments in which they operate; to the so-called Industry 4.0 technologies that are gaining momentum across the manufacturing sector: advances in connectivity are helping to make our homes more energy-efficient, our factories more productive, and our interactions with technology more seamless.

While it's an exciting time, there's a clear flip-side to the connected world. Where once your machine tool or vehicle was sealed off from the wider world, it's now part of a network, and therefore potentially vulnerable to risks that manufacturers, users and regulators are only beginning to understand. In this issue's cover story, we take a look at these risks and examine how one group of experts in the UK is looking at the steps that we can take to ensure that the connected revolution isn't derailed by the cybercriminal.

Finally, a couple of quick plugs. Firstly, for our annual Collaborate to Innovate awards competition which is now open for entries. As always, we're on the lookout for the UK's most innovative and exciting engineering collaborations, so if you're involved in a project that you think might fit the bill, let our judges know all about it at: [conferences.theengineer.co.uk](http://conferences.theengineer.co.uk).

Also, please do join us at our free annual conference, which runs from 5-7 June at the NEC, Birmingham. With presentations from the CTOs of Rolls-Royce and McLaren, along with insight into projects ranging from the world's most advanced prosthetic limb to the UK-designed BAC Mono supercar, it promises to be a fantastic celebration of the best of UK engineering. You can find out more about our amazing line-up of speakers on page 40.

“While it’s an exciting time, there’s a clear flip-side to the connected world”

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ENERGY

# Small molten salt reactors project given funding

**Danes hoping to make six-metre units that can power 200,000 homes** HELEN KNIGHT REPORTS

**A** Danish company is aiming to build smaller, safe nuclear reactors based on thorium and molten salt, after securing funding in its first pre-seed investment round.

Copenhagen-based Seaborg Technologies, which is developing thorium-based Molten Salt Reactors (MSRs), has received funding from an investment coalition led by Danish innovation incubator PreSeed Ventures.

The company hopes the funding will accelerate development of its CUBE (Compact Used fuel BurnEr) reactor concept.

The compact, modular CUBE reactor, which can fit inside a six-metre container, could provide enough power for 200,000 homes, the company claims.

Unlike conventional nuclear reactors, which are based on solid pellets or rods of low-enriched uranium, MSRs use a liquid fuel – molten salt.

In a conventional reactor the solid uranium pellets must be submerged in water to keep them cool. If this cooling water is lost, the reactor melts down.

In contrast, in an MSR the molten salt acts as both the fuel and the coolant, meaning that if the reactor loses its coolant it also loses its fuel, and the reactor stops automatically, according to Troels Schönfeldt, CEO of Seaborg Technologies.

“Molten salt reactors cannot melt down, or suddenly explode, and their

safety is based on physics instead of engineering,” he said. “That means you don’t need a lot of engineering solutions to ensure safety, which in turn saves you a lot of money.”

As a further passive safety measure, if any residual heat produced once the reactor has shut down causes the core to reach a threshold temperature, it causes a plug of frozen salt to melt at the bottom of the core. This drains the warm salt to a dump tank where it cools down by itself.

By using thorium as a catalyst, the reactor is able to burn nuclear waste from conventional reactors, meaning it could help to reduce the problem of radioactive waste storage.

“We take waste from existing nuclear power plants and we burn

the transuranic elements of it, the longest-lasting part of the waste,” said Schönfeldt.

What’s more, while conventional nuclear reactors must operate at very high pressures, MSR reactors operate at just one bar atmospheric pressure, making them simpler to construct.

The new investment will allow Seaborg’s team to increase its staff to 16 employees, making it the largest reactor development start-up in Europe.

“We don’t want [the technology] to be usable for nuclear weapons, so we are putting a lot of science and effort into making that impossible,” said Schönfeldt.

The company will begin carrying out initial, small-scale experiments within the next few months.

Seaborg has previously received funding from the EU and the Danish Innovation Fund, and will be looking to raise an additional €2m (£1.76m) from investors as soon as possible.

As well as accelerating its own technology development, the company hopes the investment will also help speed up the road to market for all MSR developers. In particular, existing regulatory systems

act as a barrier for thorium-based MSRs, said Schönfeldt.

Simulation of an MSR must include modelling the interdependence between neutron transport, fluid dynamics, heat transfer, and the associated chemical reprocessing, he said. Existing tools are either not compatible with the current regulatory requirements, or not able to include these effects, he added.

“This represents an important barrier to the deployment of MSRs.”

The investment will allow the company to develop advanced simulation software that can be used by all developers and regulators within the licensing process, said Schönfeldt. ■



## Read more online

### Aerospace

ESA and NASA to investigate bringing Martian soil back to earth

### Automotive

Industry Brexit fears grow as automotive sector slowdown continues

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UK-China developed radiation source could offer safer alternative to x-rays

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LDC backs £22.5m management buyout of Precision Micro

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# Helping UK advanced manufacturing get closer to perfection

National Physical Laboratory (NPL) is on a mission to help UK advanced and precision manufacturers become the best in the world. Applying the latest advances in measurement and calibration, it works with manufacturers of all sizes to get their products closer to perfection and gain a competitive edge in the global economy.

NPL's many success stories include helping British specialist engineering firm, Aeromet, become the first UK company to achieve Nadcap aerospace accreditation; Cambridge-based precision engineering company, Anglia CNC Engineering (ACE), find an annual cost saving of £50,000; and putting another manufacturer on track to double its turnover by 2022.

## Did you know?

NPL is leading a new national activity to engage UK industry in emerging quantum technologies to accelerate the industrialisation and commercialisation of new products. A key outcome target for the national quantum programme has always been economic growth for the UK based on the increased success of UK industries. #TalkQuantum

Paving the way to smart factories, NPL is working to establish a National Sensor Systems Innovation Centre to accelerate the commercialisation of sensor technology.

NPL alumni include renowned scientists: Alan Turing, Louis Essen and Donald Davies.

How did NPL work with these businesses to achieve all this? Through measurement science, it finds ways for organisations to streamline their manufacturing processes, reducing rework and material usage. This results in manufacturers unlocking savings, improving their products and making them more desirable to new markets – creating fresh business opportunities.

In the case of ACE, which supplies high quality milled and turned components and assemblies, the company wanted to eliminate inefficiencies in its production processes caused by machined components not meeting the required standards by customers.

Measurement experts from NPL worked with ACE to conduct a full product verification health check. They worked with the machine

operatives and engineers to help them better understand the measurement and verification processes taken as part of the quality control checks, and identified two opportunities to optimise and streamline ACE's production process. Now components are manufactured right first time, every time.

Speaking about the impact that working with NPL has had on his business, Graham Fenn, Managing Director at ACE, said:

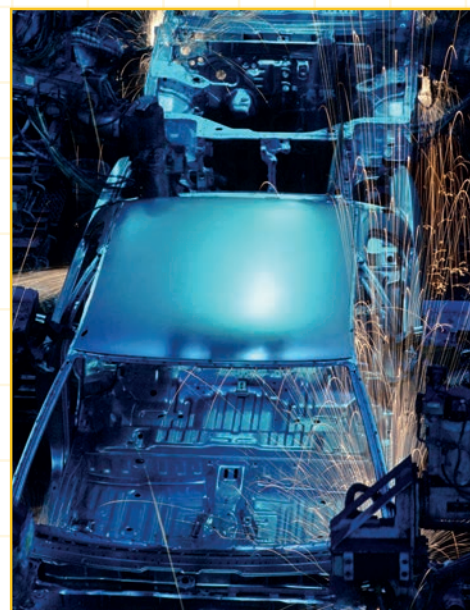
*"The team from NPL quickly understood my company's challenges. They were flexible to my business needs, which really impressed me, and their contribution made a valuable, immediate and tangible difference to the business."*

In addition to its consultancy services, NPL offers training courses to upskill workforces to become

## Because almost perfect just isn't good enough

Advanced manufacturers have to ensure that the shark and child stay separate. NPL helps to improve products and aid innovation through better measurement, creating greater confidence in safety. This means the glass can be stronger yet thinner, so she feels closer than ever.

Visit [advance.npl.co.uk](https://advance.npl.co.uk) and find out how you can get closer to perfection



If you're a UK **precision or advanced manufacturer**, discover the ways in which NPL can help support your business and get closer to perfection by visiting: [advance.npl.co.uk](https://advance.npl.co.uk)

## ENVIRONMENT

# Building a use for captured carbon

Converting CO<sub>2</sub> for construction HELEN KNIGHT REPORTS



**G**reenhouse gas emissions could be converted into valuable products such as building materials, following the creation of a spin-out company to commercialise carbon capture and conversion technology.

The new company, called CCM, aims to commercialise technology developed by researchers at Aberdeen University. The technology is capable of converting carbon dioxide emissions into carbonates for use in products such as plastics, adhesives, cements, concretes and

other construction materials, according to Dr Mohammed Imbabi from the university's School of Engineering, the project leader.

"If you're trying to deal with global CO<sub>2</sub> emissions approaching 40 gigatonnes per annum, you need a sink in which to put these emissions that is big enough to accommodate them, and the construction industry is probably one of the few that can do that," said Imbabi.

The technology dissolves the CO<sub>2</sub> in dilute alkali, converting it into carbonate ions. The carbonate solution is then reacted with either calcium or magnesium brines to produce precipitated calcium

carbonate (PCC) or precipitated magnesium carbonate (PMC).

The converted feedstocks, which are carbon negative, can be used in a range of industries. PCCs are already used in paper making, plastics, paints, and adhesives, for example, while the researchers have recently developed a cementised PMC for use in buildings. The material can be thermally cured at low temperatures.

Cementised PMCs have low density but high compressive strength. They are water-resistant, non-toxic, fireproof and have thermal and acoustic insulation properties.

The technology can use waste calcium and magnesium brines from sources such as desalination plants, and oil and gas production.

Unlike many other proposed techniques, the technology can capture CO<sub>2</sub> from any emission source, said Imbabi. Although the team is initially focusing on developing the technology for large industrial settings such as power stations, cement factories and breweries, it could ultimately be used to capture emissions from people's homes and cars, he said.

"Our focus is on large CO<sub>2</sub> emitters first of all, because we want to push down as quickly as we can on emissions, but we also have a development stream which is looking at miniaturising the technology; so, for example, you could have a carbon capture machine fitted to your home," said Imbabi. ■

## AWARDS

## Competition now open

Awards for innovative engineering JON EXCELL REPORTS

The Engineer's 2018 awards campaign – Collaborate to Innovate – is now open for entries.

Collaborate to Innovate (C2I) was launched to uncover and celebrate great examples of engineering collaboration – a dynamic considered critical to solving many problems faced by society. The competition is open to any project, whether from industry or academia, that is truly

innovative, represents a collaboration between two or more separate organisations and has had, or is likely to have, a demonstrable impact in its area of application.

The scope of the awards has been cast as wide as possible. Entries are invited from projects addressing fundamental engineering challenges across 10 categories, including automotive, aerospace, manufacturing technology, health, energy, defence, and data and connectivity. There are three categories specifically focused on education and engagement: Academic Innovator (for a university department that demonstrates excellence in innovation and collaboration across multiple

projects); Young Innovator, which will spotlight collaboration between businesses and schools; and Young Innovator Engagement – which will celebrate broader initiatives aimed at educating and inspiring young people about the role of engineers.

Previous winners include: The QE aircraft carrier, the Swansea Bay Tidal Lagoon project, and SMASHFest UK – aimed at inspiring young people to consider a career in engineering.

The closing date for entries is 28 May. Winners will be announced at an informal party in the City of London on 18 September, and winners will present their entries at a one-day conference in December at the Lloyds Bank Manufacturing Technology Training Centre, Coventry. ■

## Newsinbrief

### Rocketing investment

Reaction Engines, the UK company developing a hybrid engine blending jet and rocket technology, has raised £26.5m by securing backing from Rolls-Royce and Boeing HorizonX Ventures. Abingdon headquartered Reaction Engines will use the funding to support the development of its Synergetic Air-Breathing Rocket Engine (SABRE), which is capable of Mach 5 in air-breathing mode and Mach 25 in rocket mode for space flight.

### Truth about manufacturing

Manufacturing accounts for nearly a quarter of the UK economy and more than 7.4 million jobs depend on it, according to research by the Manufacturing Technologies Association. The figures show the sector is responsible for 23 per cent of UK GDP, well over double the figure that is routinely quoted.

### Biofuel rules in force

New biofuel targets came into force in April aimed at doubling the use of renewable fuels in the UK transport sector within 15 years. Owners of transport fuel, who supply at least 450,000 litres a year or more, have to make sure the mix is at least 12.4 per cent biofuel by 2032.

### Boost for Luton workers

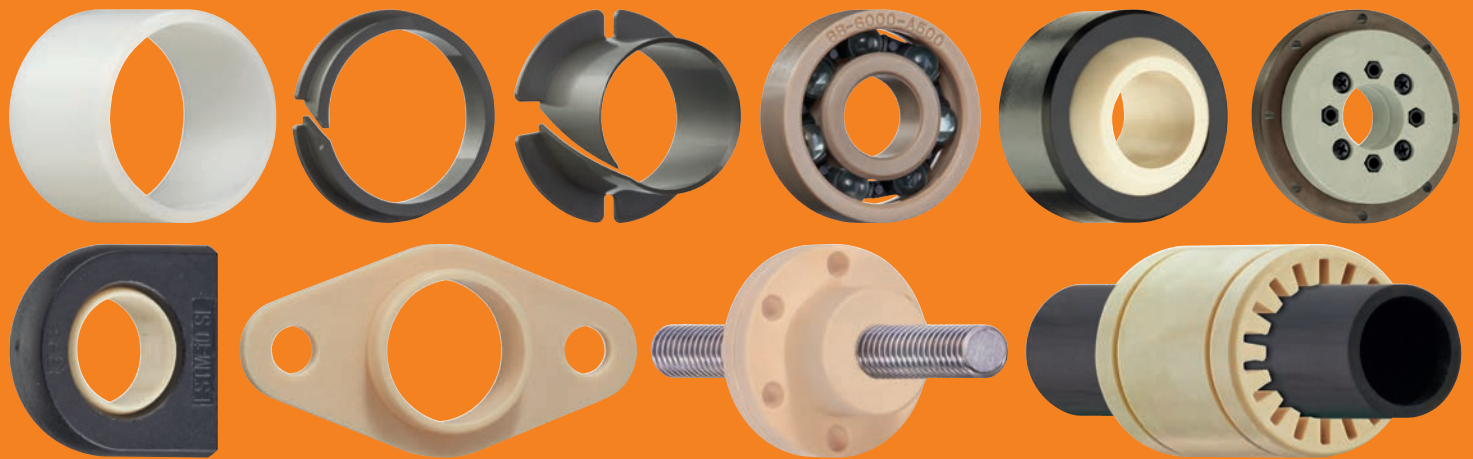
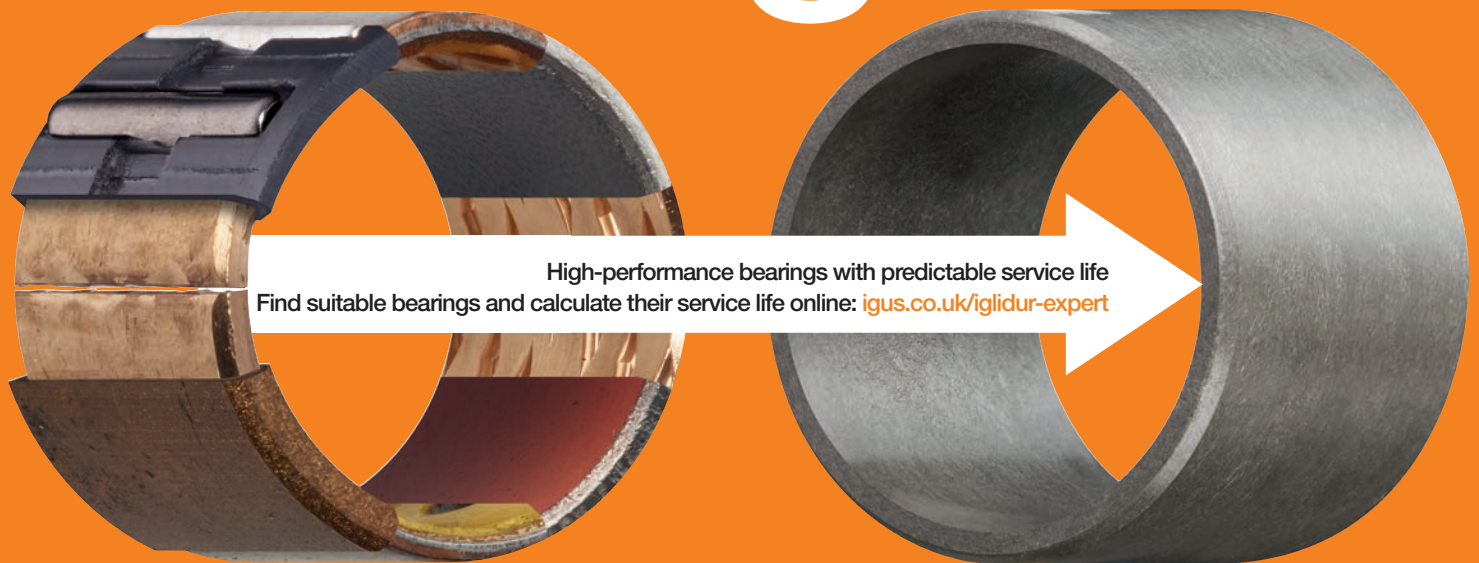
PSA Group is to produce next generation Vivaro light commercial vehicles at its Vauxhall Luton van plant, a move that safeguards the existing workforce and will create new jobs. The aim is to increase production capacity in Luton to 100,000 vehicles per year from 2019.

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## MATERIALS

# Team works on new hydrogen storage solution

**Porous materials could safely take in and release gas inside vehicles**

HELEN KNIGHT REPORTS

**A** 'nanocage' capable of trapping and releasing gases on demand could be used to safely store hydrogen on-board cars and other vehicles.

Hydrogen has long been seen as a low-carbon transportation fuel but as a low-density gas, it is difficult to store safely and compactly within vehicles.

Now researchers at Bristol University, funded by the EPSRC, are developing composite materials capable of adsorbing hydrogen gas and storing it at high densities, within nanometre-sized pores.

What's more, the materials are being used to allow trapping and release of the hydrogen molecules on demand, according to Dr Valeska Ting, a reader in smart nanomaterials at Bristol University.

"Hydrogen is a gas at room temperatures and pressures, so if you want to carry it around it takes up a lot of volume," said Ting.

This has prompted research into porous materials such as nanostructured carbons, metal-organic frameworks or zeolites,

which have a high surface area. These materials act like a sponge, sucking in the hydrogen and storing it in nanometre-sized pores at far higher densities than is possible in gas form. "Because it is in a solid material, you can carry it around, instead of carrying a giant balloon of hydrogen gas or a high-pressure tank," said Ting.

Unlike existing porous materials though, which typically need to store the gas at very high pressures or very low temperatures in order to carry the amount of hydrogen needed for

transportation, these composite materials should allow for use at room temperature.

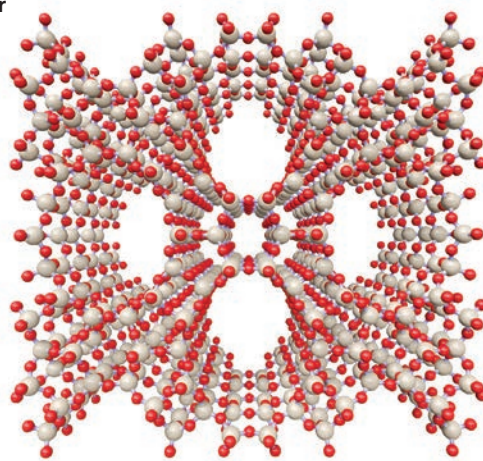
That is because the team is incorporating active responsive polymers into the composite, which may change their shape in response to light, heat or a magnetic field. In this way the material can be triggered to undergo a change in structure, either blocking or unblocking the pore, to obstruct or allow the movement of gases to or from the pores.

The technique could allow such porous materials to store ten times more hydrogen at room temperature than existing materials, making them far more suitable for use in the field of transportation.

The materials could also potentially be used in carbon dioxide capture, drug delivery and smart packaging.

The project will additionally involve development of new measurement techniques for hydrogen storage materials. ■

**A molecular model of the zeolite, known as UTD-1**



## MEDICAL

## Preserving donor livers

**Metra device keeps organ in better shape**

HELEN KNIGHT REPORTS



Oxford-based OrganOx has published the findings of a randomised, multinational clinical trial, in which transplanted livers were shown to function better when preserved with its metra device.

When a liver is donated for transplant, it is stored in an ice box. However, the organ deteriorates every second it is preserved on ice, limiting the length of time an organ can be stored to between six to nine hours, according to Andy Self, commercial director at OrganOx.

"When the liver is in an ice box, the surgeon has very little information to go on. He can't assess the function of the liver, all he can do is look at the donor history and make a judgement call about whether to transplant it," said Self.

This decision is particularly important in liver transplants, where in the event of a complication surgeons have 24 hours to find an alternative donor organ. "For that reason, liver transplant surgeons are rightly quite conservative about the organs they transplant," said Self. "That results in quite a large number of the organs that are retrieved for transplant being discarded."

The metra device maintains the liver at normal body temperature and provides it with oxygenated blood, nutrients and medication. This reduces the risk of tissue injury when blood supply is returned to the organ. The device also continuously monitors the liver while it is being preserved, measuring blood flow, pressure, blood gasses and bile production. ■

## TRANSPORT

## Electrified rail to charge up vehicles on Swedish road

**Trial may lead to nationwide roll-out**


A 2km stretch of road in Sweden has been embedded with an electrified rail as part of the latest trial by a consortium hoping to roll the technology out across the country.

The eRoadArlanda project sees DC energy transferred from a rail in the road to vehicles passing above using a movable arm. Sections of rail,

connected to the grid, power up individually as vehicles travel over them. The arm detects the location of the rail and remains in contact as long as the vehicle is above. When overtaking, the arm automatically retracts. The system is also able to calculate energy consumption so that customers can be billed on a pay-as-you-go basis. It is expected to operate only on primary roads, with vehicles relying on their batteries once they exit on to arterial routes.

Up to one kilometre of electrified rail can be installed per hour and interruptions to existing infrastructure can be minimised. AW






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## ENERGY

# Warwick team pressing for more solar energy

**Squeezing crystals in photovoltaic cells generates increased energy** HELEN KNIGHT REPORTS

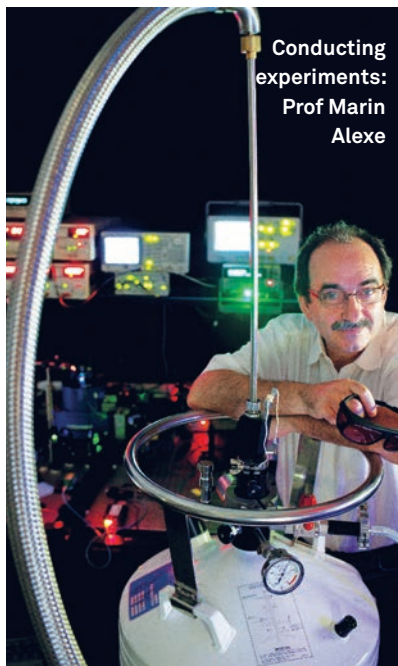
**R**esearchers at Warwick University have demonstrated that more energy could be generated by photovoltaic solar cells by deforming the crystals within the semiconductors, simply by pressing on them.

Silicon solar cells typically consist of two layers: p- and n-type semiconductors, which are placed together to form a p-n junction.

When light is absorbed by the cell, this p-n junction generates an internal field within the device, which splits the charge carriers in opposite directions, generating a current and voltage across the junction.

While such junctions play a crucial role in extracting power from solar cells, they have a fundamental efficiency limit, known as the Shockley-Queisser limit. This means that only 33.7 per cent of the power contained in sunlight falling on an ideal solar cell in ideal conditions can

be converted into electricity. To find out if this limit could be overcome, the researchers turned to a less well-known effect known as the bulk



Conducting experiments:  
Prof Marin Alexe

photovoltaic effect. This effect is only found in certain semiconducting materials which have a lack of symmetry around their central point, known as a non-centrosymmetric structure, according to Prof Marin Alexe, who led the research.

"This is a type of symmetry which allows for the spontaneous splitting of those light-induced carriers without any requirement for a p-n junction," said Alexe.

However, these materials have very low power generation efficiencies of up to six per cent, compared to up to 26 per cent for p-n junction photovoltaic solar cells, he said. So the researchers wondered if they could recreate this bulk photovoltaic effect in conventional semiconductors used in solar cells, by forcing them into a non-centrosymmetric structure.

"Our idea was to introduce an inhomogeneous strain into the material, which breaks the symmetry locally, meaning the bulk photovoltaic effect kicks in," said Alexe.

To do this, they pushed the semiconductors into shape using conductive tips from atomic force microscopy devices. They found that when they squeezed individual crystals of strontium titanate, titanium dioxide, and silicon in this way, all three were able to show the bulk photovoltaic effect.

This so-called flexo-photovoltaic effect may one day give commercial solar cells an additional efficiency boost, he said. ■

## ARTIFICIAL INTELLIGENCE

## Making car parks smarter

**New system will tell you where spaces are**

HELEN KNIGHT REPORTS



There is nothing worse than driving round and round a car park, unable to find a free space when the sign at the entrance tells you there are 33.

Now Cambridge Consultants has developed a deep learning and machine vision system that can not only tell you how many spaces are left, but where to find them.

Dubbed Goldeneye, the AI system uses information from 12 security cameras to continuously monitor the availability of parking bays.

Goldeneye was trained on footage of the car park in different lighting and weather conditions, day and night, teaching itself to recognise vehicles and empty and occupied bays.

Existing car park monitoring systems use sensors for each space, which can be expensive to install and maintain, according to Thomas Carmody, head of transport and infrastructure at Cambridge Consultants. "Our approach was to take the existing camera feed coming from security cameras, and put it into a deep learning system to monitor individual bays, which is a much more cost-effective way to manage parking," he said.

The system can be connected to the cloud, allowing users to choose a parking location, and reserve and pay online. The technology could also be used to monitor vehicle occupancy rates, footfall from vehicles and dwell time at retail locations.

"The use of deep learning and machine vision could be extended to other uses, so if you have this sort of system on a retail park, you could reprogramme it to monitor pedestrian flow to and from the centre, for example," said Carmody. ■

## TRANSPORT

## Zero-emission truck to be on the road this year

**Hydrogen-fuelled combustion engine on-board Volvo lorry to be unveiled soon**

Engineers at Liverpool-based hydrogen fuel specialist ULEMCo have announced plans to demonstrate a zero-emission truck powered by a hydrogen-fuelled combustion engine.

The technology will be demonstrated on a modified version of Volvo's FH16 truck and is expected to take to the roads this year.

Claimed to represent the world's first

application of a 'zero emission' combustion engine, the project – jointly funded by ULEMCo and Innovate UK – is designed to provide a demonstration of how hydrogen fuel can be deployed to decarbonise heavy goods vehicles.

Unlike other 'hydrogen fuelled' vehicles, the so-called Mega Low Emissions (MLE) truck uses hydrogen to power the vehicle using a combustion engine rather than via fuel cells and an electric motor. ULEMCo claims that, in common with fuel cell versions, there will be none of the usual emissions from hydrocarbons that impact on air quality.

It believes that using conventional engines and existing truck designs, the time frame to the target of zero carbon emissions can be shortened. JE



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## MEDICAL

# Graphene spikes could kill bacteria on implants

Vertical flakes may prevent infection and reduce the risk of rejection

HELEN KNIGHT REPORTS

**M**edical implants could soon be protected from bacterial infection by tiny spikes of graphene. The vertical graphene flakes, being developed by a team of researchers at Chalmers University of Technology in Sweden, have been shown to kill bacteria on impact, in research published in the journal *Advanced Materials Interfaces*.

When added to the surface of implants, they could stop bacterial infections during surgery, which in some severe cases can prevent the devices from attaching to the human bone effectively.

Bacteria travel around the body in blood and other fluids, looking for a surface to cling to. Once they find a suitable surface, such as an implant, they start to propagate, forming a biofilm.

But adding a layer of vertical graphene flakes to the surface prevents the bacteria from forming

this biofilm, according to Jie Sun, associate professor at the Department of Microtechnology and Nanoscience, Chalmers University of Technology.

This could eliminate the need for antibiotics, and reduce the risk of implant rejection.

"The vertical graphene acts like a knife, it will cut into the bacteria and kill it," said Jie Sun.

The membrane surrounding bacteria has a very strong affinity for graphene, he said. "So the bacteria will attach themselves to the

graphene, and then get cut." For stability, the spikes are attached to the surface with roots.

Human cells are much larger than bacteria – 25µm in diameter compared to 1µm – meaning they are not damaged by the graphene spikes.

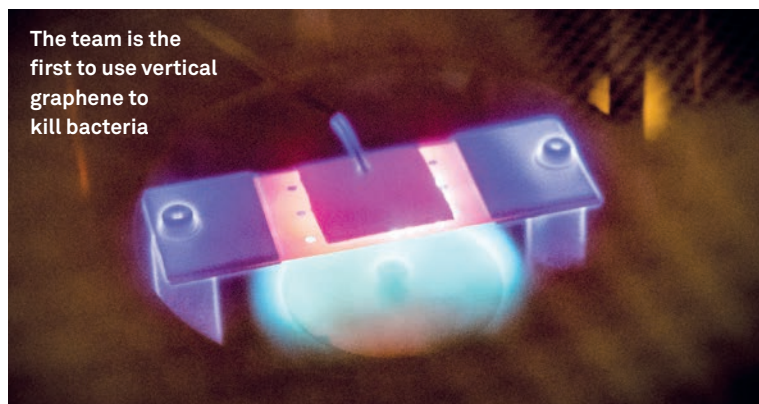
The researchers are now planning further work to make the graphene spikes suitable for use in medical applications. Firstly, the substrate they have been using to grow the graphene is quite small, around 2.5-5cm across, so they plan to increase its size.

They also hope to reduce the cost of the process, said Jie Sun.

"We cannot grow the graphene directly on medical devices. We have to grow it on to our substrate and then transfer it to the devices, and that process is expensive, so we need to reduce that cost," he said.

Finally, further experiments will be needed to ensure graphene is not harmful to human cells, in the event that a flake were to come loose, he said. ■

The team is the first to use vertical graphene to kill bacteria

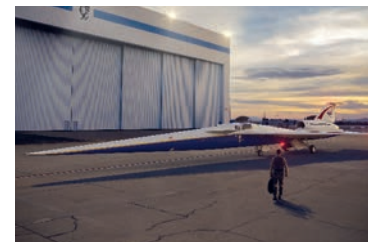


## AEROSPACE

## Low-boom plane project

Supersonic aircraft set to go on trial in US

STUART NATHAN REPORTS



NASA has awarded a contract to Lockheed Martin to build a full-scale experimental aircraft (X-plane) to be known as a low-boom flight demonstrator. The contract is the culmination of a decade of collaboration, and takes forward a contract awarded in 2016 for preliminary design of the aircraft.

The agreement is part of a project called QueSST (quiet supersonic technology), which aims to dull the volume of a sonic boom to about the level of a car door closing. At 75 perceived level decibels, the target noise is more of a dull thump than a boom. The aim is to establish an acceptable commercial supersonic noise standard that would allow the current regulations which ban supersonic travel over land to be overturned. It was these regulations which severely hampered Concorde's use in the 1970s and 1980s.

The low-boom flight demonstrator research programme has two goals: to design and build the aircraft, which, although large-scale, would still be smaller than any aircraft that went into service; and to fly it over selected US communities to gather data on human responses to the sonic thump. The project is based across all four of NASA's aeronautical research field centres.

The aircraft will be designed to cruise at an altitude of 55,000ft (16.7km) at 940mph (1,512km/h). The contract, which runs until the end of 2021, is valued at \$247.5m (£182m). The schedule will see Lockheed Martin hand the aircraft over to NASA at the end of the period, and NASA plans to begin the flight and data collecting phase in mid-2022. ■

## AEROSPACE

## Marsbees flying concept creates a buzz

Swarm of electronic 'insects' could help with exploration of the red planet

A swarm of flapping winged flyers laden with sensors and wireless communication devices could one day help with Martian exploration and science missions on the red planet.

The so-called Marsbees are among 25 ideas chosen to receive a 2018 NASA Innovative Advanced Concepts (NIAC) award, which provides recipients with funding to develop their early-stage technology for space exploration.

"Flying on Mars is challenging because of the ultra-low density in the Martian atmosphere," said Dr Chang-kwon Kang, an assistant professor of mechanical and aerospace engineering at the University of Alabama in Huntsville (UAH). "Our preliminary work shows that bio-inspired aerodynamic mechanisms can help in generating sufficient lift to fly on Mars."

Kang's Marsbees are robotic bumble-bee-sized flapping-wing platforms whose large cicada-like wings would have the ability to generate sufficient lift to hover in the Martian atmosphere. Integrated with sensors and wireless communication devices, the flyers would work in a swarm, with a mobile base serving as their recharging station and main communications centre. **JF**



**E**verybody knows that tightening is very important. Whether as security measures, or as quality guarantees, control and traceability become strategic key concern of all industries. Drawing on his 47 years of software, hardware and mechanics experience, One Too has succeeded in developing a product specifically to be used in the all-new 4.0 Industry.

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One Too has recently developed a mechanical click extension, which provides a distinctive "Click" when reaching the pre-set torque value.



Extensions up to 1,000 Nm



Mechanical click extensions up to 340 Nm



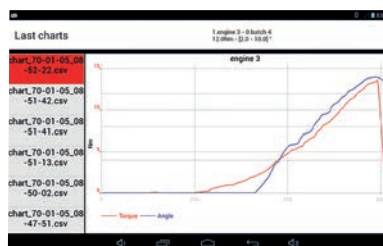
Tightening OK

Date	Heure	Op	Pro	Cho	Couple	Angle	St
03/08/14	11:04	A. 7 Nm	1 Pp	-	-	-	NOK
03/08/14	11:04	A. 7 Nm	0.7 mm	0	-	-	NOK
03/08/14	11:04	A. 7 Nm	0.7 mm	0/0	1.32	0.00	OK
03/08/14	11:04	A. 7 Nm	0.7 mm	0/0	0.27	0.00	NOK
03/08/14	11:04	A. 7 Nm	0.7 mm	0/0	0.16	0.00	OK
03/08/14	11:04	A. 7 Nm	0.7 mm	0/0	0.00	0.00	OK
03/08/14	11:04	A. 7 Nm	0.7 mm	0/0	0.70	0.00	NOK
03/08/14	11:05	A. 7 Nm	0.7 mm	0/0	0.47	0.00	NOK

Details of tightening results



Tightening NOK



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## ENVIRONMENT

# Ultra-sensitive infrared detectors

Reducing dark current means devices can be used at room temperature **HELEN KNIGHT REPORTS**

**A**utonomous vehicles, telecommunications systems and environmental monitoring networks could all benefit from a new generation of ultra-sensitive infrared detectors, developed in a European collaboration.

Unlike existing devices, the detectors, developed by researchers at University of Leeds, ETH Zurich and the Université Paris Diderot, quickly and accurately measure infrared radiation, even when operating at room temperature.

The devices, described in *Nature*, could be used for more accurate environmental monitoring, according to Prof Giles Davies, pro dean for research at University of Leeds' Faculty of Engineering.

"Many molecules will emit radiation just through their normal vibration in this frequency range, and so by being able to detect this radiation sensitively one could monitor for pollutants in the atmosphere, or the kinds of trace gases that might have implications

for better understanding climate change," he said.

Infrared radiation is emitted by any object at room temperature. When a light photon hits an infrared detector, it generates an electron, which will create a current in the presence of an electric field. In this way the photon's presence can be detected. However, the ambient temperature alone is enough to cause the detectors to generate an electric current, even without the presence of infrared light. This so-called dark current can be so large that it completely masks the photo-current.

To remove these thermally excited electrons, and therefore reduce this dark current, existing detectors must be cryogenically cooled. This makes them expensive and unsuitable for applications outside the laboratory, said Davies.

Those devices that do operate at room temperature, such as night vision goggles, tend to be slow and imprecise, he said.

To reduce this dark current effect, the researchers patterned the surface of their detector with a grid-like array of tiny metallic patch antennas.

These structures are able to collect the light that hits the surface of the detector and focus the photons onto the active semiconductor area of the device, said Davies. ■

**The devices could be used for environmental monitoring**

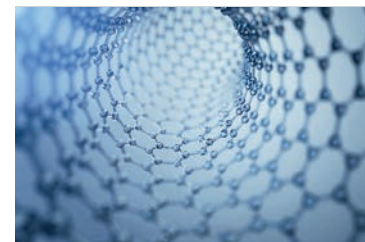


## MANUFACTURING

## Graphene breakthrough

New technique for making membranes

STUART NATHAN REPORTS



An MIT team has developed a process that could be the basis for the production of large sheets of graphene for ultrathin membranes.

Graphene is often made by heating up a copper foil and sending a stream of methane and other gases over it, which then grow into sheets of graphene. The new technique also uses copper foil, but it is unwound from a roll and sent into a small furnace through a pair of tubes.

In the first tube, the copper foil is heated to the ideal temperature for graphene deposition. In the second, a specified ratio of methane and hydrogen gas is pumped over the copper. "Graphene starts forming in little islands, and then those islands grow together to form a continuous sheet," said Prof John Hart, director of MIT's Laboratory for Manufacturing Productivity. "By the time it's out of the oven, the graphene should be fully covering the foil in one layer."

As the now-graphene coated foil emerges from the furnace, it is wound onto a second spool. Hart's team then cut the foil into samples and cast a mesh on top of the graphene, before etching away the copper. This technique was developed by Harvard University. The polymer mesh had protuberances, known as drumheads, which were larger than the graphene's pores, which provides additional stability and also keeps the pores open.

The team then tested the resulting supported membrane by passing solutions of salts and other molecules over them, confirming that they were effective at filtering out specified molecules while withstanding the fluid flow. ■

## AEROSPACE

## New metamaterial developed for cooling spacecraft

University of Southampton researchers involved in European project

A pan-European consortium has developed a new type of metamaterial surface coating to assist in the thermal control of spacecraft.

Known as metamaterial Optical Solar Reflectors (meta-OSRs), the coatings are designed to reject solar radiation while at the same time dissipating the heat that is generated on-board satellites and space vehicles.

Currently, OSRs are usually made of quartz tiles

that combine thermo-optical properties with an ability to withstand the environment in space. However, these tiles are heavy and fragile, adding significantly to launch weight. Furthermore, they cannot be applied to curved surfaces.

The team, which includes researchers from the University of Southampton, patterned metal oxide into a metamaterial with very strong infrared emissivity while retaining a low absorption of the solar spectrum.

Using this metamaterial design, the researchers developed a 'smart' radiator which allows tuning of the radiative cooling of the spacecraft using another type of metal oxide. The consortium's work is described in the journal *ACS Photonics*. **AW**





viewpoint | **peter thompson**

# A quantum leap in energy exploration

**Many industries would benefit from quantum technology, but the most telling gains could be in oil and gas, where it could help maintain supplies**

**T**he first quantum revolution was about mapping the workings of the world in granular detail, discovering hitherto-hidden rules that frame physical reality. Now, there is the great possibility it can have a similar effect for almost every industry, opening up new avenues and providing opportunities for developing previously unheard-of technologies.

Quantum technology has the potential to make our computers more powerful, our communications systems better synchronised, and provide more robust sensors for driverless cars.

One area widely held to have great quantum technology potential is global energy; in particular, helping to map out vast, hidden energy reserves by opening an ultra-high-definition window into the earth.

Portable quantum gravity sensors that measure the gravitational field at the surface of the Earth in order to reveal subterranean secrets could both revolutionise the maintenance of underground energy pipelines, and produce high-speed, non-destructive methods of oil and gas exploration.

This technology could also dramatically lower the cost and environmental impact of energy exploration and enable us to find new fossil fuel reserves at a speed and scale that was previously unimaginable.

So the emergence of quantum technology in the area could not be timelier. The current global oil glut masks a dangerous underlying problem that spells peril for our future energy demands.

Despite a marked growth in the prevalence and availability of renewable energy, fossil fuels are still forecast to provide more than half of primary world energy in 2040. However, research shows oil firms are no longer sufficiently investing in the quest for new reserves, presenting a huge potential problem for the future. Recent figures revealed a 12 per cent drop in investment in oil exploration last year, with discoveries of conventional oil falling to 2.4 billion barrels, half the level of 2015, the year of the fewest new discoveries since 1952.

Causes are complex, from the collapse in crude prices deterring investment in exploration, to the

high risk and cost of that exploration in challenging environments, such as the quest for deep-water reserves.

The effects of this could be catastrophic, sending future energy prices skywards as demand exceeds supply and leaving the world facing power shortages. Critically, it could turn inflexible power sources such as wind and solar energy into a single point of failure at the heart of our national grid. This is dangerous because wind and solar power sources cannot be seamlessly scaled up or down to meet fluctuating demand as they only work when the wind blows or the sun shines. Without new investment in exploration, a supply crunch could come as early as 2020, warned the International Energy Agency recently.

The emergence of new quantum technologies, not just for oil and gas but many other industry sectors, is a success of the Government's investment in the UK Quantum Technologies Programme. The recent Blackett review argues that industry, academia and government must dramatically speed up the identification of areas of quantum with economic benefit, and that industry should also inject funds into those promising areas to accelerate commercialisation.

Part of the barrier may be that quantum technology is based on advanced and extraordinary physics at the very cutting edge of science, which means it lacks the validation needed to drive early investment.

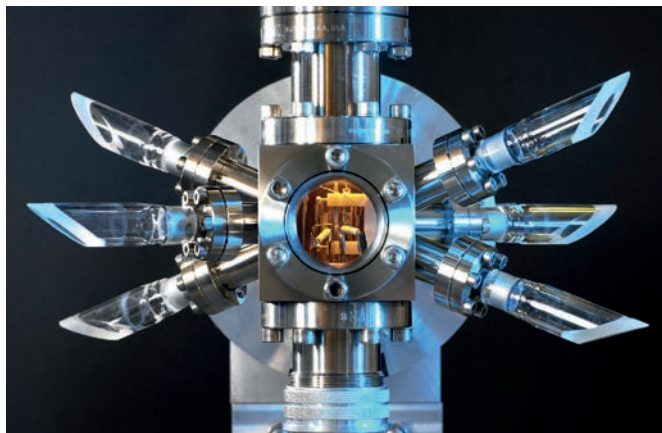
As the CEO of the National Physical Laboratory, the UK's National Measurement Institute, I am leading a new national activity to engage UK industry in emerging quantum technologies, matching their needs to the potential of these new technologies.

I am working alongside colleagues in Innovate UK and EPSRC, as well as other stakeholders in the UK Quantum Technologies Programme, to achieve this goal.

The example given earlier, of how quantum technology could help avert a future energy crunch by helping locate, tap and transport future energy reserves at a far lower cost than ever before, could be the tip of the iceberg. Quantum technologies hold enormous promise for a wide range of sectors, and could form a multi-billion-pound industry here in the UK.

This will require an increasingly joined-up approach with industry and government working closely together, something that any future government investment will aim to promote. We will work to create the optimum environment for public and private investment to turn these opportunities into reality. This approach aims to give UK businesses first access to disruptive quantum technologies to drive international trade and business growth. ■

**Dr Peter Thompson is CEO of the National Physical Laboratory**



A strontium end cap ion trap, used in quantum computing

# Mailbox

## The **hot** topic

### Charging into the future

**April's cover feature sparked a lively discussion on grid-scale energy storage**

Check out the MIT group and their liquid metals (and molten salt) battery now running at a mere 270C. The parasitic losses from high operating temperature of the early batteries have been removed (by a high percentage), and these batteries never give up, and won't back down.

They are extremely stable during cycling tests, and offer energy capacity and power density commensurate with the needs of the modern grid. Move over lithium ion, the days of sodium-sodium-antimony (or bismuth) in molten lead, with molten salt electrolyte, are almost here.

I also recently saw a presentation on large pumped hydro where the mass being lifted is essentially stone held sealed (with some neat O-ring tech) over an underground water reserve. This removes virtually all of the site requirements for pumped hydro (except the part where the underground strata must be a strong, nearly monolithic stone formation).

**James Stewart**

Consider FWG carbon batteries – no lithium, cobalt or nickel and better energy density using a graphene-based ink and paper. Could be easy to manufacture in the UK using existing printing technology and any carbon we have lying around in the ground.

**Tom Foreman**

Batteries are good for very short time period intervention or frequency response but not, and probably never, for five to seven days (which happens occasionally in the UK) of low wind energy in winter, in our industrial economy.

While increased renewable pumped hydro, compressed air, cryogenic, etc. can take some of the strain, they are costly.

Gas, which scales well, preferably renewable and low-carbon – methane, gasification, power-to-gas, etc. can be used only occasionally but still keep us below agreed CO<sub>2</sub> emission levels. Gas turbines OTC are relatively cheap, and existing combined cycle gas turbines (CCGT) (bought for peanuts by the state!) can also be ramped up.

**John Daglish**



Bulk battery storage of whatever form is not the solution because of inherent disadvantages too numerous to list. A much, much better sustainable technology is high radius of gyration and mass and comparatively low rpm flywheels.

The recently installed Tesla Powerpack in South Australia mentioned in the article could have been delivered using about 400 x one GJ flywheels 99x116MJ on the same shaft giving the same storage capacity, in about the same area, without any of the serious disadvantages of using a battery-based system. This flywheel-based alternative could be used for hundreds of years with no loss of performance, which would

hugely reduce its comparative operating costs and would save the planet from the short-termism and toxicity of battery-based proposals. I have already developed the casting drawings and the general circuit diagrams to support single or three-phase delivery.

**Richard Masters**

The recent development of batteries is indeed impressive, and augurs well for the future. However, as with most developments there are problems that also need to be pointed out to maintain a realistic sense of

proportion. The popular press reported that a Volvo hybrid car ignited outside a house and the family had a narrow escape. When batteries charge they heat up and can become very hot – even small batteries have caused serious fires. Gas turbine 'black-start' battery packs used to have a full fire protection system: albeit they produced hydrogen that had to be ventilated.

**Jack Broughton**

## In **your** opinion

**Readers blame a diesel 'witch hunt' for JLR's latest job cuts**

The Discovery has a Euro 6 Diesel engine and is a very low emitter of particulates and NOX. However, the ridiculous 'all diesel is evil' campaign being waged by politicians and large sections of the media ignores this – why let facts get in the way of a witch hunt. Diesel sales have crashed. Consequently, it's no surprise that people have lost their jobs.

**Edward**

Land Rover has turned its back on utilities/farmers/smallholders etc. with no follow-on replacement for the Defender. A cave-in to

Mitsubishi, Isuzu etc. in those sectors. More imports to worsen the balance of payments situation. Nothing to do with 'Brexit uncertainty', just UK politicians railing against diesel and the fact that finance is not as easy to get as before.

**David Tinsley**

Euro 6 diesels produce much less particulates and still produce more power and less CO than petrol cars. The diesel technology is far from past its peak.

**Tim**

Was the government decision to demonise diesel engines, which has caused this major fall for Jaguar/Land Rover, an example of the Law of Unintended Consequences or just simple incompetence? New survey please!

**Jack Broughton**

### Industry 4.0

A successful Industrial Strategy based around Industry 4.0 has to recognise that we have to replace much of our industry, not just use it to keep the weaker parts of it going, since that will just store up problems for the future.

**Paul Reeves**

The main hurdles to UK industry implementing 4.0 are lack of investment, too little insight about what to do with the information generated, and inertia – or why bother?

**Sandy**

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## The secret engineer

We have a responsibility to improve processes and protect the planet, so why do we focus on consumer demands? asks the secret engineer

I recently got into an argument with a friend on a certain social networking site. Mind you, I get into so many arguments on it that I'm convinced that's the whole reason for its existence – or perhaps it's just me?

Anyway, we were talking about the ecological impact of cars and the best way forward. Tesla was lionised, as one would expect, and there were various discussions about the true environmental cost of electric cars. However, what caused absolute apoplexy was my suggestion that it would be more beneficial if we just simplified all vehicles.

My point was that if you consider the powered gizmos (with their sensors) that are standard on all cars these days – and then the wiring to connect them – and then the power needed to make them work; it all adds up to something quite significant.

Volkswagen made about 11 million vehicles last year and even if you only saved one gram of carbon (as a vague indicator of greenness) in each vehicle, that's 11,000kg in total. From one manufacturer alone, in one year. My friend, however, could not cope with the concept of any new car finding a buyer if it's not "fully loaded".

We spent God knows how long going around in circles with regard to the idea of omitting the power steering. A significant proportion of this time was spent with him arguing about the efficiency of hydraulic and electric systems because he simply could not fundamentally grasp the concept of not fitting it at all. For context, with regard to this particular aspect, I was on about small town cars only.

Now, he's a successful jet-setting businessman and hardly a dullard, so although I could accept a disagreement I was genuinely shocked that it was based purely in such a deeply entrenched paradigm. I was reminded of an associated situation when I was designing widgets a few years ago. We were only allowed to claim a certain power for our widget if the draw from the mains supply could be demonstrated, so we would make it work in a particularly inefficient way to get a bigger number on the packaging.

The paradigm then was that the buyer would be mesmerised only by the number, without any consideration that this actually meant it performed its function whilst consuming more electricity than a competitor's machine in a box with a smaller number.

Utter lunacy!

As an engineer, this wanton and unthinking



waste of resources is anathema. We have a responsibility to improve processes and designs so that we decrease our ecological impact in this increasingly environmentally aware age, and yet we are forced by the Smoke and Mirrors Department (or 'Sales' as they're otherwise known) – backed by those lacking in vision – into reinforcing these illogical practices.

It's not surprising that we have reached this position after over a century of flagrant consumerism, just that so many remain so brainwashed that they are oblivious to it.

So what can we do about it? There has to be education for a start. When all is said and done, why should power steering on a small city car be seen as being so essential? It doesn't have to be hair-trigger responsive around corners and it doesn't have to be steered through the medium of a tiny wheel. There is no reason why the thoughtful application of mechanical advantage alone cannot result in acceptable forces being applied by the driver whilst navigating around a generic supermarket car park.

Equally, there is no reason why the vast majority of people cannot understand that they will be better off with a Widget that takes 700 Watts to perform a given function than one that takes 900 Watts. Once the expectations and wants of the consumer change, we can stop compromising by investigating ever more sophisticated ways to chip away at protecting our planet and be let loose to show what we can really do instead. ■



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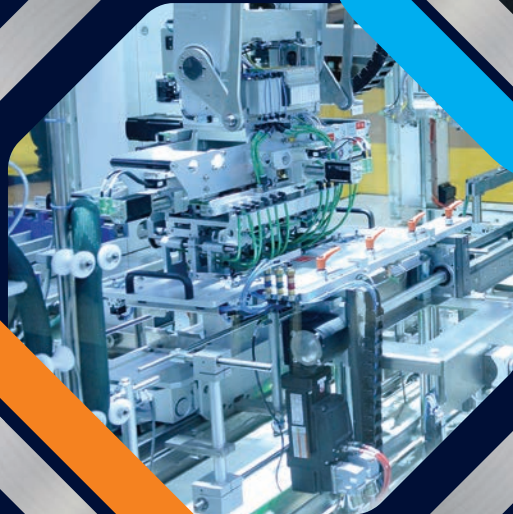
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view from the academy | hayaatun sillem

# Engineering excellent teaching on an international stage

Career framework is a global response to the challenge of improving and measuring the skills of educators

One of the Academy's top priorities is to secure the future talent pipeline for engineering and ensure that the UK can produce world-class engineers. Our ability to do this depends critically on engineering educators, but in the UK higher education system, there is very little incentive for academics to focus on teaching – as reflected in the oft-quoted phrase 'publish or perish'!

The introduction of the Teaching Excellence Framework (TEF) by the Government aimed to address this lack of parity between teaching and research, but it has proved a controversial intervention, partly due to lack of confidence in the metrics that underpin the assessment.

Over the past four years, the Academy has worked with partners around the world to develop a Career Framework for University Teaching, which was launched at a conference in London at the end of April. The career framework complements the TEF and aims to help universities improve the way they evaluate and reward the teaching achievements of their academic staff. While the TEF assesses teaching standards at an institutional level, the career framework addresses the teaching performance of individual academics. Importantly, this is not a framework just for academics involved only in teaching: it's for those who are research active as well.

The project was originally targeted at assessing engineering educators, but it soon became clear that career progression policies are created at a university level rather than within departments or faculties. We therefore had to make sure that our framework was applicable to all subjects taught in universities. We also recognised that higher education is a global marketplace – for students and for lecturers. This meant that, to be successful, the framework would have to be relevant not just in the UK but around the world. This led us to embark upon one of our most ambitious, but possibly most important, projects – to create a global framework for measuring teaching quality.

The framework we developed identifies four levels of teaching achievement. These range from an 'effective teacher', which marks the threshold of the acceptable level for university teaching, through to a 'national and global leader in teaching and learning', to identify those who have influence and impact across UK higher education and on the international stage. A set of criteria has been developed for each level. Those at the second level, 'skilled and collegiate teacher', for example, might mentor other teaching staff or serve as



"We have been working with 15 universities across 12 countries"

external examiners. It also incorporates a flexible set of evidence categories to help academics demonstrate teaching achievement, both informal and formal. Crucially, the framework has been informed not just by global perspectives but through implementation in a wide range of academic contexts around the world. Over the past two years we have been working with 15 universities across 12 countries, including some of the highest ranking in the world, such as Harvard and MIT, the National University of Singapore and the University of New South Wales. Closer to home, we've worked with EPFL in Switzerland, Chalmers University of Technology in Sweden and UCL in the UK. These institutions have played a pivotal role in testing and refining the framework.

The framework has been used to make improvements to the 'educator track', the teaching and learning career pathway at the National University of Singapore and the redesign of the academic career pathways at the Universiti Teknologi Malaysia. It has underpinned the introduction of new teaching qualifications at Chalmers University

of Technology, the introduction of a new education-focused career pathway at the University of New South Wales and the design of the academic pathways at University of Technology and Engineering in Peru.

Within the UK, the framework has supported the redesign of all three academic career pathways at UCL – candidates for promotion at all grades of the academic track are now required to meet a threshold level of teaching quality and people on either the academic track or the teaching fellow track can now progress to a full professorship. In addition, the UK's newest university, NMIITE, in Hereford, will be using the framework as the structure for its career and professional development system. Excitingly, the Dutch Ministry of Education has used the framework to design a new bursary scheme for academics across all universities in the Netherlands.

This project is a great example of how adopting an engineering approach can enrich policy work. The approach has been data-driven, informed by real-world experience, iterated in response to piloting and feedback and has ultimately delivered a simple, practical tool. In addition, the project has created a network of practitioners and champions who can support each other in driving forward this agenda.

We were delighted to see many at the launch, but we can only succeed if everyone recognises the value of teaching and adopts a common framework for measuring it. ■

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**Dr Hayaatun Sillem is Chief Executive of the Royal Academy of Engineering**

# Time to be smart

**In an increasingly connected world, the safety and resilience of devices is more important than ever. A new report is highlighting the challenges, as Stuart Nathan explains**

**W**hen EM Forster exhorted his readers to “Only connect!” at the end of his novel *Howards End*, he couldn’t have imagined how connected we would all become barely a century later. Not only does ubiquitous internet mean that we are plugged into media services constantly, but it is becoming increasingly difficult to buy technology that is not ‘smart’ in some way. For most of these devices, that smartness derives from connectivity to the Internet and to other devices and systems.

The average UK house already contains around 15 connected devices, some obvious such as phones, laptops, tablets, televisions and smart meters, and some much less so, such as kettles, coffee makers, thermostats and switches. This number will only grow in the coming years.

The workplace, and particularly the manufacturing workplace, is even more connected. The rise of Industry 4.0 and the Internet of Things is seeing sensors and other monitoring equipment proliferate on almost every piece of equipment. Some of these are hardwired into IT systems that oversee and fine tune the operation of machinery in the factory, while others – such as tools used on production lines in the automotive and aerospace industries – use wireless technologies to receive instructions to alter their operating parameters and to send data back to the factory IT systems.

All this poses risks that have not been seen before in either the domestic or workplace environments. From the earliest intimations of connected systems, the risk of incursion by digital criminals was foreseen by science fiction writers and other futurists, and cyberattacks are indeed a constant threat, with instances occurring in healthcare systems, critical infrastructure and in the entertainment industry. But criminal activity is not the only threat. When everything is connected, knock-on effects from non-malicious IT outages can be severe; as was found with recent floods affecting electricity substations in Lancaster, which subsequently affected landline and mobile telecommunications, and an outage at British Airways caused by a power failure that threw schedules and reservations into chaos.

Against this background, the Royal Academy of Engineering recently launched a report into the safety and resilience of cyber systems,

working alongside PETRAS, the EPSRC-funded Cyber Security of the Internet of Things (IoT) Research Hub.

Bringing together specialists from the universities of Warwick, Oxford, Surrey, Lancaster, Southampton and Cardiff with UCL and Imperial College in London, PETRAS (privacy, ethics, trust, reliability, stability and security) was set up in 2016. It is co-funded by industry and involves more than 120 academic, industrial and public sector partners, looking at social and technological issues, aiming to solve potential conflicting interests of government, industry and academia.

Safety and resilience are distinct issues, explained Nick Jennings, vice provost and professor of artificial intelligence at Imperial College, one of the report’s authors, at its launch. “Safety for us is what happens to a system when it’s operating normally. You want it to do particular things and not do other things under normal operation, and that’s how you construct any digital system. Resilience is where the system might be under stresses and strains and you want it to be able to recover from events, whether malicious or otherwise, and not end up in a bad state.”

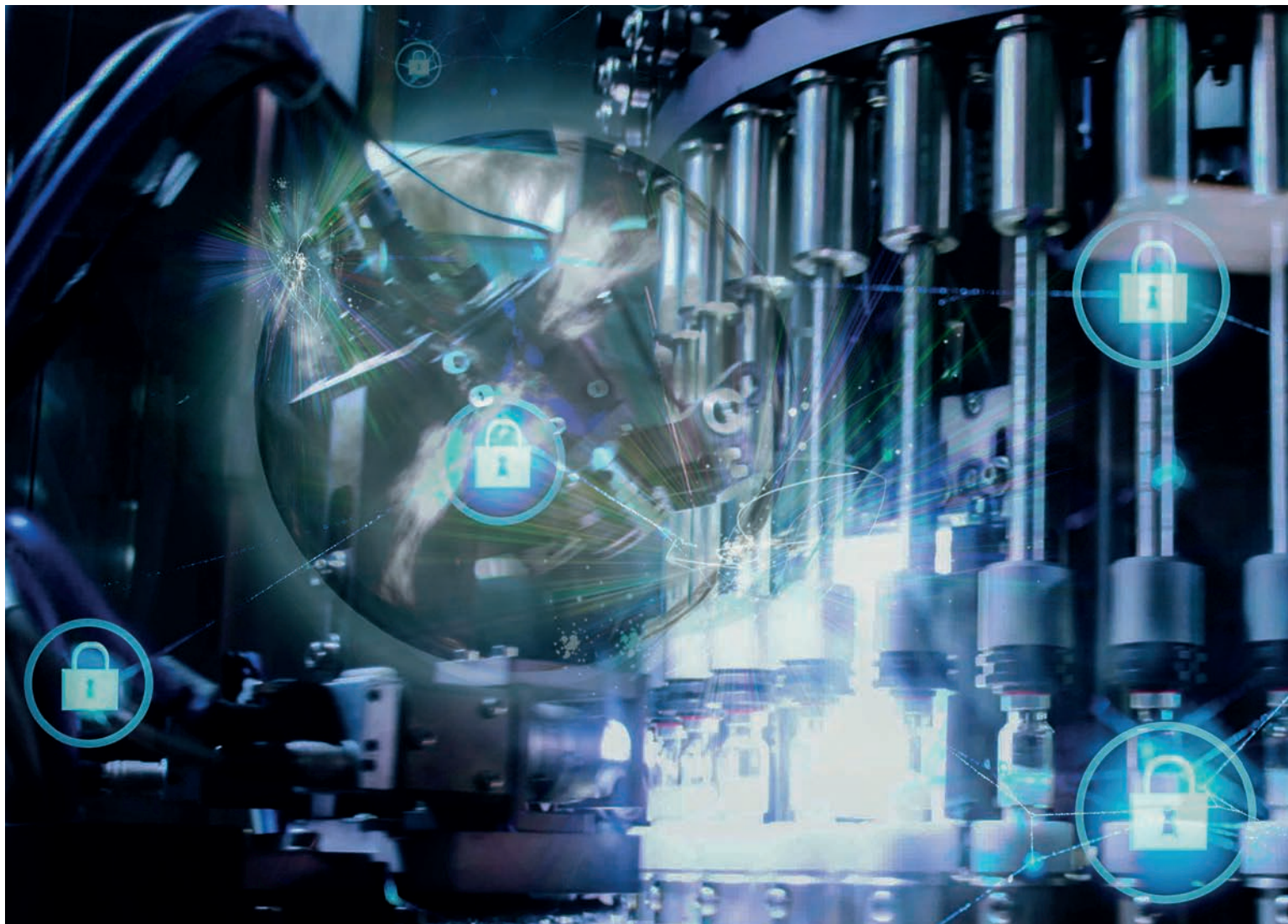
Connected devices pose a dual risk in cybersecurity terms. The device itself can be penetrated and its data accessed, which can be a serious problem, sometimes in unexpected ways. For example, in the domestic environment, a robot vacuum cleaner could provide hackers with a floor plan of the home, and a thermostat could tell intruders whether a home was occupied. But this is not the only risk. If the device is connected to other systems – for example, a smart meter might have a link to the financial records of the house owner because of its use in billing – the hack could be used as a back door for “lateral movement” and financial cybercrime.

There are already examples of such lateral access being achieved in tests of hacking. For example, a wireless tyre pressure gauge manufactured by Bosch was used in a simulated hacking exercise to gain access to the engine management system and other software in a Mercedes car. The gauge is intended to give drivers useful information about the status of their vehicle, but this vulnerability was unforeseen.

In another automotive exercise, hackers found the problem with hacking into a Jeep’s systems wasn’t the hack itself, but confining the penetration to a single vehicle rather than a large number of them.



# art on security



Cyber vulnerabilities have also been found in CT and MRI scanners, and in insulin pumps. In the TV thriller *Homeland*, one storyline saw a US politician assassinated by a hacker using his pacemaker to induce a heart attack; which is reputed to have so alarmed then US vice president Dick Cheney that he asked the Secret Service to assess the vulnerability of the software embedded in his own pacemaker. Pacemakers and insulin pumps send data wirelessly so that clinicians can monitor the health of their patients, but this could have the unintended consequence of rendering them vulnerable to attack.

Another of the report's authors, Paul Taylor,

UK lead partner for cyber security at KPMG, recalled a case where smart lightbulbs proved themselves to be a liability. Their original software – which has now been changed – allowed the first lightbulb plugged into a house to access the household's Web ID and network passwords, which was then shared with all subsequent lightbulbs plugged in to the circuit. "This was the system trying to be helpful," he said. "It meant that you didn't have to re-enter the details every time you put a new lightbulb in, but somebody figured out that you could pretend to be a lightbulb and get access to all these details. When that became clear, the software was replaced."

Rachel Cooper, professor of design management and policy at Lancaster University, and theme lead at the PETRAS IoT Research Hub, highlighted another safety problem with connected systems. "We've done some research with a smart kettle, and we noticed it leaked data to a random server in Iceland," she said. "You can download apps on your mobile phone so you can activate all these items in your home. So I've got the smart kettle app, and I can turn it on with an app I downloaded, but I can also turn it on from my sofa when it's empty."

If these vulnerabilities exist in domestic appliances, it's easy to be alarmed by the potential for risk in the far more connected

environment of an Industry 4.0-enabled modern factory. Paul Taylor, in conversation with *The Engineer*, said that cars are a good model for this because they are engineered to meet such exacting standards in terms of safety.

The RAeng/ PETRAS report, which aims to begin setting out guidelines to minimise such risks, states that configuration of connected devices is currently too difficult, and that manufacturers and distributors should be responsible for ensuring that devices are much more secure when they come out of the box. "If you're buying a connected device, you ought to know what standard of safety it has been produced to meet, and it should be fit for purpose," Taylor said. "We believe that government and regulation have a role to play here. Government has a great convening power both internationally and nationally to bring people together to start setting standards, whether those are going to be through the BSI (British Standards Institute), based on US NIST (National Institute of Standards and Technology) regulations, or through the Consumers' Association. From there, it's a short hop and skip to say we can start developing some common standards. We are actually quite good at that in the UK, so why shouldn't we take the lead?"

Nick Coleman, chair of the IET information technology policy panel and former UK national reviewer cybersecurity for government, added another warning. "All of these standards have to be global, really, because we run global infrastructure with global supply chains and so you need to have clear interoperability between certifications," he said. "Preferably we need as global an approach as we can."

So if the manufacturer is responsible for standards, what is the responsibility of the user of connected equipment, whether that is in the home or in industry? A shift in thinking may be needed here. Previously, equipment has been regarded as 'dumb'. But in the case of modern appliances, devices and equipment, many more things need to be thought of as computing devices, and these need the same sort of care as any other computer.

Specifically, security updates and fresh iterations of operating systems have to be downloaded and installed as they become available, and this can only be the responsibility of their owner. "If you say to someone, I've designed a smart kettle and have given it a label or a kitemark, the expectation is that you don't go back and patch your kettle every couple of weeks even though you do on a computing device," said Coleman.

Taylor went into more detail. "At the point of sale it should be quite clear to what level of security standards it has been built, if any, and what the process is for updating those security standards in the future, again if any. So ideally we'd like to see manufacturers being quite clear what security standards they use, when the standards exist, and how they can be updated. And then from that point, responsibility will pass across to the user to make sure that updates are uploaded and installed in a timely fashion to make sure that their equipment is as secure as it can be at that point in time, in the same way that you would with your own computer. You buy your laptop or tablet in a certain state and it's your responsibility thereafter that you apply the patches and update the antivirus."

Updating is particularly important for industrial systems, Coleman stressed, because unlike domestic appliances and personal devices, these tend to have a longer lifetime. "We need to remember that systems tend to last longer than you think they will, particularly in critical infrastructure; you might think 'I will replace my smart phone every couple of years,' but legacy technology in some of these systems lasts about 20 years, so we're talking about building it now and getting a design right for the resilience as well as usability and other factors to consider, but we are also talking about its life-cycle: how does it get maintained, how does it get backed up?"

It's also important to remember that industrial systems operate in a particular, and sometimes challenging, environment. "Think about it like an oil rig. It's not sitting in a shiny office, these are systems that have to operate in the

**01** Insulin pumps are among the medical devices found to be vulnerable to Wi-Fi hacking.

**02** Hacking into Jeep systems proved easier than confining the hack to a single vehicle

**03** Smart lightbulbs configuration was supposed to save time, but instead created a vulnerability



01



02



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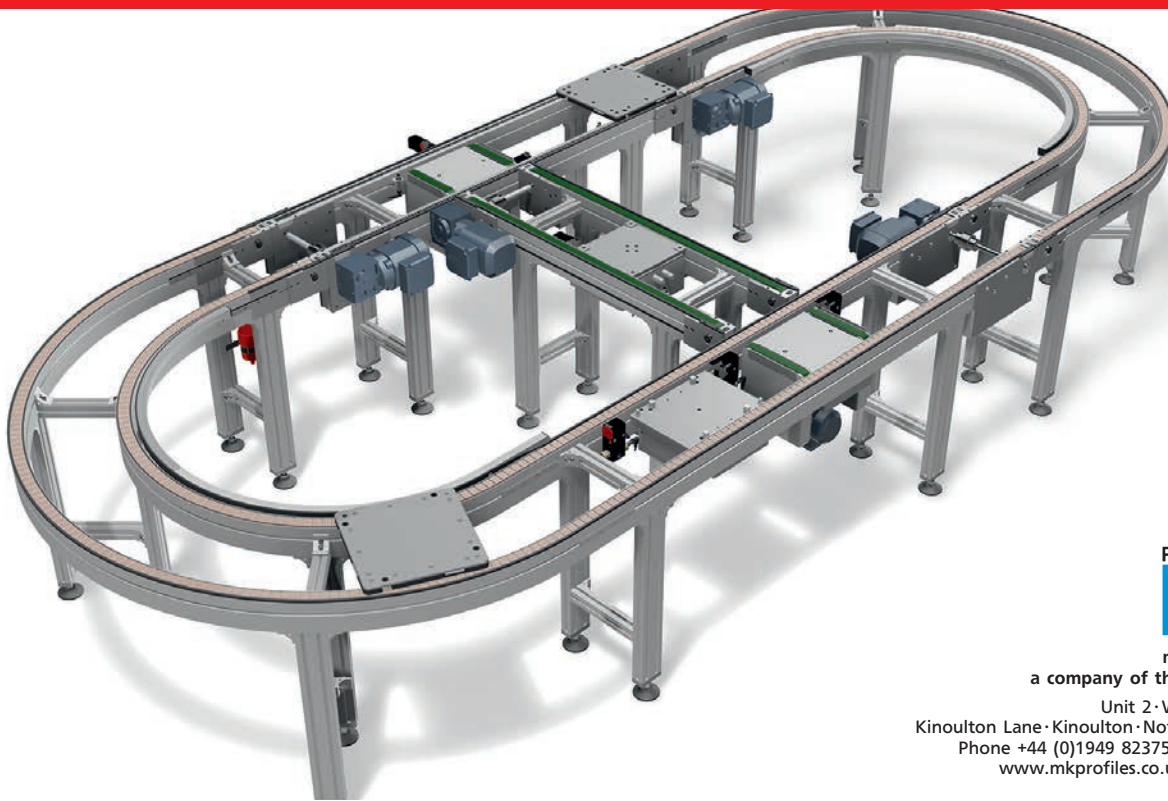
environment in which they are built, so you have to build resilience for that."

It's a challenging world, and it's not going to get less complex. But it's important not to lose sight of the advantages that connected technologies bring. "The first thing is to recognise putting digital and physical systems together in an integrated way is a good thing to do," said Nick Jennings. "There's lots of benefit that one can get from that in terms of monitoring, in terms of measuring, in terms of constantly interacting with systems, so that's a good thing."

Moreover, raising these concerns is not an attempt to scare people off, Taylor stressed. Factory owners are often nervous about installing new technologies like Industry 4.0 or IoT-enabled devices, and Taylor is anxious not to increase that anxiety. "I think it is the opposite: by raising concerns like this or the thinking we put in the reports of raising the issue of standards and of getting a common set of standards, that will help Industry 4.0 to become more easily adopted and more successful. The idea is to make helpful contributions towards increasing confidence in security and safety rather than running around with our hair on fire and saying don't do it. That isn't the idea at all." ■



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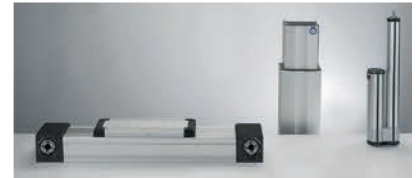
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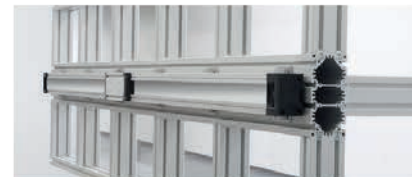
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# Let there be light

Inspired by a humble crustacean, Oxford startup First Light Fusion is aiming to achieve energy gain from fusion by 2024. Andrew Wade reports

**T**here are some who believe that fusion will always be just out of reach, a mirage on the horizon that humanity is doomed to pursue forever in vain. However, the promise of limitless clean energy is difficult to ignore. It's an elusive prize that attracts some of science and engineering's brightest minds, not to mention vast sums of investment. But as billions are spent in the search for energy's Holy Grail, UK startup First Light Fusion is aiming to crack the code on a shoestring, and do so within just a few short years.

In theoretical terms, the basic science behind fusion is relatively straightforward. Hydrogen isotopes (deuterium and tritium) are forced together to form helium, expelling vast amounts of neutron energy as they fuse. While the physics may be simple, creating the conditions for the reaction to occur is anything but. It's the same process that powers stars, where enormous temperatures and pressures are at work. Replicating those conditions on Earth is a huge challenge, and one that has spawned massively complex machines such as ITER (International Thermonuclear Experimental Reactor) in France and the Wendelstein 7-X stellarator in Germany.

Those two engineering marvels use giant magnets to keep superheated hydrogen plasma confined in reactors. However, this is not the only way to achieve fusion. Scaling down, inertial confinement creates the extreme temperatures and pressures required in a tiny pellet, forcing outer layers inward so that fusion is achieved in the very centre of a minuscule target.

"Instead of there being this big external force of these huge magnets which are holding the plasma together, for inertial fusion there's not any external force holding the plasma together," explained Nicholas Hawker, co-founder and CTO of First Light Fusion.

"It's held together by its own inertia. So, it just can't get out of its own way fast enough. If you imagine the bit of plasma in the middle, it can't release its pressure until the bit next to it has released its pressure, and that can't be released until the one on the outside has."

The very centre of the pellet remains confined for just long enough that the temperature, pressure and density create the requisite conditions for fusion. Enormous amounts of energy are focused on a tiny target, usually in the form of a high-powered laser. This is the method used by the National Ignition Facility (NIF) in California, the world's leading exponent of inertial confinement. First Light is taking a slightly different route, however, using hypervelocity projectiles to collapse targets in very specific ways.

In comparison with the vastly complex machines



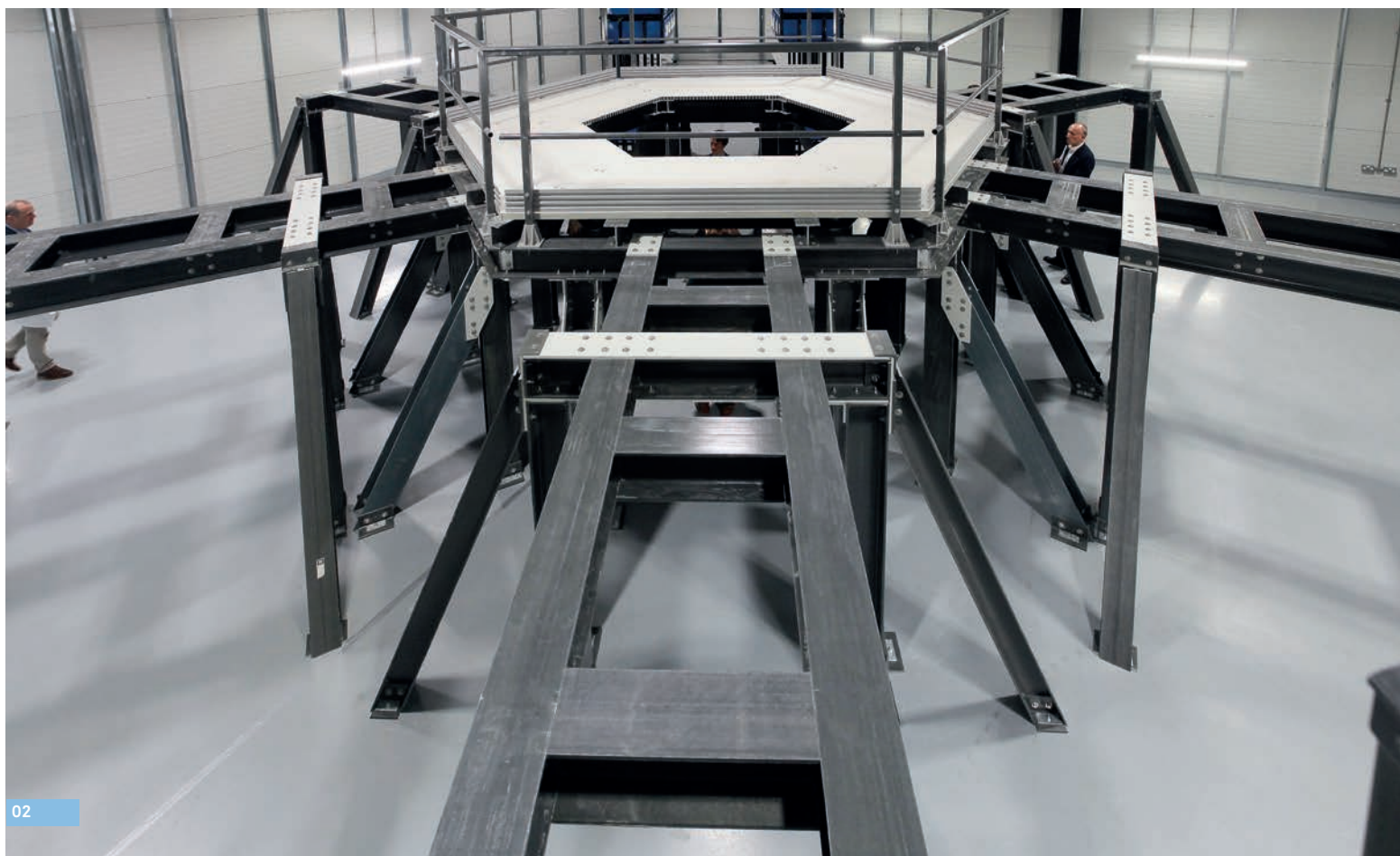
required for magnetic fusion, First Light's equipment is relatively simple. Its current experiments use two-stage gas guns and electromagnetic propulsion to achieve projectile speeds of around 8 kilometres per second. At its Oxford HQ, the company is working on Machine 3, a high-voltage pulsed power device that will deliver the equivalent of around 500 lightning strikes. Similar to a railgun, it will use electromagnetism to fire projectiles at around 20km/s.

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

While the engineering is certainly impressive, the real complexity – and the key intellectual property – comes in the form of First Light's advanced fuel targets, designed to maximise fusion efficiency. Inspiration for the confinement process came courtesy of the pistol shrimp, a crustacean that clicks its claw to produce a shockwave which stuns its prey and causes the surrounding water

**"Machine 3 launching the projectile is 1,000 times cheaper"**

Nicholas Hawker



02

to cavitate. The air and vapour inside these cavities is heated as they implode, causing a plasma to form. Apart from supernovas, it's the only known example of inertial confinement in the universe.

"This was the starting point for my PhD, to take this phenomena, boil it down and understand it," said Hawker, who completed his doctorate at Oxford in 2012.

The pistol shrimp's shockwaves are replicated at First Light using hypervelocity projectiles, with the geometries inside the target dictating how the cavities collapse. As the science and understanding of the target design improves, so too will the efficiency of the reaction.

"The complexity is in the target," said Hawker. "We try to keep the machines simple and finesse the target with a very high-quality understanding of the physics and dynamics of what's happening inside that target."

"By changing this target design and having this idea of the projectile, potentially we get to a much simpler, much cheaper, technology. The whole point of First Light right now is to find the target design that actually is going to work."

During a presentation at the company HQ, Hawker narrated an animation of the sole target design made public so far. Instead of a single cavity, the animation showed three, with two larger cavities directing energy into a smaller one as they collapsed into it, encouraging higher temperatures to be produced. Using advanced hydrodynamic simulation, the company is able to iterate target designs extremely quickly. This agile approach – taking as little as six weeks in some case – is where its competitive advantage comes in, according to Hawker.

"We did 17 products last year on advanced target designs, so it gets more and more painful that we can only show one publicly," he said.

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**01** Nicholas Hawker shows guests around the inside Machine of 3

**02** The frame of Machine 3, due to be commissioned later this year

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"Our vision for the business is that we keep working on the target design. It's where the trade secret is. It's the most valuable part of the IP. And we think it's something that a startup can actually be world-leading at. We have a rapid iteration cycle, agile team... and we think this is an advantage that we can defend."

Sir David King, former chief scientific advisor to the government, is the most recent addition to that team, joining in April 2018. The advisory board also includes Nobel Prize-winning physicist Steven Chu, with further pedigree coming in the shape of COO Gianluca Pisanello, an F1 veteran of 14 years and former chief engineer of Manor Racing.

Having recently secured £23m in funding, the company is well on its way to getting Machine 3 up and running, hoping to have it commissioned by the end of the year. First fusion is planned for 2019, with energy gain – the promised land of fusion – tentatively targeted for 2024.

If gain can be achieved, the plan is to partner with third parties with the engineering capability to develop power plants, ideally in the 200-300MW range. But rather than replace wind and solar, Hawker sees fusion working in tandem with renewables, more likely to replace the gas-fired plants that currently provide flexible baseload.

"What fusion can deliver is baseload power," he said. "And what we think our technology is going to be able to do is address a need for flexible baseload. If you have existing nuclear, basically it's always on, and you might not want it to be always on. You would rather it flexed in response to what the solar output is."

"We're not saying we don't need renewables, that we don't need solar and wind. We do. We should be building all of that. But energy is not generated from a single technology." ■

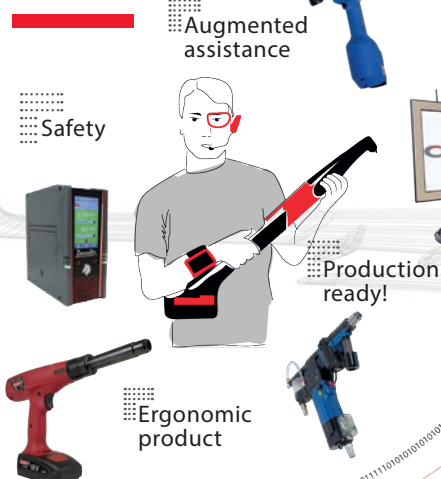


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# ‘Self-driving will improve safety’

Stuart Nathan talks to the man overseeing design of control systems for autonomous vehicles at Jaguar Land Rover about gaining drivers’ approval

**T**he age of the autonomous vehicle is undoubtedly dawning. We can already see that drivers will need to be involved less and less in the minute-to-minute operation of their vehicle, but in *The Engineer* at least we often see that our readers are less than enthusiastic about the prospect. Common responses to articles on autonomy have the tone of asking why the automotive industry is foisting this technology on its customers, many of whom actively enjoy driving.

To Mark Cund, who is responsible for design of the control system for level 4 autonomous vehicles at Jaguar Land Rover, the answer may not be welcome to current customers: it’s all about looking to the future and around the world. “We know that self-driving will improve the safety of our roads, but we also understand that it can seem like a big change for customers and that could be intimidating. However, autonomous features will all arrive iteratively and in a way that can foster trust and new habits from our customers today,” he said.

“We talk to different groups of people of different ages throughout the world. If you look at where we sell cars, people don’t always have the same attitudes as people in the UK. People have different requirements across the world – how they travel, how they interact with technology, their work-life balance – all these things greatly impact their relationship with their vehicles and we’re mindful of that in our research.”

Cund came to Jaguar Land Rover from a background in software engineering, although his Masters degree was in automotive calibration and control. “I used to work in embedded systems, writing software in assembly language,” he said. “I started doing a bit of algorithm development in MATLAB and Simulink, and from there I eventually moved into Jaguar Land Rover.”

When Cund took his Masters degree he was already working on an algorithm to work within an emergency braking system; it operated when the vehicle was in a highly dynamic situation or when a crash was imminent to automatically tighten the electric seatbelt retractor and pull the driver firmly back into the seat. “In that Masters degree there was a lot of control theory, which I have to say is really hard to understand and is not straightforward, but it is relevant to me now because my team is working on control theory projects, and as a company we have to ensure we are developing technology that is relevant.”



“We are getting to a point where you can’t just add evolutionary systems together, and as an industry we’ve got to do something else”

To Cund, the development of autonomy is a matter of evolution or revolution. Many systems that are now well accepted on cars, such as automatic braking, vehicle stability control or cruise control could be seen as components that would build up into an autonomous vehicle. “You could evolve all these systems and make them work together, but these are all deterministic systems where you know every line of code and you can test all the paths through the code, and when you’re evolving systems and putting one on top of another, the complexity becomes so unwieldy it’s virtually impossible to manage it.”

He added: “A simple change can have a massive knock-on effect on all the verification work that you do. On the flipside of that, we look at things we term as revolutionary, like artificial intelligence, that are stochastic in their nature (as in nondeterministic). We are getting to a point where you can’t just add evolutionary systems together, and as an industry we’ve got to do something else.”

Autonomous vehicle developers cannot ignore incidents such as the recent fatal collision between a pedestrian and an autonomous vehicle in Arizona. “It





highlights how important it is that we are clear what we are doing when we are testing. It kind of makes you acutely aware of all the things that can go wrong," Cund said.

For Jaguar Land Rover, when testing autonomous systems the car always has at least two people involved in the test at any time. "We've got a driver behind the wheel – it's not just someone with a driving licence, it's someone who has been trained really well, and their role is to concentrate on the road and what's going on around the vehicle and not on the system – and we have another person in the car who is there to do the operation of the system. We completely separate out the two roles and the trained person behind the wheel could still have ultimate control of the vehicle and can override the system and regain control if that's required, and they understand how emergency stops work."

In tandem with its own R&D, Jaguar Land Rover is also involved in a wider UK-based project called UK Autodrive that brings together autonomous vehicle developers and legal experts. Its role is both to help developers and to ensure that the legal framework to support operation of autonomous cars on British roads is in place when technology is ready. "You don't want to

**01** A prototype driverless Range Rover Sport being trialled as part of the Autodrive project on the streets of Milton Keynes.

**02** JLR recently announced that it is to supply I-PACEs for Waymo (formerly Google's self-driving car project)



be in the situation where you have spent a lot of money and put a lot of effort into creating a system that you can't put on the road. You want them to be lined up," said Cund. He will talk more about UK Autodrive and Jaguar Land Rover's role within it at *The Engineer* conference in June.

Some years ago, Jaguar Land Rover's then R&D director Bob Joyce spoke at a previous *Engineer* conference and said that the company would not be the first to launch a fully autonomous vehicle. "I don't think that's changed drastically, I still don't think we could be the first car company to put an autonomous car on the road, so I think Bob's original statement is still accurate," Cund said. The lack of a legal framework is one reason for this, he admits. He also believes there may be an advantage in introducing some of the features to consumers gradually.

"I think there's a misconception in the public's knowledge about what an autonomous car is. It certainly makes more sense to put them first in environments like motorways, where everybody's going in the same direction, and then add another sensor to enable it in a more urban type of environment. That also helps engineers, because we can break down the situation into actual problems and solve them." There is a precedent for this, he added. "You know the way that ABS and stability control was introduced in a sort of stealth-like manner, and people didn't know that they needed them? There's an analogy with autonomy as well," he said. "There are benefits that autonomy can bring that are fairly obvious, but things like not being distracted and not being tired and that stuff; people sometimes don't realise what they need."

Younger consumers might be more accepting of autonomy technologies, but ironically older drivers are likely to benefit more. "When I talk to my dad about it – he's 71 and a bit of a technophobe – he'll say he doesn't like the idea of autonomy," Cund said. "But I point out things like if he lost his mobility and couldn't go up to the Lake District for a wander around Derwentwater, then he'd be more likely to spend more time in his house, and that isn't a very nice thing to look forward to. If all it did was take him to the supermarket and enable him to go on holiday, I bet his attitude would change. If I can convince my dad, I don't think it'll be too hard to persuade others." ■

**Mark Cund will be speaking on Day 2 of *The Engineer* Conference, which runs alongside Subcon from 5-7 June**



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**The Alpina D5 S is the product of a unique partnership between a small family firm and one of the world's largest car manufacturers.**

Chris Pickering is in the driving seat

**T**he two silver badges perched on the tail of the Alpina D5 S speak volumes. Firstly, they signify that the depth of engineering that goes into this 171mph super saloon is such that BMW is happy for the small, independent manufacturer to badge these cars as its own. Secondly – and perhaps to some people's surprise – the 'D' signifies that this formidable machine drinks diesel.

We'll get on to the driving experience in a minute, but first it's worth pausing to look at how these cars are built. Alpina, as we know it today, began life in 1965 when the owner of a typewriter company started producing revised cylinder heads and carburettors for the BMW 1500 saloon. BMW was so impressed with the quality of these conversions that it granted the vehicles a full manufacturer warranty. It was the start of a unique relationship that endures to this day.

Alpina has its own factory in the town of Buchloe, an hour to the west of Munich. It's here that final assembly is carried out on the firm's model range, which spans from the 3-Series derived D3 to the mighty B7 Biturbo, based on the 7-Series limo. It's also home to a substantial R&D centre, including climate chambers and an emissions laboratory. Alpina uses these facilities to develop its own models, as well as carrying out consultancy work for BMW.

The story of the D5 S, however, begins on the BMW production line at Dingolfing. Each of the cars is assigned an Alpina-specific build code right from the start. The company supplies a comprehensive kit of new and revised parts that is fitted by the BMW technicians as it progresses down the line. Part-way through the build, however, the vehicle is shipped to Buchloe, for the remainder of its assembly.

The full list of modifications is too numerous to list. Unlike Alpina's petrol models, the internal components of the D5 S engine are unchanged, but virtually every other part of the powertrain is revised in some way, starting with a bespoke pair of sequential turbochargers. Next comes a heavily modified cooling pack, followed by new intake and exhaust systems.

Such is the level of detail here that Alpina has developed its own specifications for the diesel particulate filter (DPF) and the selective catalyst reduction (SCR) system. Naturally, the ECU calibration has been thoroughly reworked, too. The result is 326bhp – a healthy 65bhp increase over the BMW 530d, on which the D5 S is based. More to the point, though, it now produces 700Nm of torque. That's more than a Lamborghini Aventador.

The engine quietly spins into life and settles into an inoffensive idle that sounds much like any other premium diesel. Shift the ZF-sourced 8-speed automatic into Drive, however, and things get a lot more interesting. Cruising around at light loads, it emits a gentle burble, somewhere in between a petrol

“A lot of work has gone into Alpina's blend of comfort and agility”

01

V8 and a Riva speedboat. But put your foot to the boards and it hardens into growl that lasts all the way to the 5,500rpm red line.

Before we get too carried away, it's worth stating that there are fleeting moments – particularly at low rpm – when you can still sense that it's a diesel. Listen very carefully and you can also detect a faintly synthetic edge to the soundtrack, which betrays the presence of a noise enhancement system. This uses a microphone placed in the intake to sample the engine's natural tones and then boosts the more favourable frequencies with constructive interference piped through the stereo. That might sound a bit contrived, but this principle is applied on virtually every modern performance car and this is one of the more subtle examples we've come across.

The bottom line, however, is that this diesel unit sounds, revs and responds better than a lot of modern petrol engines. Its appetite for revs is particularly uncanny. Alpina actually limits the torque at low rpm to give the engine a more progressive character – much like Ferrari does with its turbocharged petrol engines. The end result is a torque curve so unswervingly linear that it might as well have been drawn with a ruler.

The D5 S makes an effortlessly refined motorway cruiser, capable of around 45mpg. But it's out here on the sinewy roads of the Yorkshire Dales that the chassis really has a chance to shine. Suddenly, this near-two tonne saloon miraculously shrinks around you, flowing down the road with agility and precision. The only real reminder of its size is the sharp intake of breath that accompanies the appearance of oncoming traffic on these narrow roads.

A lot of work has gone into the Alpina's incredible blend of comfort and agility. The springs are some 40 per cent stiffer than their BMW equivalents, yet the electronically-controlled dampers are nominally softer in compression and firmer in rebound. The bushes and top mounts have also been re-engineered, while the 20-spoke forged alloy wheels shed around 15kg of unsprung mass compared to normal cast items.





02

03

**01** The D5 S is bespoke but backed by a car giant

**02** The engine produces 326bhp and more torque than some Lamborghinis

**03** The Alpina feels more relaxed than a standard BMW limo

In the softest Comfort Plus setting the Alpina actually makes a more relaxed limo than the standard BMW, despite offering a much sharper, sportier drive in the more aggressive settings. It's the perfect combination of Dr Jekyll and Mr Hyde.

This particular D5 S comes with a modified version of BMW's hydraulically controlled anti-roll system, dubbed Adaptive Drive. It's similar in principle to a passive anti-roll bar, but it is automatically adjusted front and rear to adapt to different drive modes and changing road conditions. The same options pack also brings rear-wheel steering. At low speeds, this steers the rear wheels in the opposite direction to the fronts by up to 2.5 degrees to improve agility. At high

speeds, meanwhile, both sets are steered in the same direction for increased stability.

Alpina has sprinkled its magic on the drivetrain, too. All-wheel drive is standard on the D5 S, but the BMW xDrive system has been recalibrated for a more pronounced rear-bias. It never feels wild in the same way as a Mercedes-AMG E63 or indeed BMW's own M5, but the changes are enough to make it feel noticeably rear-driven when you're in the mood. At the same time, there's almost limitless traction when you want it, even with all that torque.

The icing on the cake is the driving environment, which feels wonderfully bespoke, despite amounting to little more than a re-trim. In fact, that's quite a good metaphor for the D5 S as a

whole. Most of the changes are incremental, but they add up to a car that feels genuinely special and a great deal more than the sum of its parts.

In that context, the D5 S's starting price of £62,000 is not at all unreasonable (you can spec a normal 530d to more than that if you try). Even our generously equipped test car – optioned to £86,690 – feels special enough to justify the premium. And it's certainly exclusive. Alpina UK expects to sell around 12 in 2018 – you have the same odds of spotting a Bugatti Veyron. Unlike the Bugatti, however, the D5 S can be supplied with the badges and decals removed, meaning most people would have no idea what a remarkable vehicle it is. And that, we suspect, is just how Alpina buyers like it. ■





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# A technology coming of age

After the initial hype, additive manufacturing is now starting to deliver practical benefits. Jon Excell reports

**A**s *The Engineer* has frequently observed, few areas of technology have been more hyped in recent times than 3D printing.

But fortunately, the excitable and often ill-informed speculation that characterised much of the early coverage of the topic has given way to a more measured view of the technology's potential. And today, the broad suite of processes and systems that sit under the 3D printing/additive manufacturing (AM) banner are increasingly seen as complimentary tools in the manufacturer's toolbox, rather than some existential threat to the established order.

There was a visible illustration of this at last month's MACH 2018 show, the UK's biggest and longest-running showcase of manufacturing technology, where organisations ranging from home-grown firms like Renishaw to the likes of Mazak and DMG-Mori – companies long-associated with traditional subtractive techniques – were all keen to demonstrate how 3D printing fits into their vision of manufacturing's future.

Wandering the halls of Birmingham's NEC, *The Engineer* heard from two of the sector's undisputed heavyweights, Stratasys and 3D Systems, about how a technology once viewed with suspicion by some is now moving firmly into the manufacturing mainstream.

The history of these two firms is a useful reminder of 3D printing's relatively long history – a pedigree that may still surprise some. 3D Systems founder Chuck Hull invented stereolithography back in 1986, while his opposite number at Stratasys – founder Scott Crump – pioneered another staple additive technique, fused deposition modelling (FDM), just a couple of years later.

Clearly, the technology has moved on considerably in the last three decades and both firms were keen to use MACH to demonstrate the degree to which techniques once used purely for design prototyping are now being adopted for a range of different production applications.

Elena Terraz is EMEA business manager for tooling at Stratasys. She told *The Engineer* that whilst prototyping still accounts for the largest share of the firm's revenue, manufacturing is now viewed as the key growth area. "The opportunities to add more value are in manufacturing," she said, "especially in industries where they don't produce huge volumes or are moving towards customisation."

One key area identified by Terraz is the use of 3D printing to produce customised tools for the assembly process. She highlighted a number of components designed to do just this, including assembly tools produced on FDM machines and used by automotive giant



Opel to attach roof components on some of its vehicles.

She added that FDM is also proving an attractive option for the production of tooling used to produce composite parts. FDM composite tools, which take just days to produce, offer a compelling alternative to traditional tool fabrication techniques, which are labour intensive and can take weeks or months. "We can do an

economic mould without having to build a big block of material," she said, adding that this kind of capability is attractive in low-volume, high-tech areas – such as motorsport and aerospace – where the geometric complexity afforded by 3D printing can provide serious advantages.

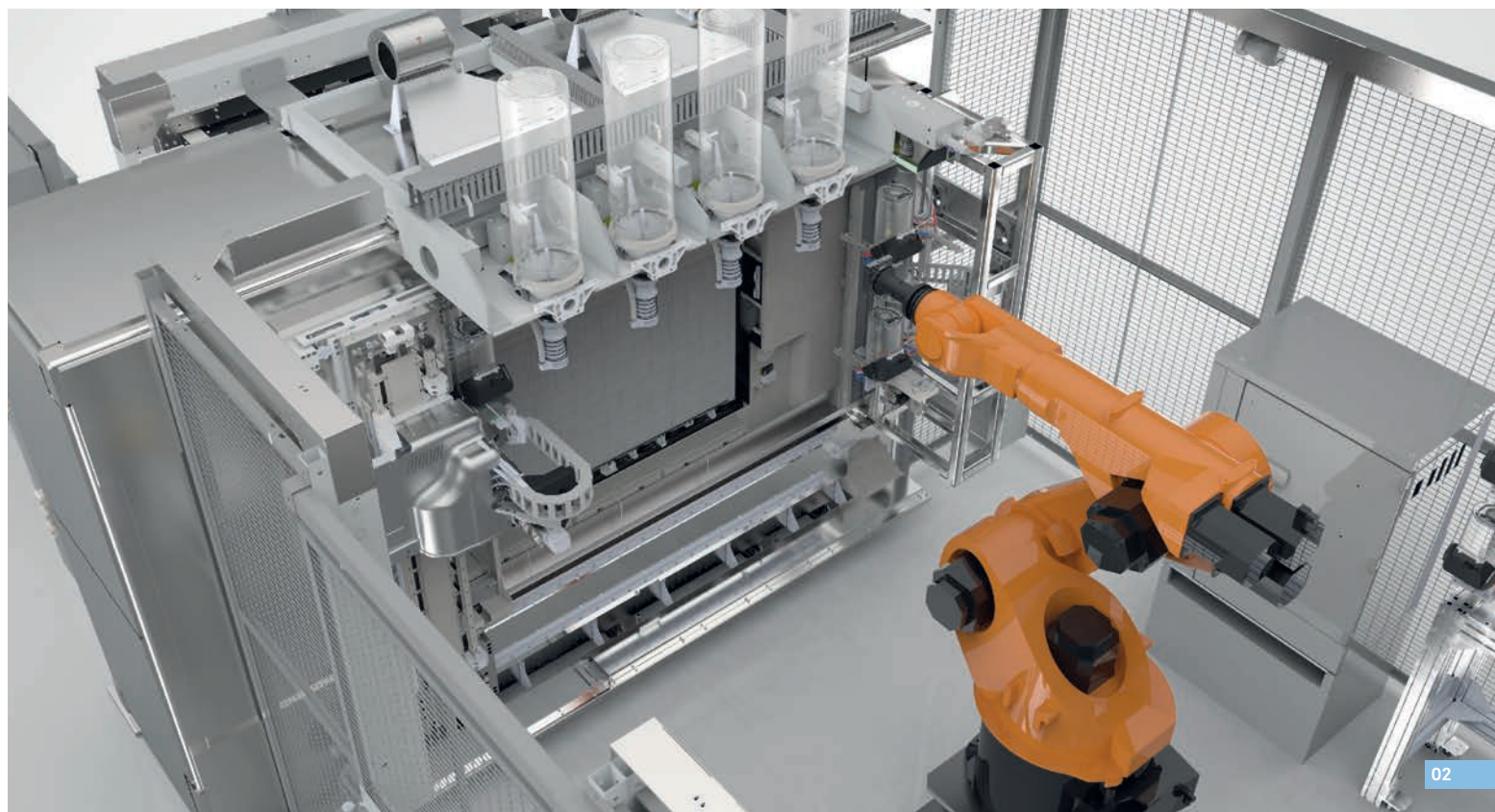
One great example of this is Stratasys' work with McLaren Formula 1 Racing – for whom it has produced a number of manufacturing tooling components, including sacrificial tools used to create the hollow composite brake cooling ducts on the MCL32 race car.

As well as tooling, Stratasys technology is also increasingly being used to produce final parts. For McLaren, for instance, the brackets that attach the MCL32's hydraulic line have been produced using FDM.

Meanwhile in the aerospace field, the firm recently announced that it had joined forces with Lockheed Martin to develop key final components for NASA's Orion project, the spacecraft that will ultimately be tasked with taking humans to Mars and beyond. This mission will use more than 100 3D printed production parts, including a complex and critical part on the outside of the docking hatch, which is made from a new material called Antero, which is specially

"Now the opportunities to add more value are in manufacturing"

Elena Terraz of Stratasys



optimised to cope with the extreme temperatures and mechanical conditions encountered in space missions.

Terraz explained that while the development of speciality materials such as Antero helps open up new applications for 3D printing, the company is also developing the printing technology itself by examining new ways of depositing materials.

An example here is the Infinite Build 3D demonstrator, a concept system, developed in collaboration with Boeing, designed to show how by printing on a vertical plane, FDM could be used to make much larger lightweight parts. Another interesting development is a new robotic technology developed in collaboration with Siemens and aimed at the composites sector. This system demonstrates how a multi-axis robotic deposition approach, that orients fibres as it deposits them, could be used to produce complex composite components.

Whilst Stratays used MACH to demonstrate manufacturing applications of its plastic-based techniques, fellow additive giant 3D Systems told a different story, and focused on the world of 3D metal printing.

Simon van de Crommert, the firm's 3D printing sales manager, explained that Direct Metal Printing (DMP) is one of its fastest growing areas, and MACH, he said, was the perfect opportunity to cut through the hype and have serious manufacturing discussions. "There's a gap between what you read in the newspapers to where people are comfortable using it," he said. "The hype helps – without that we wouldn't

have the demand we're seeing – but the people here need to have a full technical understanding and the conversations are a little more in-depth."

These conversations are clearly beginning to bear fruit, and he pointed to a growing market for DMP in a number of sectors, notably aerospace and healthcare, where the technology is increasingly being used to make functional final parts.

He echoed the view that the technology is particularly compelling for low-volume applications, where its ability to build highly optimised components – impossible to machine with existing techniques – at no extra cost, can deliver significant advantages.

One showcased example was a titanium bracket produced for a geostationary satellite manufactured by Thales Alenia Space. Designed to hold the satellite's solar panels, the component is topologically optimised to be 25 per cent lighter than a traditionally manufactured alternative – a major gain for a space project. The brackets were produced on one of the firm's direct metal printing laser sintering machines in which a high-precision laser is directed to metal powder particles to selectively build up thin horizontal layers.

The latest product in this line is the so-called 8500 Factory Solution – a system that follows a growing trend in metal 3D printing machines of introducing multiple lasers – in this case three – to boost the productivity

**01** Stratays works with McLaren racing on the development of tooling and final parts

**02** Stratays' Infinite Build demonstrator represents an effort to look at how 3D printing could be used to produce much larger components

**03** A lightweight titanium satellite bracket produced on a 3D Systems' DMP machine

of the technology. "By fitting more lasers you triple the productivity of the machines, whilst maintaining more or less the same footprint. In a factory environment that's going to be crucial," explained van de Crommert. It uses its three lasers to produce metal parts up to 500mm by 500mm by 500mm, one of the largest diameter build sizes possible with existing machines.

The system's hefty 5cm-thick doors belie another key element of the design aimed at meeting the demands of a real-life production environment. To ensure

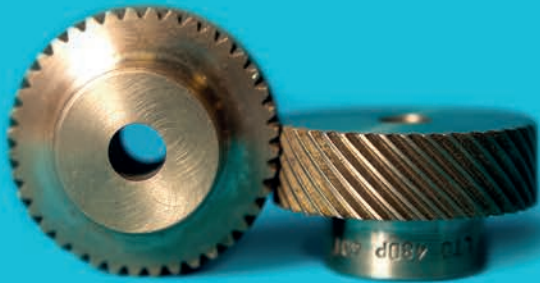
no impurities are introduced during manufacturing, and that the components are as close to possible as CNC quality, the system creates an inert environment by pulling a vacuum of -1,000 millibar, and backfilling the build area with argon. This is likened by van de Crommert to an extreme example of the way welding is carried out in inert conditions. ■





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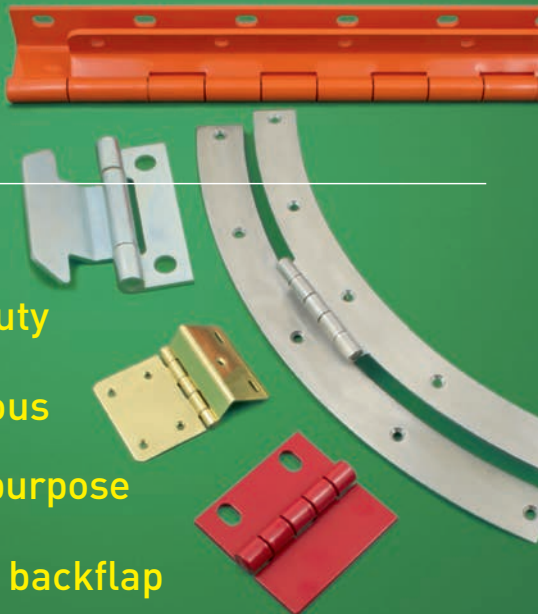
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# Movements in technology

Focusing on significant developments around the world to improve vehicles and robots

## Schaeffler

**A highly manoeuvrable vehicle is being developed by the German automotive and industrial group**

**A** concept autonomous urban vehicle developed by engineers at German automotive and industrial group Schaeffler boasts an innovative compact wheel module that combines both the drive and chassis components of the vehicles. According to the firm, the so-called Schaeffler Mover's Intelligent Corner Module enables a high degree of vehicle manoeuvrability and could potentially be implemented on a range of different vehicle type.

This module is installed in all four wheels of the vehicle and includes the wheel hub motor; wheel suspension, including the spring system; and the actuator for the electromechanical steering system.

The steering system of the wheel module is designed as an electromechanical steer-by-wire system. The wheel suspension design selected enables a steering angle of up to 90 degrees. This allows the vehicle to be manoeuvred in narrow alleys and to be parked in short parking spaces. Its turning radius of less than five metres makes the vehicle

extremely manoeuvrable in city traffic and even turning on the spot is possible.

The traction motor of the wheel module has been designed as a permanently-excited synchronous motor and is a variant of the wheel hub motor already developed by Schaeffler in a development project in 2013.

In the current design for the Schaeffler Mover, each of the four electric motors – with 300V operating voltage – supplies a continuous output of 13kW and a temporary peak output of 25kW. The nominal torque of 250 Nm per motor can be doubled for short periods.

A specially-developed driving dynamics control system enables individual control of each Intelligent Corner Module and the combination of the functions of the driving dynamics control system (ESP), the distribution of torque between the driven wheels (torque vectoring), and all-wheel steering.

The feasibility study, which can be seen at the 11th Schaeffler Symposium, will be developed by Schaeffler in the coming months. There are plans to produce a roadworthy prototype, including the cabin and air conditioning, during the course of the year.

### One platform – many possibilities

The Schaeffler Mover with wheel-hub drive provides a flexible and zero-emissions platform for diverse vehicle concepts. All drive and suspension modules are installed in a single unit, the "Schaeffler Intelligent Corner Module." The module is easily scalable in terms of vehicle length and width as well as for maximum space for new cabin concepts.

### SCHAEFFLER

#### 01

#### Maximum manoeuvrability

The Schaeffler design permits a steering angle of up to 90°. This results in enormous agility of the vehicle and also makes parking maneuvers possible with minimal space requirements.

#### Variable vehicle concepts

The vehicle's platform, the "Rolling Chassis," houses the entire drive technology. Various body versions for passenger and cargo transportation can be installed on top of this platform without any modifications of the drive system and suspension.

#### Intelligent Corner Module

Steering motor with transmission  
Volute  
Spring and damper  
Wheel-hub drive

#### Various body versions

"Rolling-Chassis"



## Maxon

**Meeting challenge of improving flexibility of a surgical robot**

**W**hen it comes to gearheads, Maxon Motor has produced customised assemblies for every type, be it planetary, spur, worm or spindle. Take the example of Maxon's gear projects team, who were approached by a customer who had designed a mechanical actuator assembly using standard Maxon Motor gear combinations for a surgical robot.

The actuator was quite complex, with a total of seven motors and gearboxes. The Maxon team saw an opportunity to make the system smaller, more reliable and more efficient. They created a concept for a completely new actuator assembly. Maxon not only incorporated the most effective standard custom gear trains and worm gears, but also redesigned the entire actuator assembly. This assembly included six motorised actuator levers, which control the fine movements of the robot's medical instruments, and a motorised track system, which allowed forward and backward movement of the medical instruments.

Working with Maxon sensor and control specialists in Switzerland, a drive train with high accuracy and high signal resolution was designed. The new drivetrain, which still had to fit within the existing customer design constraints, is half the original size and subsequently much lighter but simultaneously more robust.

Similarly, the team developed a special low backlash gear motor system (lower than 0.05o) for smooth motion with high power density. A typical application for this system would be as a prosthetic 'wrist' rotator or various joints for prosthetics, as well as for robotics. This design is especially compact, flat and features a hollow centre shaft so that additional cables or wires can pass through.

The gear projects team won the 2018 Automation & Motion Control: Robotics award at the Golden Mousetrap Awards for the development of a superior knee joint for an exoskeleton. The drive system uses a Maxon EC 90 flat motor with a planetary gearbox and magnet encoder.

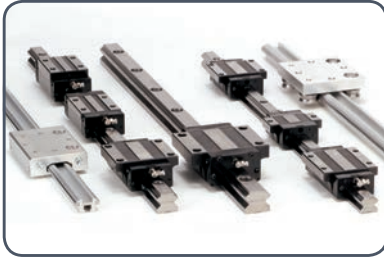


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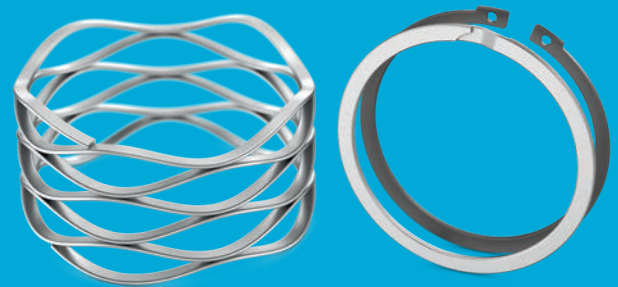


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**Adhesives offer attractive and flexible options for the bonding of decorative elements to vehicles**

**C**ar buyers expect high standards in their purchase, and these days the plain, unadorned look won't do. From emblems on steering wheels to chrome rings around ventilation slots and wooden mouldings on doors, decorative elements are an important feature of car interiors and are often attached with adhesives. These offer additional safety, as they prevent the overlying element from shattering or splintering in accidents, and offer an invisible method of fixing, unlike hooks, clips or screws.

Delo offers a range of adhesive systems suitable for automotive applications. One popular option is a single component epoxy resin. These can be irradiated for a short time in a 'pre-curing' process. The adhesive has a short 'open time' during which it remains liquid, allowing adjustment of the decorative element if

necessary to be certain it is in the right position. After irradiation, the adhesive cures solid in a few minutes. This allows opaque materials to be used for decoration, and is suitable for fully automated production processes, with only very

**"The adhesive has a short 'open time' during which it remains liquid, allowing adjustment"**

small quantities providing effective bonding.

The adhesive has a glass transition temperature of -65°C, so will remain flexible within the interior at the vehicle's service temperatures without becoming brittle.



**01** Delo provides adhesive systems

**02** Böllhoff's Rivkle rivet is perfect for climbing walls



## Supplier: Böllhoff

**Rivkle rivet takes climbers to new heights in complete safety**

**O**ne of the UK's fastest-growing sports, indoor climbing requires skill, strength and patience. It also demands a fairly unique infrastructure and some robust engineering, in particular when attaching climbing handles to the indoor walls.

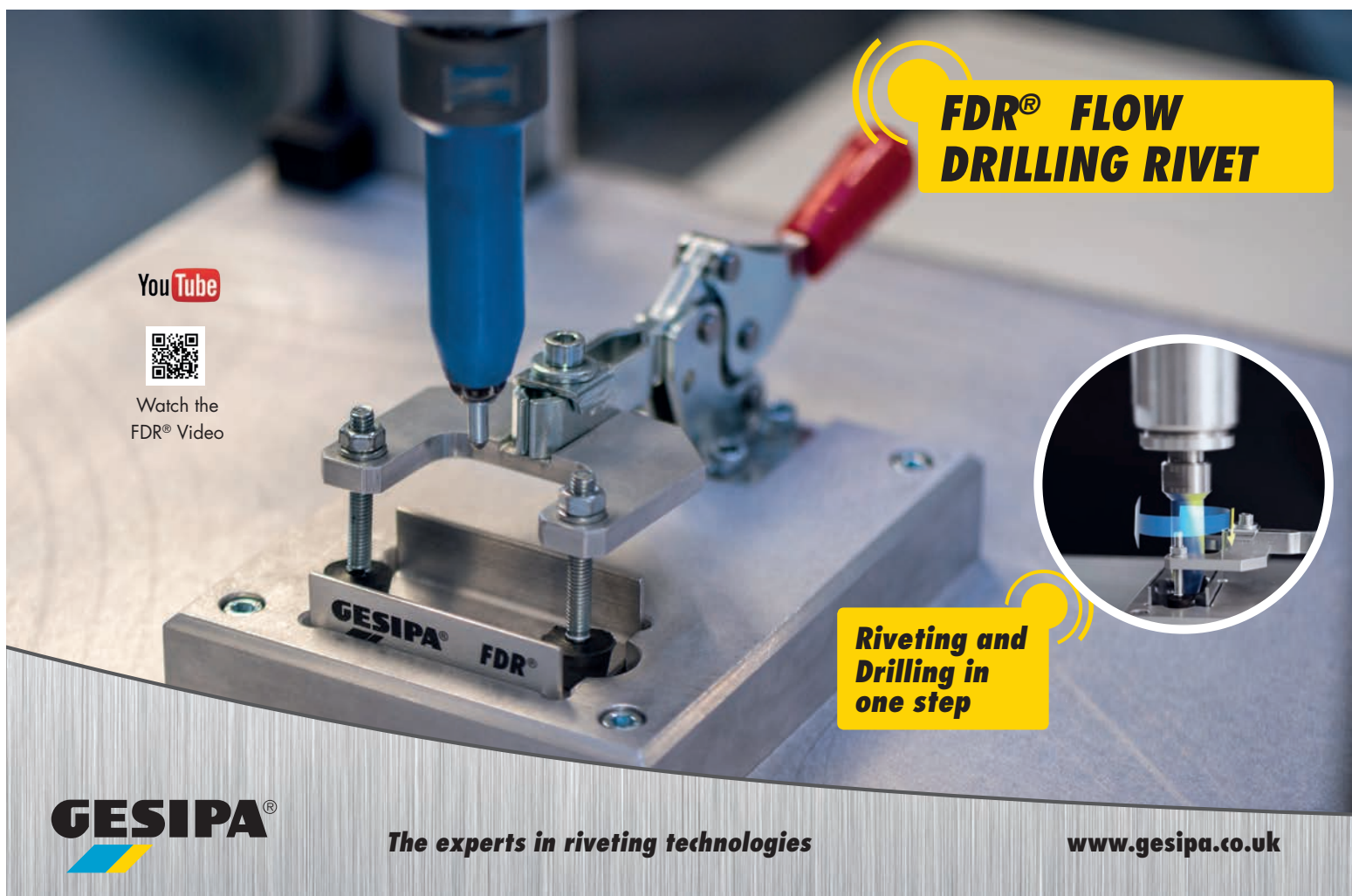
To this end, Böllhoff Fastenings has been supplying its Rivkle blind rivet nuts to climbing centres, helping climbers around the world stay fit and safe. The application calls for significant features. The rivet must be a high strength, dependable fastening capable of firmly attaching climbing handles to a polyester or fibreglass wall. But indoor walls are frequently reconfigured to keep the climbing experience fresh, so handles need to be removed and reinstalled constantly.

This 'switchability', coupled with the demand for high pull-out strength and fastening integrity, presented a unique challenge to the Böllhoff engineering team. It tested a variety of potential solutions prior to delivering a proposal that saw M10 Rivkle rivet nuts specified as the safest and most practical solution for attaching the handles.


According to Böllhoff, Rivkle was developed specifically for applications requiring a high load-bearing (threaded) blind fastening with exceptional pull-out resistance when used in thin-walled materials – as here with the climbing wall. Essentially a rivet nut set into a special elastomer or thermoplastic material, Rivkle is inserted into a drilled hole in the host material and held in place by unique clamping nodules until the threaded fastener (in this case attaching the climbing handle) is torqued up as required.

Since the metal part of the nut is only joined to the elastomer in the lower area of the fastener, as it is tightened a bulge forms against the inner face of the host material. This feature helps to provide the load distribution and pull-out resistance that makes Rivkle such a good fit for climbing walls.






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# A glimpse into the future of engineering

**Top industry experts to share their insights on trends and opportunities in three-day event at Birmingham's NEC**

**T**he Engineer's 2018 conference, which runs from 5-7 June at the NEC, Birmingham, features a number of UK industry's most prominent engineers, as well as insight into some of its most inspiring projects and the technologies and trends that are shaping the future of UK engineering and manufacturing.

Keynote speakers include Rolls-Royce CTO Paul Stein, who will be talking about the disruptive technologies that are shaping the aerospace sector; McLaren Applied Technology CTO Dr Caroline Hargrove, who will explain how the lessons learned in motorsport are being applied to fields as diverse as healthcare, manufacturing and energy; and GKN Driveline CEO Phil Swash, who will be talking about the irresistible rise of automotive electrification.

Running across three days in two theatres, the conference features 36 different sessions touching on topics such as innovation strategy, manufacturing and supply chain management, digitalisation, driverless cars, robotics, augmented reality, Blockchain and 3D printing.

A key theme this year is cross-sector collaboration and technology transfer, and delegates will be able to gain valuable insight on how to tap into innovations from other sectors, as well as how to effectively collaborate with specialists from different disciplines.

Alongside McLaren's Dr Hargrove, we'll also be hearing from McLaren rival Williams, with a presentation from Williams Advanced Engineering's technical director Paul McNamara. Staying on tech transfer, BAE Systems' Dr Henry White will explain how technology from the defence sector is being applied to the world of sport.

Other programme highlights include cybernetics specialist Nadine Stech, senior designer of Linx, the world's most intelligent prosthetic limb; celebrated UK supercar developer Neill Briggs; as well as Fujitsu UK CTO Graeme Wright, who will explain how Blockchain can be applied to the engineering supply chain.

Visitors will also be able to hear about the latest developments in driverless cars from Jaguar Land Rover's head of autonomous projects Mark Cund, and from Microsoft director Leila Martine on applications of the company's HoloLens mixed reality technology.

On the manufacturing side, the conference programme will cover everything from the practicalities of implementing Industry 4.0 technology to the latest developments in 3D printing, composite materials and advanced metrology technologies.

Highlights include Xaar's Prof Neil Hopkinson, who will explore how manufacturers can use 3D printing for part production; AMRC's head of digital Prof Rab Scott, who will explain how SMEs can tap into Industry 4.0 opportunities; Prof Dame Jane Jiang, who heads up the EPSRC's Future Metrology hub; and Cranfield University's Director of Manufacturing Prof Raj Roy on the cybersecurity challenges presented by the connected factory of the future.



The Engineer Conference runs alongside The Engineer Expo and Subcon 2018.

Subcon is the UK's only dedicated event for contract and subcontract manufacturing. It covers all sectors and technologies and allows subcontract manufacturing buyers to source suppliers, benchmark capabilities, and form new manufacturing partnerships.

The Engineer Expo is a new event dedicated to providing UK engineering professionals with the latest in-house manufacturing and design solutions, alongside developments in advanced engineering technologies. The show provides a unique platform for engineers to source the latest advanced engineering technology, products and services, enabling them to optimise production and process throughout the manufacturing cycle. ■

**01** In prospect:  
electric  
aircraft

**02** Futuristic:  
Williams' FW-EVX  
concept

**The two shows run together at the NEC from 5-7 June 2018. Visitors can register at [www.subconshow.co.uk](http://www.subconshow.co.uk). A pass to Subcon gives visitors free access to The Engineer Expo and Automechanika Birmingham.**



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# Uniting all sides of the motor industry

## Invaluable opportunity to reconnect with suppliers

**R**unning from 5-7 June at the NEC, Automechanika Birmingham will bring together over 150 suppliers with automotive engineers and purchasing teams from the UK vehicle manufacturing sector.

Companies exhibiting include Bosch UK, Magal/Arlington, TR Fastenings, Schmidt Light Metal, Pritex, Keyence, Autocraft Drivetrain Solutions, COBA Plastics and many more. The Society of Motor Manufacturers & Traders (SMMT) and the Motorsport Industry Association (MIA) will have their own member pavilions during the exhibition, too.

Hall 6 is the dedicated area for tier 1, 2 and upstream manufacturers to showcase technological advancements and solutions for the vehicle production sector.

Simon Albert, managing director of Automechanika Birmingham, commented: "Every year, we create a great networking platform for the UK automotive industry. This June, we have introduced new features showcasing future technologies, advancements in high-performance engineering, as well as connected and autonomous vehicles, electrification, ultra-low emissions and battery technology. It really is an invaluable day out of the office to reconnect with new or existing suppliers and learn what lies ahead for the future of the automotive industry."

The exhibition will offer visitors a series of high-level forums and seminars delivered by industry heavyweights and innovators covering topics such as Innovation, Tomorrow's Mobility, UK Automotive, Skills, Advanced Manufacturing and Logistics. Speakers will come from the SMMT, Industry Forum, the Automotive Council, the Institute of the Motor Industry (IMI), the MIA and more.

Also new this year is the Motorsport Valley Innovation, presented by the MIA sponsored by Stäubli, which will deliver an exciting showcase of the newest technologies of high-performance engineering. It will bring together



automotive OEMs and Tier 1 suppliers with members of the motorsport and high-performance automotive industry.

The organisers are working closely with Innovate UK, Knowledge Transfer Network who will present a new feature called Tomorrow's Mobility, a dedicated area showcasing the UK's capabilities with the latest technologies in connected and autonomous vehicles, electrification, ultra-low emissions and battery technology.

In addition to the suppliers and new features on the show floor available all three days, Thursday 7 June will deliver a Future Skills Day, a series of initiatives to cater for anyone with an interest in skills, training and development. The day will be specifically focused on future training priorities of the emergent technologies and how to address the industry skills gap.

Automechanika Birmingham is held in association with the SMMT, who will once

again be hosting their flagship events: Open Forum on the 5 June, and Meet the Buyer on 6 June. From supply chain presentations to connecting buyers with suppliers, their presence at the show offers huge opportunities to network and improve your business.

Connecting with suppliers is another focus of the organisers at Automechanika Birmingham, who have introduced a facilitated meetings programme. The software matches visitors' interests with the capabilities of suppliers to increase relevant business conversations on stands.

As last year, the show will be held at the same time as Subcon, the UK's premier subcontract manufacturing supply chain show. Visitors need only register once to enter both events. ■

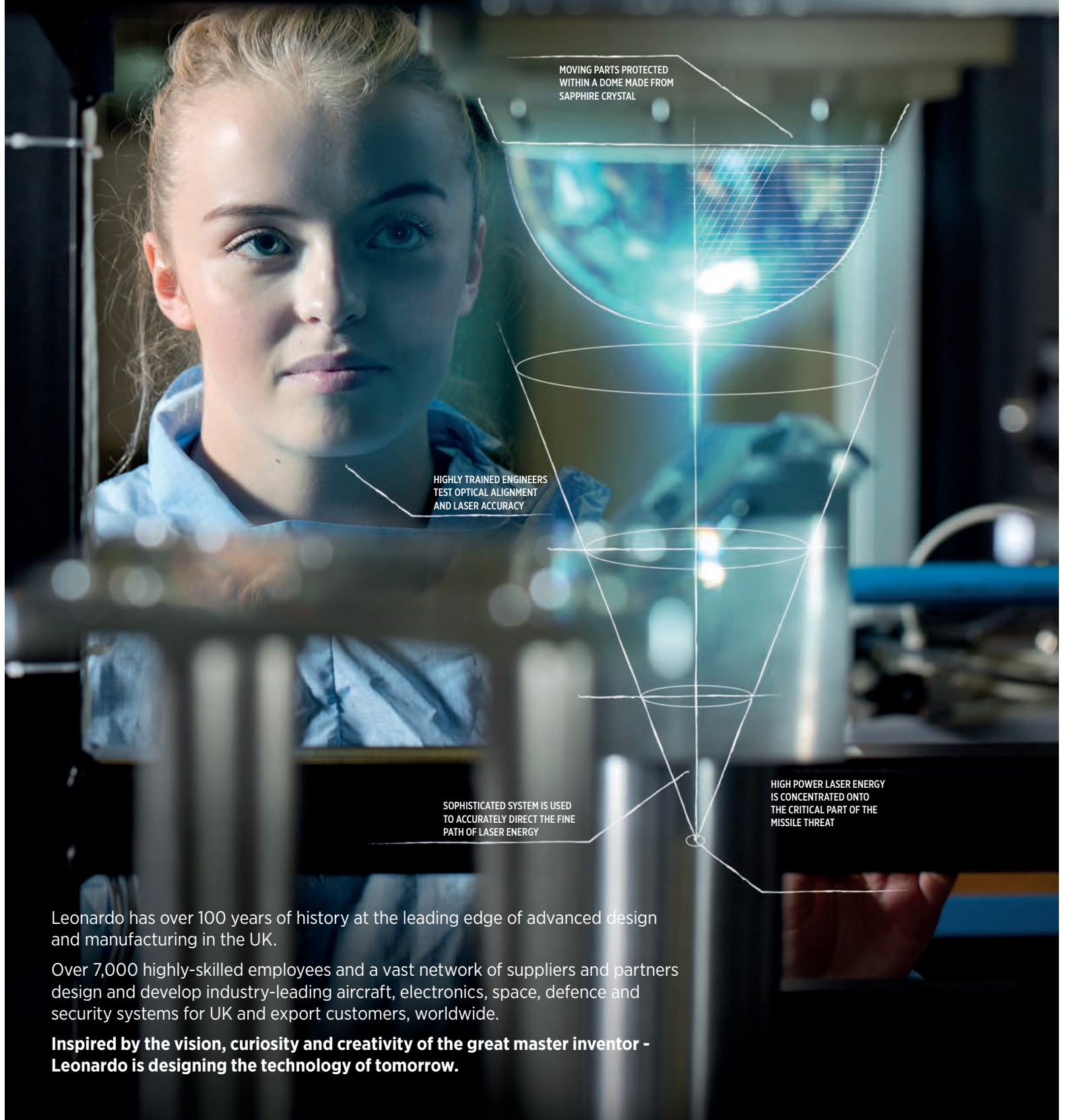
**Register free today at:**  
[www.automechanika-birmingham.com](http://www.automechanika-birmingham.com)

**01** The show provides a networking platform for the entire automotive industry

**02** Seminar topics will include future mobility, skills and logistics



# Over 100 years invested in the UK's future



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

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

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

## Sherwood Aluminium chooses Emmegi (UK) as machinery partner

### Tekna 4-axis CNC machining centre added to Emmegi Comet T6HP Sponsor: Emmegi (UK)

Emmegi (UK) proved its strength as a machinery partner to Wolverhampton based Sherwood Aluminium, with the supply of a four axis CNC machining centre from Tekna.

In recent years, the global Emmegi group has acquired both the Tekna and Keraglass machinery businesses, extending the options available to customers.

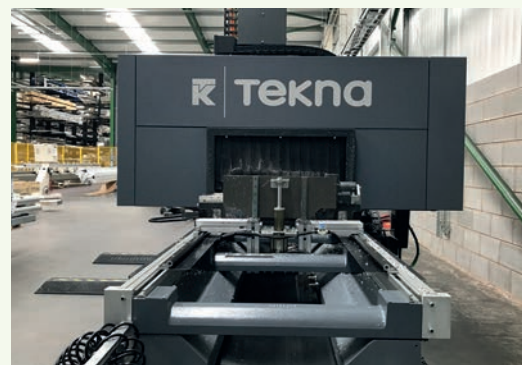
Sherwood wanted a flexible machine with a larger capacity than its existing Emmegi Comet T6HP machining centre for drilling, milling and threading, and needed it to be compatible with a Renishaw probe.

Emmegi (UK) recommended the Tekna 944, which can accommodate the Renishaw probe, and has a number of

other significant benefits as well.

The 944, with a mobile gantry and 8kW high torque, electro spindle, is suitable for heavy duty machining of large sections of aluminium and steel. The electro spindle moves along the A axis, allowing machining through a full 180° around the section.

It can travel up to 7000mm machine in the X axis and meets Sherwood's specific requirement of a wide workable section, with travel in the



Y axis going to a maximum of 1,070mm. A clamp unit ensures the correct positioning of the sections even at this extended width and counterblocks can be mounted quickly and accurately.

A 12 piece tool magazine mounted on the gantry gives customers maximum flexibility and reduces tool change times to optimise productivity and efficiency.

## CRP Technology reinvents the Energica dashboard

### Professional 3D printing and Windform® composite material. Sponsor: CRP Group

In Modena, motor valley of Italy, the first high-performance full electric motorcycles Ego was born in Energica Motor Company S.p.A. Ego was developed using CRP Group's know-how.

Right from the very start, the Energica team endorsed the idea of creating an innovative dashboard capable of containing, protecting, and isolating cutting-edge and very complex electronics: the studies and tests conducted by Energica, led to the creation a 4.3" dashboard made up of a display with 16.7 million active matrix colours that provides excellent visibility.



The Energica team worked with the injection mould supplier to develop the dashboard. Both took advantage of the support and expertise of CRP Technology, the CRP Group company leader in the field of professional 3D printing.

CRP Technology produced three functional prototypes, using Laser Sintering technology and Windform® LX 3.0, a polyamide-based composite material reinforced with glass-fibres from Windform family of materials created by CRP Technology.

On all three prototypes the development and validation activities of the components and the verification of the design solutions were carried out applying specific test plans aimed at verifying both the full correspondence to the functional needs and compliance with the quality and reliability objectives required.

The use of Laser Sintering technology and Windform® LX 3.0 enabled Energica to be on the market quickly, accelerating the prototyping and product development phase.

## Riveting and drilling in one step

### GESIPA® FDR® Sponsor: GESIPA®

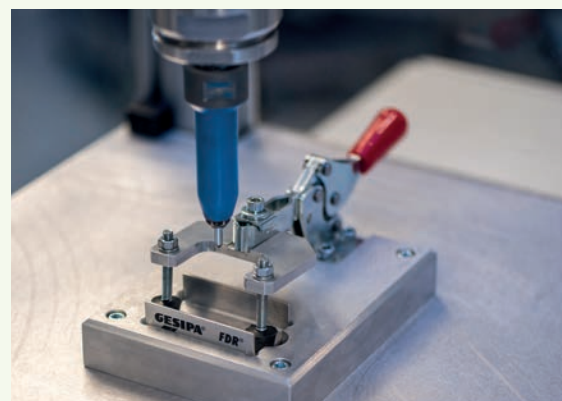
FDR® is a riveting technology by GESIPA® that combines the mechanical joining technology of flow drilling a hole and riveting an application in a single step.

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

The specially designed rivet head, rotation and joining force enables the new blind rivet to pierce

light metals as well as plastics. Proven GESIPA® technologies such as the jaws system and three window process monitoring have also been integrated into the development of the automated processing tool. This brings together both functionality and reliability saving cost and time in the application process.

This technology provides many solutions for the joining of different



materials for example, a material mix of high-strength steel, light metal as well as carbon fiber materials and is therefore a step forward in the automation industry.



# Overtaken by Europe

## 1956

**The Engineer was abroad to assess the UK's car industry**

**T**he UK's strong showing at the 1956 Geneva Motor Show failed to mask a self-inflicted malaise befalling Britain's carmakers.

The 2018 edition of the automotive showcase witnessed over 110 world and European premieres alone, along with 180 exhibitors displaying their wares. By contrast, and just over a decade after the end of the Second World War, the 1956 show hosted 82 makes of car with the UK contributing 29 models to the line-up.

"This impressive number indicates that the British motor industry is fully aware of the importance of the Swiss market and, generally speaking, of the necessity to increase its export drive on the Continent," wrote *The Engineer's* correspondent.

But while the UK had the numbers, they did not necessarily have the products that would allow them to compete with European manufacturers, specifically those from a resurgent Germany, which was 'probably the greatest motor exporter of the world' by 1955.

Volkswagen in particular was singled out for reinvigorating market interest in its pre-war 'people's car' – known latterly as the VW Beetle – by building up an organisation, offering cheap and easily available after-sales service and fixed-price maintenance, thereby establishing a dealer-to-customer relationship equal to the best American standards.

"Further, cleverly conducted propaganda has greatly assisted in eliminating any inferiority complex the owner of a small, inexpensive and not particularly stylish car might feel, by stressing such points as unfailing reliability, longevity and so on," wrote our correspondent.

At the time of writing, VW were producing around 1,400 Beetles a day and had sold approximately 50,000 to Swiss customers alone. In 1947 Britain sold 8,257 cars to Switzerland (30 per cent of demand) but by 1953 this had dropped to 11 per cent and remained around that figure in the following two years due largely to the reappearance of continental competition.



**The British had lots of models on show, but competitors on the Continent were catching up**

year sold 10 per cent more units of the Taunus than of four British models, and the General Motors Corporation sold eight-and-a-half times as many Opels as Vauxhalls.

"This rather striking discrepancy is partly due to the fact that many accessories and components, especially in the electric equipment, are to a great extent standardised on the Continent, so that spare parts and service facilities are available almost everywhere."

To compound matters further, the UK's automotive sector was perceived as having become complacent despite being reliant on exports. While British cars were seen as mechanically sound and reliable, the added extras – once marketable in a relatively uncompetitive marketplace – were becoming standard.

"Perhaps the most serious criticism, however, is made against the general attitude of the British motor industry which, so far, has taken little interest in the European market and is still regarding suggestions from abroad as idle ill-conceived interference," our correspondent said.

"Swiss dealers, indeed, more or less imply that British motor manufacturers seem to be more concerned in producing vehicles which customers at 'home' in Australia, New Zealand and other Commonwealth countries are just content to put up with, than cars which are acceptable to all world markets."

Another stumbling block – among many – was the general perception of British cars, which were seen as out of date.

"For this lack of initiative they blame the older generation of automobile constructors, which does not possess the artistic flair of the French designer, the scientific thoroughness of the German research worker nor the aesthetic talent of the Italian stylist," concluded *The Engineer's* reporter in Geneva. JF

## Word of the issue

### Anthony Poulton-Smith explores origins of the word 'tyre'

The pneumatic tyre was first patented in 1847. But this was not the first tyre, for centuries earlier the word had been applied to other protective covers on wooden wheels of carts and waggons, first made from leather.

Later, the tyres were of metal. By heating, the metal expanded and, when fitted to the wooden wheel, quenching contracted the metal. So the tyre provided a protective cover and pulled the wooden pieces together.

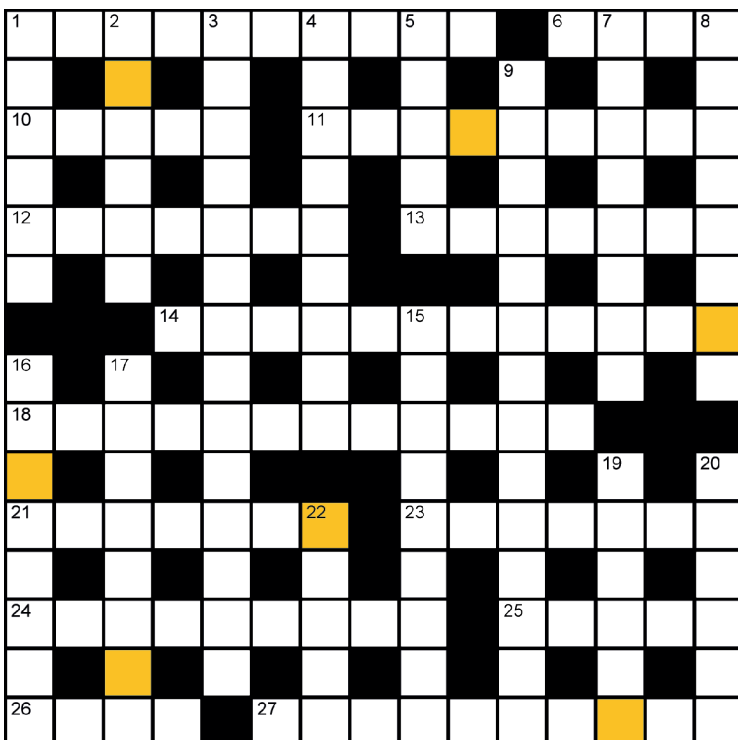
Neither of these processes may be seen relevant to the etymology, yet both demonstrate how the word came into being. The first written mention was around 1300, when recorded as 'tire' and, derived from 'attire' for it was seen as a way of dressing the wheel. Note also the spelling is 'tire' and remained so in Britain until 1840 when 'tyre' came into use for railway wheels only.

This will come as something of a shock for those who see spellings used by our American cousins as 'wrong'. In fact, 'tire' remained the preferred spelling in *The Times* until 1905.

# Bigpicture



Airbus' new Ultra Long Range variant of its A350 aircraft has taken to the skies for the first time, ahead of entering service on the world's longest passenger route. The Ultra Long Range Airbus A350 XWB made a short maiden flight from Toulouse-Blagnac Airport as part of a test programme. The aircraft will have a range of 9,700 nautical miles.



## Prizecrossword

**When completed** rearrange the highlighted squares to spell out a large and imposing house. The first correct answer received will win a £20 Amazon voucher. Email your answer to [jon.excell@centaur.co.uk](mailto:jon.excell@centaur.co.uk)

### Across

- 1 Device that regulates temperature (10)
- 6 Active volcano (4)
- 10 Method of detecting aircraft (5)
- 11 Underlying structure (9)
- 12 The state of being more than full (7)
- 13 In the normal manner (2,5)
- 14 Gears that transmit power from an engine (12)
- 18 Routes intersecting a main road (5,7)
- 21 Landing strips (7)
- 23 Distinct form of a species adapted to a particular environment (7)
- 24 An authorisation to sell a company's goods (9)
- 25 To drive forward (5)
- 26 Part of camera (4)
- 27 Temperature measurement on the Celsius scale (10)

### Down

- 1 Push forcefully (6)
- 2 Last and be usable (6)
- 3 Information on consumer preferences (6,8)
- 4 Guarantee of professional or financial security (6,3)
- 5 Girl's name (5)
- 7 Measurement of weight (4,4)
- 8 Having a pH greater than 7 (8)
- 9 Making a formal request for official services (14)
- 15 World's highest peak (2,7)
- 16 Expressing extreme contempt (8)
- 17 Artificially produced flow of water (8)
- 19 Eyesight abnormality (6)
- 20 Force, power (6)
- 22 Move smoothly along a surface (5)

April's highlighted solution was Stretcher. Winner: **Alan Tinker**



Awards Entry Deadline 28<sup>th</sup> May 2018

# **ENGINEER** collaborate to innovate

## Celebrating the best engineering collaborations and innovations

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

### Enter collaborative projects in 10 categories



AUTOMOTIVE



AEROSPACE



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DATA &  
CONNECTIVITY



HEALTHCARE &  
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