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## Ground control

Advanced taxiing systems are helping reduce aviation's emissions impact

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The hybrid powertrain system that promises to clean up the UK's ageing bus fleet

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## Subcon preview

A look ahead to June's Subcon exhibition and conference in Birmingham



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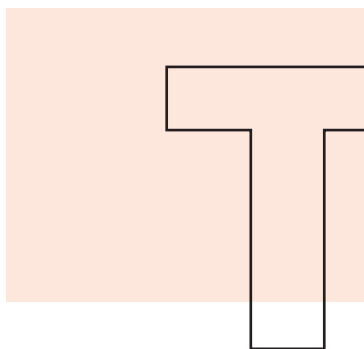
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## our opinion

# From side to side



The crucial vote on the UK's future in Europe is now just weeks away. As we've consistently reported, there are strong views on both sides. And while it seems to us that the industry consensus favours remaining in Europe, it's also clear that many readers are still undecided on whether a 'Brexit' will be good or bad for the UK economy, and specifically its manufacturing and engineering sectors.

In our previous issue (April 2016), EEF chief Terry Scuoler outlined the manufacturing case for remaining in Europe. Citing his organisation's own poll on the debate – indicating that more than 80 per cent of EEF members

want to stay in Europe – he mounted some familiar arguments: with half of all of the UK's trade going to the EU, membership benefits large and small manufacturers; underpins the UK's world-leading research base; and cements our status as a critical route into the European market for some of the world's biggest companies.

This issue, in the interests of balance, Simon Boyd from Dorset-based SME REIDSteel outlines the case for leaving (p14). He argues that while large multinationals with the clout to lobby in Brussels may benefit from EU membership, SMEs – who form the bulk of the UK's manufacturing base – are less well served, and that the bureaucratic costs of doing business in the EU far outweigh any advantages.

Not all SMEs will agree – indeed there are some in this issue's Subcon preview

"It's clear that many readers are still undecided on whether a 'Brexit' will be good or bad for the UK"

(p56) who fear an exit from Europe, but Boyd's arguments will undoubtedly resonate with some. As always, we welcome all of your views on this emotive and divisive topic.

Elsewhere in this issue there's a distinct aerospace theme to proceedings: from our feature on the taxiing technology that's helping further improve the efficiency of aircraft (p25), to our report on the way in which cloud-based design tools are beginning to drive radical change in this most conservative of sectors (p20).

Finally, please do take a few minutes to check out our new awards scheme, Collaborate to Innovate, which is seeking to uncover and celebrate some of the UK's most exciting engineering collaborations.

To find out more, and to enter this prestigious competition, take a look at: <http://conferences.theengineer.co.uk>. The deadline for entries is 31 May. ☺

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AEROSPACE

# Hybrid looks set for future skies

Hybrid-electric aircraft could help control emission levels HELEN KNIGHT REPORTS

**H**ybrid-electric aircraft that produce lower emissions than existing aircraft could be in the sky by 2030, as a result of a collaboration between Airbus and Siemens.

The companies have launched a joint project to investigate various hybrid/electric propulsion systems by 2020, in a bid to determine which are the most technically feasible, and how soon they could be applied to aircraft, according to Martin Nuesseler, head of e-aircraft systems at Airbus.

"We are targeting a significant further fuel reduction on top of the improvements we will reach in the next years by incremental optimisation of existing systems," he said. "In the years 2030 and beyond our project could gain an additional 30-40 per cent step in carbon fuel reduction."

Airbus is working on efforts to investigate electric aircraft, including its E-Thrust with Rolls-Royce, which has developed a concept vehicle based on distributed propulsion.

The concept centres on a single large gas turbine, which would generate electricity to power six electric fans producing thrust. Such a system could significantly reduce emissions and improve fuel efficiency, and offers scope for greater flexibility in the design of aircraft.

"But what is missing are the technologies to support this idea," said Nuesseler. "So this is a gap we would like to close with this project, to determine if the technologies are feasible, does the performance support such a concept, and in what timeframe?"

The 200-strong project team will develop prototypes for the different propulsion systems, which will be designed for aircraft of power classes ranging from a few hundred kilowatts up to 10 or more megawatts, said Dr Frank Anton, head of electric aircraft at Siemens Corporate Technology.

"We are looking at all those technologies that, in the long run, will be able to propel large aircraft, of 60-100 passengers, over distances of around 1,000km," he said.

The companies expect the aircraft to enter commercial operation by around 2030, added Anton.

One of the biggest challenges will be in achieving a sufficiently high power-to-weight ratio for the drive system, said Anton. "The power electronics, electric motors and generators will need to improve by a factor of 10," he said.

A second challenge will be to make the technology work in the harsh environment of an aircraft, where it will be subject to low temperatures, wind, rain and cloud, said Anton.

"In order to do that we have to look at all sorts of new technologies, including possibly superconductivity for some of the components," he added.

A further challenge will be in transporting the electric current from the gas turbine in the body of the aircraft to the motors under the wings, without adding too much additional weight. So lightweight cables will be needed to transport the electricity, said Anton.

Siemens last year unveiled a 50kg electric motor with a power output of 260kW, or enough to power a two-tonne, four-seater electric aircraft when used in conjunction with a small jet engine. This particular motor has a power-to-weight ratio of 5kW/kg, or a factor of five higher than existing industrial motors.

Since then the company has begun installing the motor into a flying testbed, in order to investigate how it performs in flight. The technology is also being scaled up to larger motors of around 1MW. ©

Hybrid electric aircraft will bring significant fuel savings



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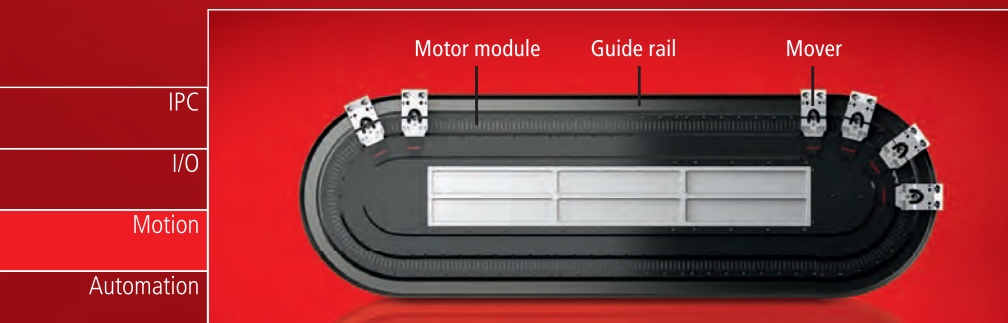


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## MATERIALS

# Melted moves into car components

Upscale casting process could lead to lighter recycled parts

GLYNN GARLICK REPORTS



Cars could be made 40 per cent lighter

**R**esearchers aim to upscale casting techniques so industry can make lighter and completely recyclable car components.

They aim to scale up research at Brunel University London's Brunel Centre for Advanced Solidification Techniques (BCAST) and the Liquid Metal Engineering Centre led by Prof Zhongyun Fan.

He and his team have shown it is possible to condition molten aluminium alloys using melt shearing to produce

castings with a much finer grain structure, so car components can be made up to 40 per cent lighter.

BCAST deputy director Dr Ian Stone said: "One of the problems with liquid metals is that they contain oxide, so their surface oxidises and that oxide gets entrained within the liquid metal. It tends to act as a crack, so the industry spends a lot of time trying to remove oxide."

"The high shear process applies very high shear forces to the liquid metal and that disperses those oxide films into very fine sub-micron particles," he added.

"Partly by breaking that oxide up into very fine particles you make the oxide more benign, because it is not in a film form, and those oxide particles can act to enhance the nucleation of the grains as they solidify. By enhancing the nucleation you get more grains and therefore they must be finer."

The team uses a high shear rotor stator device, which uses a rod with a small rotor on the end that sits within a fixed cylindrical stator.

"We spin the rotor at high speeds, let's say 5,000rpm," Stone said.

"That sucks the liquid metal up into the device, and then applies the high shear between the rotor and the stator. It then pushes the liquid metal out through little holes in the walls of the stator, so you get recirculation of the liquid. That causes the oxide films to be dispersed into the small particles and when you solidify, those particles act as a nucleating agent. You are doing this to liquid metal, not during the solidification process.

"It means you can do a lot of recycling, because you are using that oxide rather than having to downcycle your material. It also allows us to remove iron, which is one of the major impurities when you recycle."

Melt shearing is one of three methods being looked at by BCAST researchers to improve casting techniques, the others being grain refinement and ultrasound. Other work is aimed at making stronger and more ductile alloys.

Researchers will be able to test under industry conditions at Brunel's new £17m research facility, the Advanced Metal Casting Centre, which was officially opened on 7 April 2016. ©

## Newsinbrief

### Counting the losses

The UK could lose strategic influence on EU science policy in the event of a Brexit. This is one conclusion of a report from the House of Lords Science and Technology Select Committee, which said Britain plays a leading role in the development of EU policies that relate to science and research, but expressed concern over the poor level of engagement by large businesses in securing EU funding.

### Indigenous potential

Nuclear AMRC has found that Britain has the advanced manufacturing capabilities to build critical systems for a small modular reactor (SMR). Nuclear AMRC examined Westinghouse's SMR, focusing on the reactor pressure vessel (RPV), which contains the reactor coolant, core shroud, and reactor core. Westinghouse's use of indigenous advanced manufacturing techniques offers a potential 50 per cent reduction in delivery lead times.

### Steel for sale

Tata Steel UK is to sell its Long Products Europe business — including the Scunthorpe steelworks — to Greybull Capital for a nominal fee. The sale includes two mills in Teesside, an engineering workshop in Workington, a design consultancy in York, and associated distribution facilities, plus a mill in northern France.

### Deep-space extension

NASA has awarded Aerojet Rocketdyne US\$67m to develop a new electric propulsion system for future space missions. The Advanced Electric Propulsion System (AEPS) will be designed to extend NASA's deep-space exploration capabilities, and is expected to be a key component of the agency's Journey to Mars and Asteroid Redirect Mission.

## PRODUCTION

## Project will be keeping tabs on steel production

Method could help improve upon competitiveness

GLYNN GARLICK REPORTS

A new method of assessing steel production could be set to boost the competitiveness of the UK and EU steel industries.

This is the aim of Dr Manuchehr

Soleimani from Bath University's department of electronic and electrical engineering, who is leading the Shell-Thick project to develop an induction tomography system for assessing steel solidification.

It aims to improve the continuous casting process of steel by providing a real-time, non-destructive and reliable method of measuring molten steel to detect defects as it solidifies.

Induction tomography is a non-invasive imaging technique already used in a number of applications, including medical diagnostics.

Soleimani, an associate professor at the university, said: "Magnetic induction tomography attempts to image the passive electromagnetic

properties of an object by measuring the mutual inductances between pairs of coils placed around its periphery.

"Measurements are acquired by passing an alternating current through excitation coils, producing a primary magnetic field."

The system will form a contactless bracelet around a billet of molten steel and take continuous measurements as the steel solidifies. It will visualise the electrical conductivity of the different states of the solidifying steel and provide an image of its structural composition as it cools.

By monitoring and altering the cooling process, the technique should improve the competitiveness of the UK and EU steel industries. ©

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MEDICAL

# Plasma pen gets beneath the skin

Treatment could be used to replace some surgical procedures HELEN KNIGHT REPORTS

A handheld plasma pen that fires ionised gas at damaged or unhealthy skin could be used to treat a range of conditions, from acne to diabetes.

The plasma pen could be used for cosmetic procedures such as skin cleaning and rejuvenation, and for sterilising long-term wounds, including diabetic ulcers and bed sores, without the risk of infection or the need for drugs.

The plasma treatment, which is non-invasive, could be used to replace some surgical procedures, and can significantly reduce scarring. It has been designed by product consultancy Triteq for Fourth State Medicine.

The technology behind plasma sterilisation is not new, and was first

used by NASA. However, unlike previous devices, the new pen generates a range of plasma states, depending on the medical application it is being used for, according to Ken Hall, managing director of Triteq.

"The handheld device consists of a hand-piece containing the plasma engine and nozzle," he said. "It has a connecting umbilical cord that supplies the gas and the electrical power to drive the plasma."

As the gas enters the device through this cord it flows across a special combination of electrodes within the nozzle, which are fed by a high-voltage power supply. The voltage between the electrodes ionises the gas, creating a plasma.


Varying the power fed to the electrodes results in different types of plasma. The plasma is then fired out of the nozzle onto the patient's skin.

At the end of the nozzle is a spacer and hygiene component, which ensures that the plasma is released at exactly the right distance from the skin for the treatment, said Hall. "You basically just run the nozzle over the area that you need to be treated," he said.

A control panel allows the medical professional to select the type of plasma required and the power level.

A foot pedal can also be used to switch the device on and off.

"With our in-house test facilities we have proven that the technology works, so we're now entering into the next stage, where we will create a version of the device suitable for medical use," said Hall.

Fourth State Medicine hopes to launch the product by mid-2017. 



Plasma pen will treat dermatological conditions

AUTOMOTIVE

## Good moves in the city

Car puts improvements in fuel efficiency and emissions onto the agenda

A lightweight concept city car from Shell has been predicted to offer dramatic improvements in fuel efficiency and emissions.

The Shell Concept Car, which has been developed through an initiative called Project M, is the result of close collaboration between engineers at Shell Lubricants; Formula One designer Gordon Murray; and Geo Technology, a specialist automotive firm established by former Honda F1 director Osamu Goto.

The project set out to demonstrate that by designing a car from scratch, and employing



The Shell Concept Car

a 'co-engineering' process whereby vehicle body, engine design and lubricants are all created together, it should be possible to achieve huge efficiency savings.

According to Shell, if the new concept car were to go into full production it would use around half of the energy usually required to build and run a typical small family car. **JE**

ROBOTICS

## So that robots can really take it all apart

Disassembly processes could get robotic input

GLYNN GARLICK REPORTS

Research into disassembly processes could lead to autonomous robots coming into use in the UK remanufacturing industry.

The EPSRC is providing £1.94m for the five-year project led by mechanical engineers at Birmingham University.

The researchers aim to gain an understanding of disassembly processes before developing systems that can autonomously handle variabilities in a product.

Prof Duc Pham, principal investigator, said: "In remanufacturing you need to take things apart as a first step. We want to understand how mechanically all the forces – the torques and so on – affect the success of the disassembly operation."

Tasks will include unscrewing, removal of pins from holes with small clearances, separation of press-fit components, extracting elastic parts such as O-rings and circlips, and breaking up of 'permanently' assembled components.

Feedback will be used to help guide the robot and avoid damaging the components being taken apart.



Feedback will be used to guide robots

The basic process knowledge will be used to create models, scheduling algorithms and learning tools to enable autonomous or semi-autonomous disassembly by robotic systems.

"We intend to make the robots collaborative, which means they can work with people safely and do not need to be put into cages," Pham said.

"We want to study these operations in order to help the design of products so that later on they can be taken apart more easily. That will make it a lot easier in the future for people or robots to take things apart," he added.

Strategies for planning and implementing multi-robot operations will also be developed, for when a disassembly task is too complex for one machine.

The disassembly research project is being run in partnership with manufacturers Caterpillar, Meritor and MG Motor, along with the High Speed Sustainable Manufacturing Research Institute and the Manufacturing Technology Centre. 



# Innovation Experience

Automotive application, combination of Windform Additive Manufacturing and high-performing CNC Machining. Courtesy of Ilmor Engineering



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## SECURITY

# Laser eyes are on crowded spaces

Device could be used to detect explosives in areas such as airports

HELEN KNIGHT REPORTS

A laser device that has been designed to detect traces of explosive material could soon be used to protect crowded spaces such as airport terminals from a terrorist attack.

The device, which has been developed at Loughborough University, can scan large numbers of people as they enter a building, for example, to spot anyone who has been in contact with explosives.

The ExDtect system, which was developed by Prof John Tyrer of the university's Wolfson School of Mechanical, Electrical and Manufacturing Engineering, uses a set of pulsed ultraviolet lasers to remotely scan people, luggage, cargo or vehicles for traces of a wide range of explosives.

As the ultraviolet lasers illuminate a target, they are designed to

to scan its cargo, and the team is also in discussions with several other organisations.

The laser device has been in development for 15 years. To develop the technology, the team first had to identify a type of laser system safe enough for use around people, said Tyrer. "Because we are operating around human eyes, for example, we needed relatively low power densities, and when we talked to our chemists it became clear that meant we had to

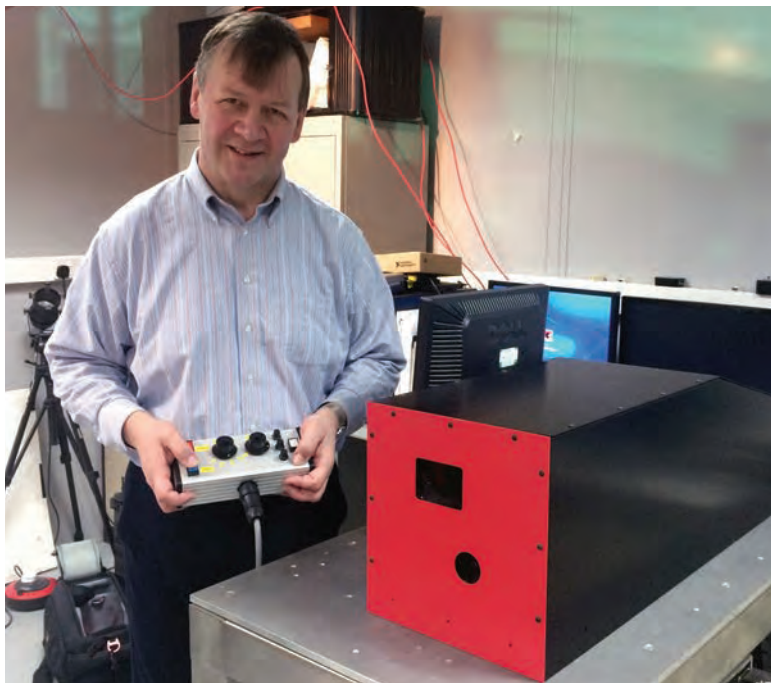
look at laser-induced fluorescence," he said.

The researchers have since been working on techniques to improve the performance of the device, and making use of more advanced laser and camera equipment as they have become available, he said.

To protect heavily populated areas such as airport buildings, the technology could be fitted into door frames, for example, to detect traces of explosives on people before they are able to enter, he said.

"Each door frame could house one of our inspection systems, and that would act as a deterrent, because you would be making it clear that everyone is guaranteed to be scanned," said Tyrer. "We could even package the door frames so that if the system detects explosives the person would be contained inside them," he added.

The system can also be easily updated to search for new types of explosive material, he said. ☺



ExDtect can be installed unobtrusively in airports

"Each door frame in an airport could house one of our inspection systems"

Prof John Tyrer

Loughborough University

specifically excite any explosive materials present, causing them to glow, said Tyrer.

The non-invasive, real-time device is fully automated, eliminating the risk of human error. It will soon be used by an international courier

## WEARABLES

## Unobtrusive approach to smart clothes

Shirt comes with sensors to monitor movement

HELEN KNIGHT REPORTS

Smart textiles that track their wearer's movements could be used to help monitor people's wellness.

However, it has been found that the technology is difficult to incorporate unobtrusively into clothing.

In light of this problem, a prototype smart shirt, equipped with sensors that monitor movement, is being developed by a team at Germany's Fraunhofer Institute for Silicate Research (ISC) in Würzburg.

The MONI shirt contains a transparent material printed with a piezoelectric polymer sensor paste.

The ferroelectric polymer paste is flexible, non-toxic, and registers any pressure and deformation, which allows the material to act as a touch and motion sensor.

The paste is also pyroelectric, meaning that it is sensitive to changes in temperature.

The polymer paste is deposited onto the fabric or surface using a screen-printing process. It is then applied to a screen, which is then placed onto the substrate, according to Dr Gerhard Domann, head of the competence unit for optics and electronics at Fraunhofer ISC.

"A squeegee or blade presses the paste through the screen, which is partly covered by photo-patterned coating, so that only on the positions where there is no coating on the screen is the paste transferred to the substrate," said Domann.

In order to ensure the process results in a good print, the paste must have a high viscosity, but act more like a liquid under pressure, said Domann. "Thus, the paste can be transferred easily through the screen, but after printing the material's viscosity increases, which helps to ensure the paste is not smeared," he added.

Once printed onto the material, the sensors are subjected to an electric field, which ensures the piezoelectric polymers all align.

Any change in the sensor's alignment caused by pressure or deformation will then generate an electric charge that can be measured as a voltage. ☺

## ENERGY

## Parking the running costs

Parked electric cars could be a source of power to help reduce railway energy bills

Engineers at Sheffield University are working with the rail industry to investigate whether batteries from parked electric vehicles could be used to help reduce railway running costs.

The team from the university's department of electronic and electrical engineering has received £1.5m

funding from the EPSRC to develop an energy-storage test facility at a site alongside a train line, the first of its kind in the UK.

It will examine two types of energy storage – batteries and supercapacitors – both as a hybrid solution for the high levels of electricity needed to power trains accelerating and to harvest charge from trains braking.

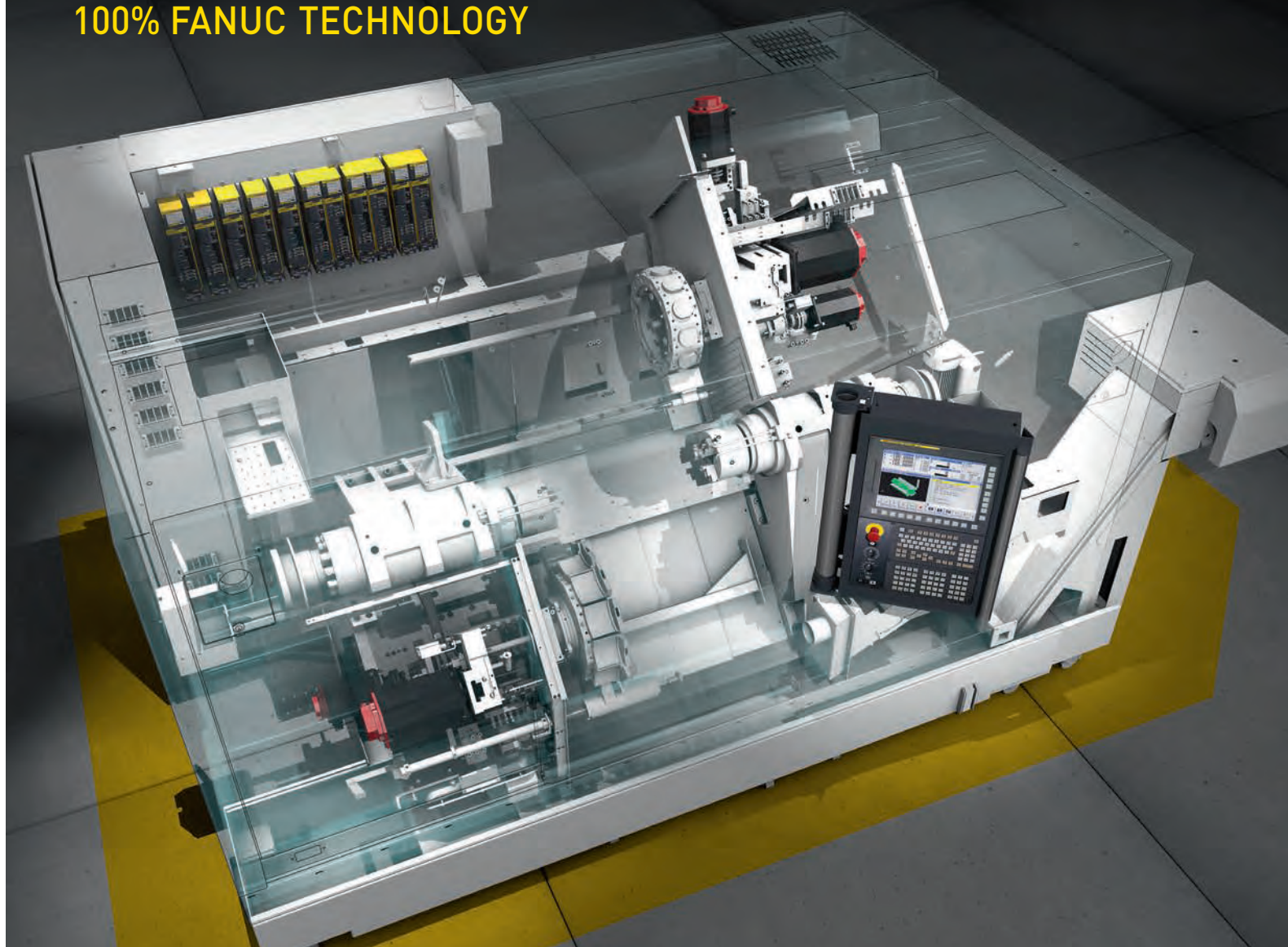
As train companies try to increase the frequency of trains on existing railway infrastructure, electricity supply is under greater pressure to be available at peak times. It is thought that the use of batteries could reduce the demand for electrical energy supply in these periods. JE



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## ENERGY

# Purity comes with a lower price tag

**New method could increase yield of ultra-pure hydrogen from coal and biomass** HELEN KNIGHT REPORTS

**D**emand for high-purity hydrogen is increasing thanks to its use in fuel cells for heat and power and transportation, and in industry, but producing the gas can be expensive.

A new method for increasing the yield of ultra-pure hydrogen from cheaper feedstocks such as coal and biomass could help bring costs down.

Hydrogen is most commonly produced from natural gas in a process known as steam reforming, in which methane is heated in the presence of steam, to convert it into a hydrogen-rich mixture known as synthetic gas, or syngas.

The hydrogen is often then separated from this syngas in a step known as Pressure Swing Adsorption (PSA), in which the gas is attracted to a solid surface, or adsorbent, under high pressure.

Reactors that use coal or biomass to produce hydrogen have previously been unable to match the high yields possible with natural gas, according to Dr Hyungwoong Ahn, a senior lecturer in chemical engineering at Edinburgh University.

But the new method, developed alongside researchers at Yonsei University, South Korea, can improve their yield, while also capturing carbon emissions.

To produce hydrogen from methane, heat is needed to operate the reactors, said Ahn. The waste tail-gas from the PSA process is often recycled as fuel for the reactor.

"But if you use solid fuel such as coal or biomass instead of natural gas, the reactor does not require heat, so the PSA tail-gas can be utilised for other purposes," he said.

The researchers found that the tail-gas can be split into three streams and used to improve the hydrogen yield from the reactor.

**"If you use solid fuel instead of natural gas, the reactor does not need heat"**

Hyungwoong Ahn  
Edinburgh University

One stream can be used as a supplementary fuel for a carbon-capture unit, to remove carbon dioxide from the synthetic gas stream.

A second stream of the gas can then be recycled to the reactors to improve the hydrogen yield by converting more carbon to hydrogen. Finally, the third stream can be used as a fuel for drying the coal or biomass, rather than using clean synthetic gas. ☐

Hydrogen is most commonly produced from natural gas



## ADDITIVE MANUFACTURING

## Spinning a 3D web

**Spider-like robots can be used together to construct complex structures and surfaces**

Researchers have demonstrated prototype spider-like robots equipped with 3D-printing technology that work together to construct complex structures.

Developed by a team at Siemens Corporate Technology's Princeton campus, the devices – dubbed SiSpis – are the latest step in the development of autonomous mobile manufacturing techniques that Siemens believes could play a major role in manufacturing.

Designed and built almost entirely in house, and underpinned by a modified version of Siemens' NX PLM software, each spider is



The Siemens' SiSpis prototype

equipped with an extruder that prints a corn starch and sugar cane substance known as polylactic acid.

Each robot has an onboard camera and laser scanner that enables it to interpret its immediate environment. Knowing the range of its 3D-printer arm, it will work out which part of an area it can cover, while other robots use the technique to cover adjacent areas. **JE**

## MATERIALS

## Generation of energy is a real waste

**Manipulating alloys to increase energy yield**

HELEN KNIGHT REPORTS

Materials that are able to generate energy from waste heat could help to produce more fuel-efficient cars and power plants.

Thermoelectric generators (TEGs) produce electricity from a temperature difference between two types of electrical conductors, in a process known as the Seebeck effect.

The devices have no moving parts and are extremely reliable but typically require toxic or scarce materials, limiting use to niche applications, including powering space probes, for example.

Dr Jan-Willem Bos at Heriot-Watt University is now attempting to use nanotechnology to reduce the cost of thermoelectric generators, facilitating use in wider applications.

The team – including researchers from Glasgow and Royal Holloway universities and Leicestershire-based European Thermodynamics – will focus on so-called Heusler alloys, which contain combinations of abundant metals such as nickel, titanium and tin.

The researchers hope that by



The material could help fuel efficiency

manipulating the nanostructure of the alloys they will be able to increase their energy-conversion efficiency to that of more toxic materials.

To achieve good thermoelectric efficiencies, a material must have a high Seebeck coefficient, as well as low electrical resistivity and low thermal conductivity, said Bos.

Heusler alloys typically have a high Seebeck coefficient and low electrical resistivity, but a high thermal conductivity.

The researchers plan to alter the nanostructure of the alloys, to create a semiconducting matrix, with inclusions of a metal inside this matrix, said Bos. "This creates interfaces inside the material, which can be used to reduce its thermal conductivity, and that is important to achieving good thermoelectric efficiencies," he added.

The devices could be embedded in car exhaust systems, where they could generate electricity from the waste heat. This, in turn, would allow the size of the alternator to be reduced, improving fuel efficiency. ☐



## SENSORS

# Get the inside track on air pollution

**Graphene-based sensor could detect molecules that impact upon health problems** HELEN KNIGHT REPORTS

**A**ir pollution in homes and workplaces, which can cause health problems such as headaches, nausea and breathing difficulties, could be detected with an ultra-sensitive graphene sensor.

The graphene-based sensor, developed by researchers at Southampton University in collaboration with the Japan Advanced Institute of Science and Technology (JAIST), can detect individual carbon-dioxide (CO<sub>2</sub>) molecules and volatile organic compound (VOC) gas molecules.

These chemicals, found in low concentrations of parts per billion in materials, furniture and household

The sensor, developed by a group led by Prof Hiroshi Mizuta, who has a joint appointment at both Southampton University and JAIST, can detect a single CO<sub>2</sub> molecule as it bonds to the graphene – known as adsorption.

The sensor consists of a 300 nanometre-long graphene beam suspended above a gold electrode formed on a silicon substrate. As a gas molecule is adsorbed onto the graphene, it alters the electrical resistance of the material to a detectable degree, said Mizuta.

"In order to detect very dilute gas molecules quickly, we apply an electric field from the silicon substrate and accelerate their adsorption onto the graphene, which gives us a detection time of only a few minutes," he said.

To build the device, the researchers applied a voltage from the bottom electrode to create an electrostatic force that pulls the central part of the suspended graphene beam down towards it, said Mizuta. "This leads to two slanted graphene beams in suspension, with built-in tensile strain," he added. This design holds the graphene beams firmly in position, even when the electric field is applied, said Mizuta.

Members of the research group recently developed thin-film, graphene-based switches that require extremely low voltages, and can be used to power electronic components. Mizuta and the research group are hoping to combine the two technologies, to create ultra-low power sensors to detect individual molecules. ©



Certain molecules are associated with headaches and nausea

"There is a detection time of only a few minutes for the gas molecules"

Hiroshi Mizuta

Southampton University

goods in homes, offices, schools and cars, are believed to contribute to health problems associated with so-called sick building syndrome. These pollutants are difficult to detect with existing sensors, which can only detect gases with concentrations of parts per million.

## IMAGING

## Wraparound insight

**Flexible sheet cameras are able to capture images through 360 degrees**

Researchers from Columbia University have created a new type of flexible sheet camera that could wrap around objects and capture images through 360 degrees.

According to its developers, the technology could have a range of applications, such as providing enhanced driver awareness by wrapping around the exterior of

a car. The sheet camera could be placed on a lamppost in a public area, providing video images from all directions.

The technology relies on a flexible lens array that adapts its optical properties when the sheet camera is bent. Bending an array of rigid lenses would lead to gaps in the images captured, resulting in what are known as aliased images. By using an elastic material for the array, the focal length of each lens can vary as the sheet is bent, preventing aliasing from occurring.

A prototype lens with an optimised geometry was fabricated using silicone, and the team was able to capture images across a range of deformations. **AW**

## ENERGY

# Thinking small for industrial carbon capture

**Devices set to combine two technologies**

GLYNN GARLICK REPORTS

Researchers are planning to combine two technologies to develop small carbon-capture devices for use at industrial sites.

Rotating packed-bed absorption and microwave-assisted regeneration will enable small devices to be installed at sites where using a large centralised system to capture CO<sub>2</sub> is inefficient as emission points are spread throughout the facility.

The EPSRC is backing the three-year £1.2m project, led by Edinburgh University, which will look at the issues surrounding the use of amine solvents for CO<sub>2</sub> capture.

Principal investigator Dr Xianfeng Fan, part of the university's School of Engineering, said: "We have tried to develop something with quite a small size and high efficiency, so we don't use the traditional absorber and desorber.

"We use a rotating packed-bed absorber, and that can reduce the size by 90 per cent," said Dr Fan. "The size depends on the size of the plant. Normally for an absorber it is about 20m high, and for that we will use a rotating bed with a diameter of less than 2m."

Rather than creating a bubble to absorb the CO<sub>2</sub>, the rotating bed creates a film with a larger surface area with which to make contact with the gas, which speeds up the transfer.

Microwave-assisted regeneration should be able to help solve the problem of high-energy consumption in solvent regeneration.

This method regenerates amine solutions at 70°C, rather than the usual 120°C, can operate without a temperature swing, and is fast, leading to further reduction in capital costs.

CO<sub>2</sub> desorption at 70°C will enable the regenerator to use low-grade industrial waste heat, and will also help to reduce corrosion and solvent degradation.

The project also involves the universities of Newcastle and Hull, plus industrial partners including Global Technology/SK Innovation, and the UK-China (Guangdong) CCUS Centre. ©





# Breaking off the Brussels handcuffs

**The EU is holding back the UK's small and medium businesses in favour of large multinational corporations**

sometimes wonder if the people campaigning for Britain to stay in the European Union have actually had any experience of running a business that has to cope with the day-to-day reality.

The Remain camp too often seem oblivious to the endless red tape spewing out of Brussels and the real damage it does to the competitiveness of British businesses. Meanwhile, the single market, the only reason we joined, has failed to deliver, with enormous trade deficits every year.

My decision to vote to leave is based on my experience of working in an SME, not on the theoretical benefits the EU is supposed to bring.

Our company has exported to 140 countries around the world – but we now do almost no business in the EU. The obstruction, protectionism and bureaucracy make it virtually impossible. We would rather work in a growing world outside, which is open for business and pleased to buy British.

The top 100 Brussels regulations alone cost the economy £33bn a year. On top of these costs we have to pay a £350m-a-week membership fee to the EU. SMEs, which employ 60 per cent of the workforce, cannot afford the human resources and compliance departments that multinationals employ, so we are at a disadvantage. Only six per cent of British companies export to the EU but all are lumbered with the regulation.

Our recent experience of trying to do business in France has

underlined just how empty the rhetoric about the single market really is. Because of this discriminatory rule, we had to walk away from a seven-figure contract in Toulouse, and another in Calais to provide buildings for security fencing against migrants trying to smuggle themselves to Britain, even though our government paid £17m towards the cost.

If a company is going to work in France in our industry (designing, manufacturing and erecting steel structures) it is required to buy 10-year liability insurance. But under French law, these so-called decennial policies can only be bought by French companies. This means businesses based in other EU countries are closed out unless they are willing to set up a full subsidiary in France.

We raised this issue with our government, which is powerless to do anything. We have taken the issue to the EU, but it has done nothing. A multinational could easily open a new subsidiary in France or pay lawyers and lobbyists to work the Brussels corridors and pursue the complaint. But those options are too expensive for a business our size.

SMEs are also disadvantaged when dealing with Brussels red tape, which is so costly that it damages our ability to compete for contracts not just inside

the EU, but around the world. When it comes to employment regulation, for example, we are required to go through all the same hoops as multinationals, but without the resources.

European health and safety standards are a particular problem. They have generated a huge paperwork industry, but have achieved precious little to put unscrupulous employers out of business. The UK enforces the rules far more rigorously than other member states, putting us at an unfair disadvantage both in the EU and globally.

The CE European conformity mark is another costly and

unnecessary piece of paperwork for us. Unlike the globally respected British Standards, which are being eroded and replaced with 'euronorms', the CE mark does not guarantee good design, safety or quality. What it does is eliminate start-ups and innovation to the benefit of multinationals; the beginner cannot get into the pool until they prove that they can swim.

There are looming threats from Brussels that will make day-to-day operations even more expensive. The EU is trying to end the right of British workers to opt out of the 48-hour weekly limit in the Working Time Directive, which will be damaging to the flexibility British businesses need. A staggering 90 per cent of UK steelworkers polled want no restriction on their right to choose when they want to work.

For a long time, I persevered with the EU. I hoped the prime minister would be able to win meaningful reforms. He achieved none of his pledges and nothing of use to us.

The EU is incapable of serious reform and improving business competitiveness comes a long way down its agenda. This is because reducing the burden of regulation means reducing the power of Brussels and the European institutions' priority is always to centralise power. It responds only to the 15,000 lobbyists in Brussels, all working for the big companies and multinationals.

The EU is doing immense damage to Britain's global competitiveness, holding back our SMEs and stifling enterprise. We cannot hold the people who make those rules to account. We need to take back control, design the right rules for our economy and help, not crush, our small and medium businesses. The only way we can achieve this is to break off the Brussels handcuffs and vote to leave the EU. ©

"There are some other looming threats from Brussels that will make our day-to-day operations even more expensive"

Simon Boyd



**Simon Boyd is contracts director at REIDSteel and chairman of Business for Britain – South West**

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# Mailbox

## The hot topic

### Safety after the event

**Our article on the 30th anniversary of the Chernobyl disaster sparked a debate on current nuclear safety**



It is more the perception of a hazard than the actual risk that scares people. The reporting of nuclear risk is generally very poor, failing to compare, for example, the level of radiation from the accident with typical natural levels or converting it into a risk level. *The Engineer* recently repeated its article after Fukushima, pointing out that whereas the tragic tsunami

killed around 18,000 people, the nuclear release killed no one. The worst-affected victims, the emergency crew that dealt with the fire, increased their risk of dying from their work by about the same amount as the increased risk of being a 'white van man' for 40 years. Not trivial and not to be ignored, but out of balance with the thousands who die every year in coal mines that are an alternative source of energy to nuclear power.

**Chris Elliott**

However well managed, however well designed, accidents will happen. In the case of radioactive pollution, the result is catastrophic and long lived. I cannot believe we are allowing the Chinese to construct a huge nuclear power station on our soil, which is unproven.

**Mervyn Edwards**

It is difficult to explain to the media that Chernobyl, Fukushima and so on actually demonstrate that nuclear problems are containable and, in historic terms, minor events. The enormous number of operating sites with over 40 years of operational history is forgotten in the hysteria. France has benefitted more than is recognised generally

from having the lowest-cost electricity in Europe, and we import about 3GW of this.

**Jack Broughton**

The fear, uncertainty and doubt that is being spread by the anti-nuclear activists cause significant problems for the nuclear industry. No one died due to radiation in Fukushima but it is still in the headlines. Eighteen thousand-plus died in the earthquake and tsunami but we don't hear about that anymore. If you read the newspaper headlines, Chernobyl is now a total no-go area due to radiation, yet the other reactors continued producing electricity for many years and people are working on site on the clean-up operation.

**Roger B**

I'm a nuclear engineer. At the time of Chernobyl, Italian politicians and journalists carried out a systematic misinformation campaign spreading ridiculous information about the nuclear technology. A taxi driver told me he had carried two people coming from a nuclear power plant and afterwards he started itching; he asked me whether that had been due to the radiation that was emitted by those two people. The Italian people, and among them that taxi driver, banned nuclear energy with a referendum, probably fearing all the possible scratching.

**Riccardo Testi**

Anyone who has filled in a risk assessment knows that there are two components: likelihood of occurrence and severity of outcome. That is the fundamental problem with nuclear – when it goes bang the whole world hears it. The trouble with stating that Fukushima has low casualties is that they may take a generation to show up in the statistics, as 30 years on the figure for Chernobyl is still contested by orders of magnitude. The capital expenditure requirements, safety record and overall culture of nuclear power make it intrinsically unsuitable when the alternatives are considered.

**Paul Arrondelle**

## In your opinion

### Race for the prize

**Engineering salaries remain a cause for concern and sparked a lively debate**

Pay in engineering has stagnated. We are not as highly prized as other professions that we work alongside, and unless we are directly associated with the money in business we never will be.

**Kris Redman**

I've never yet met anyone who feels that they are paid more than they are worth. We work in a capitalist and highly unfair society in which some essential workers are paid a pittance while other worthless people are paid massively. Engineers

have excellent opportunities for success and furtherment but, in my experience, tend to be risk averse and too many of them stay in jobs that have little potential.

**Jack Broughton**

Engineers' salaries are just like most professions: cherry pick and you will find both poorly rewarded and handsomely rewarded individuals. We live in a market-based economy. It may not be fair, but if it's not working for you, change career to turn yourself into a more valuable commodity. That way, you have no need to whinge and, one by one, you will be helping your fellow engineers by reducing the market supply.

**Neil Bertram**

Of course engineers are underpaid. And I have the wage slips to prove it. Disposable income is how you judge your wealth, and what car you drive is as good an indication of disposable income as any. Have a look around the car park of

most engineering firms. Usually you'll see an embarrassment of old heaps.

**Anonymous**

They say your salary should reflect your level of responsibility (or so I'm told). I'm a design engineer. I design the products that the company sells in order to generate revenue to pay the inflated salaries of the endless list of managers, directors and so on. I ask you, is there a more responsible position? My pay packet says yes, there are lots.

**John Harrison**

### Brexit talk

**Some readers were unconvinced by Terry Scuoler's arguments for remaining in Europe (*The Engineer*, April 2016)**

Remaining in the European Union because of current circumstances is arguing for a permanent





## The secret engineer

Our anonymous blogger reflects on a career spent dodging the auditor's bullets



We have a quality audit lined up soon, something that I don't particularly fear but that has brought to mind similar occasions from the past. I was fortunate in starting my professional career working for a company in the aerospace sector, one that was really very good with regard to this sort of stuff. Coupled to my own inherent bias for 'doing things the right way' rather than 'doing things any way you can get away with then trying to tidy it up if you have to', it has provided me with a solid basis for generally dodging the auditor's bullets.

Of course, once I'd ventured out into the wider engineering world it soon became apparent that not everyone worked the same way. The greatest application of deviousness I personally witnessed involved an untidy pile of drawings and scale models that 'needed to be stored out of sight before a planned visit' coupled with a 1ft-high mezzanine floor under the drawing office originally intended to hide various services. Legend had it that some documents of serious significant historical value had rolled off into the darkest recesses under there, and still languished awaiting rediscovery at some unspecified point in the future.

Now that we are moving away from the retention of physical data, the process of control and deception are easier. In addition, without any meaningful limit on the data that can be held there is no decision-making process regarding the jettisoning of out-of-date information.

How many of us have seen skips full of drawings, reports, wiring schedules and so on in the past? Conversely, how often have we struggled to find room to store something 'just in case?' Surely these are regular exercises that will soon be entirely banished to the history books. Still, without the need to find room for printed documents, and the associated need to have those visibly traceable, there is no longer a rush to fill every stationery cupboard or desk drawer with random documentation once every couple of years or so.

As master of my own destiny at Sleepy Hollow Electronics, I am ready for the upcoming audit. My introduction to the correct systems has made sure of that. However, there are a few files I've generated that aren't really controlled – and that don't seem to have a natural home on the computer network. I might create a new folder named 'Mezzanine' to put them in.

solution on the basis of a temporary problem. The Samaritans warn many of those they counsel against making such choices. Yes, there are economic arguments for continued EU membership but there are also positive arguments for leaving. Maybe our exporters depend on access to the EU but I don't see access being denied to US imports; why would ours? Please remember we have not run a surplus against the EU since we joined the EEC back in the 1970s. Leaving the EU would hardly make our deficit worse. And remember that the single market has only been completed in goods, to the benefit of our German friends; with regard to services, where we excel, it's always another reform away.

**Nath**

The article makes much of exporting to fellow EU countries yet doesn't mention we have an annual EU trade deficit of around £50bn. I have yet to hear a politician address this. Of course, we could address it individually in the obvious way but

apparently we don't want to. Investors from various countries set up business in the UK to make goods that we don't want because we'd rather buy German ones. Am I wrong to suspect that most investment into the UK is actually buying London apartments?

**Malcolm Scott**

Research interests and budgets will have to be re-negotiated, but it seems we put in a lot more than we take out and would probably gain from increased control of this money. I've still not seen one document that shows where the benefits of membership lie.

**Jack Broughton**

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WE CREATE MOTION



# Strategic approach to schoolchildren

**The Tomorrow's Engineers programme has a sense of collective ownership that sets it apart as a vehicle to engage young people**

“Employer support managers can work with employers to help make their outreach more inclusive”

Paul Jackson

I was struck last week by an article about a recent Big Bang event hosted at a school in Leicester. The write-up was pretty much what you would expect: details of the activities enjoyed by visitors and of the supporters present. What set it apart was that it was published on the Leicestershire Police website.

For me, that really demonstrates how Tomorrow's Engineers is doing something very different. Not just telling people how good engineering is but empowering communities to be part of that story. That's communities in education through Big Bang @ School and communities of local employers supporting schools in their area. Leicestershire Police displayed the sense of involvement we see

from many employers who are part of Tomorrow's Engineers.

In the past year, Tomorrow's Engineers has directly reached over 300,000 young people. Many of these quality engagements are the result of targeted outreach by engineering employers. Others take place at regional events or as part of a funded programme of targeted intervention.

The Tomorrow's Engineers programme is led by the engineering community and it is that collective ownership and collaborative spirit that makes it unique. Tomorrow's Engineers doesn't offer a single off-the-shelf package; it doesn't dictate how individual employers or schools should get young people engaged; and it doesn't work on the premise that one size fits all. Tomorrow's Engineers provides a platform for employers to grow the talent pipeline as part of a coordinated drive.

Tomorrow's Engineers works centrally with national employers and has dedicated support available in the north east, north west, the west Midlands, London, the south east and the south west. With funding from the Careers and Enterprise Fund, that support will be enhanced in the north west and south east, and will expand into Yorkshire and the Humber.

Employer support managers (local advisors) can work with employers to help make their outreach more inclusive and more tailored to local requirements. Tomorrow's Engineers shares good practice, encourages peer-to-peer advice and guidance, and respects the distinct needs and approaches of its companies, institutions and schools.

This growing community of employers is working to realise the ambition of reaching one million young people a year with a memorable experience of engineering in action. Mapping that work highlights hotspots: areas and schools that are engaged and active in STEM promotion. Tomorrow's Engineers is able to identify and target schools in cold

spots where engineering outreach can have the greatest impact.

Student feedback is one part of measuring that impact. A student who took part in an Energy Quest workshop last month said: “Now I think that any idea could be a reality with engineering.” That change in attitude is an important first step. Tomorrow's Engineers Energy Quest and Tomorrow's Engineers Around the World are industry-funded programmes that directly target schools with hands-on workshops and strong careers messaging, delivered by trusted partners across the UK: EDT, EESW, Learn by Design, SCDI, Science Made Simple, Sentinus, Smallpeice and Young Engineers.

Tomorrow's Engineers brings a strategic approach to schools engagement. This results in greater coordination so employer outreach extends to where the need is greatest. If, like me, you want to inspire the next generation, join Tomorrow's Engineers to really make a difference. ☐

**Paul Jackson**  
Chief executive EngineeringUK



A growing community of employers is working on reaching one million young people a year



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# Emerging from the clouds

**How web-based tools are beginning to change the rules of design and manufacturing in the worlds of automotive and aerospace.** Andrew Wade reports

S

o you've got an idea for a product. You might have gone so far as to turn your idea into a design; you might even have gone into your shed or local maker-space and transformed your idea into a prototype. But how do you turn that prototype into a product? And how do you develop a manufacturing process so that the single working widget that embodies your design evolves into a series of identical units, made for a defined cost, that customers can go out and buy and generate a profit to reward your efforts?

It's an arduous process that involves the input of many people and lots of compromises on the way. Some designers feel that the final product is quite far removed from their original vision; and the compromises that have to be made to lock the design mean that the final product might not be precisely what all the customers want or need; it's close enough but some of them might have ideally preferred something slightly different.

But things are starting to change, and powering that change is the technology known as cloud computing. The ability for multiple people to collaborate on a project in 'virtual space' means that the process of design and manufacture can be streamlined and even customised to an extent never seen before.

This is, inevitably, known by an acronym: CBDM or cloud-based design and manufacture. It's still in its infancy, but one example has already featured in *The Engineer*. Briggs Automotive Company, the small firm founded by Merseyside brothers Neill and Ian Briggs, uses CBDM to customise its single-seat sports car,

the BAC Mono, so that each car is not only a precise fit for its owner but looks exactly how its buyer wants it.

BAC uses Autodesk software products in a cloud-based system to design every car around its buyer's precise measurements. "We'll make them aware that, in essence, this is a life without compromises — so it's kind of an open space, a free flow of ideas," Neill Briggs said. "From a customer's perspective, some of them can get quite involved in the design. So they can say: 'Hey, what if I did this, this, this and this?' They can have various clippings from magazines of things that they thought were cool."

Functional, rather than aesthetic, personalisation includes the reach of the steering wheel, the pedals and seat shape and position, custom crash helmets, as well as features such as interior trim, exterior parts, choice of brakes and power upgrades, all of which can be viewed externally by the buyer and then incorporated into the manufacturing process, with all the customised machining that implies. BAC's manufacturing set-up, which eschews costly stamping processes in favour of machining from solid billet, allows parts to be customised relatively easily, with the cloud-based systems sending specifications directly from the customer to the design team and thence to the manufacturing machinery.

This customisation isn't just a matter of making the car look flashy. "It's actually safety-related," Briggs said. "So the

## 01

Elixir's large fuel tank will enable it to fly for 13 hours — enough to cross Europe

01







02

**02**

The two-seater aircraft has been inspired by yachts used in the America's Cup

made-to-measure seat and helmet are safer environments to be in. If you can make that helmet fit your head even better, then in the event of an impact, you're not going to get any hot spots. That ultimately is what causes injury where you get fractures, breaks, or whatever. If you can disperse force over the entire helmet, then, obviously, it's way better. If you can make sure that the person's grip on the steering wheel is uncompromised, you're giving them the best-possible chance when things go wrong. But you're enhancing the driving experience as well."

Still in the automotive space, Gordon Murray Design's iStream process embodies a slightly different take on CBDM. The process is a customisable system where the car is built up from welded tube sections and composite panels; which lends itself well to fine-tuning in the design phase. Again avoiding the massive investment in plant required by conventional automotive, so cloud systems can be used to tweak the design to a considerable extent.

But the automotive sector is one where a certain degree of customisation has always been part of the business and manufacturing model. Aerospace is necessarily much more conservative, with safety so much a priority that there's little room for changing designs, let alone incorporating ideas from other sectors.

Aerospace engineering's complexity and economies of scale make for daunting industry barriers. Twin giants Boeing and Airbus dominate the passenger jet market, and woe betide the brave upstarts looking to challenge that duopoly. But there is another sector of aviation that a young French company believes is ripe for revolution.

Elixir Aircraft was set up in 2015 by engineers Arthur Léopold-Léger, Cyril Champenois and Nicolas Mahuet. Based on an idea first conceived three years ago, the design for Elixir's two-seater composite aircraft was initially unveiled at last year's Paris Air Show. Since then, the company has been turning heads throughout the industry, as much for the design practices it has embraced as for the new light aircraft it hopes to bring to market.

"It's mostly based on innovations that we took from sailing competitions, America's Cup boats," said CEO Léopold-Léger, a pilot with 1,000 hours' experience who has also crossed the Atlantic solo in a boat he built himself.

"For the last 20 years they have been innovating, innovating, innovating, while on the aerospace side it's been very flat for the last 20 years, at least in the small aircraft market."

The end of the Second World War brought a massive surplus of light aircraft, with thousands of Cessnas, Pipers and Beechcraft no longer required for training purposes. Many of these were sold to private customers, but the oversupply led to market stagnation, and design updates never materialised.

"It means that today the market is over 50 years old," Léopold-Léger continued. "It's like if you were going to work in a Second World War car every day... today our mission with Elixir is to renew this fleet. And it's possible because we have technology, and because there is a new certification in place for the past two years, which allows us to make two-seater aircraft with a brand-new way of certifying it."

Integrated design and certification has helped massively reduce both time and cost, opening up possibilities for new players such as Elixir to enter the market. Using Dassault Systèmes 3DEXperience cloud platform, Elixir has been able to take the concept from the drawing board to the skies in an incredibly short space of time. According to Champenois, Elixir's COO, the entire process will have taken less than two years by the time the first flight takes place later this year.

"You start the certification as soon as you start the programme, because everything is integrated, and there >>

"For the last 20 years in sailing they have been innovating, while in aerospace it's been very flat for the last 20 years"

Arthur Léopold-Léger, Elixir

>> is no way to first do the design and then do the certification," he said.

Champenois was actually working for Dassault when Léopold-Léger got in touch about Elixir. The two friends had studied aerospace engineering together at Kingston University in the UK, and the former was able to convince the latter to join him on the project. Elixir has since been heralded as symptomatic of a new breed of designers that are changing the rules of the game, not least by Champenois' old paymasters.

"We are seeing things we have never seen before," Dassault Systèmes CEO Bernard Charles said at the company's recent event in Milan. "Who would have said, only two years ago, three years ago, that a company of 10 people would do an aircraft on the cloud? And I think they are going to do it and they are going to get the certification. It's very profound.

"Something is happening. You can take every single industry sub-segment. This phenomenon is happening, which means a new level of performability for newcomers to become world players with very small numbers of people.

"These new teams are creating things never seen before. They are turning things upside down. It's not the extrapolation of what happened in the past... it's something very different."

Something very different is what the market is craving, according to Elixir. Following the inevitable dip in the wake of Lehman Brothers, light-aircraft sales have recovered well, with annual sales in the region of 1,000 units. Despite a design that hasn't evolved for over half a century, these aircraft cost between €250,000 and €300,000. Elixir's two-seater is expected to come in at around €160,000.

There are plans for bigger aircraft in future, but for now the team is happy



**03** Arthur Leopold-Léger addresses the crowd at a recent Dassault Systèmes event in Milan

**04** CBDM has allowed Elixir to streamline its production processes

to focus on shaking up the two-seater segment. A cornerstone of the strategy is a focus on safety, and Elixir has incorporated some interesting features to distinguish itself from the crowd.

"The more safety, the happier the customer, so we have some big innovations in this area," said Léopold-Léger. "We have a parachute in the middle of the aircraft. You have a red handle, and when you pull this a big parachute opens over the plane, and the aircraft comes back to the ground safely. So that's a huge innovation for light aircraft. It means that if the pilot has a heart attack or anything, the passenger can just pull the handle and come back, and maybe save the pilot as well."

The parachute is the same as that used to bring the Soyuz spacecraft safely back to Earth, but with just a single canopy rather than the Soyuz's three. Inspiration has also been taken from the world of Formula One, with safety foam lining the fuel tank to prevent it exploding on impact. In an industry that barely spans a century, 50 years of inertia is an eternity, and Elixir is looking to improve a range of other performance metrics alongside safety.

"The speed we are targeting with the big engine is 180 knots, which is quite fast," said Champenois. "We are consuming – again depending on the engine – around 14 litres per hour, compared with 40 litres per hour, at least, with the old aircraft. So it's a huge gain in that aspect. With the big fuel tank you can fly for almost 13 hours, so you could cross Europe quite easily."

Carbon fibre makes up a large part of the aircraft's 265kg, along with materials borrowed from the America's Cup. The streamlined production process also results in a simplified aircraft that should be easy to maintain over time.

"Whereas before, a wing was made of around 1,000 pieces, and 1,000 operations to build this wing, we make the wing in one production and in one piece," said Léopold-Léger. "In this wing there are no screws, no metal, and no glue, meaning that it will not get old... and, on top of that, the wing is around 10 per cent lighter than any other wing."

Elixir bookends the aircraft's fruition as both its designer and assembler, but the actual manufacturing is left to carefully selected third parties. By outsourcing individual production processes to those with the best skill sets, the company believes the overall quality of the aircraft will be maximised, while at the same time spreading some of the risk associated with bringing a new product to market.

"We are an integrator," said Champenois. "We don't want to own all the knowledge, all the resources, all the tools to design and manufacture our aircraft. So we are sharing the risk and sharing the cost with design experts, with manufacturing experts. We are doing only the final assembly, and it allows us to be very flexible."

Another important element that has allowed flexibility is social collaboration. Dassault's platform provided a way for ideas and progress to be shared among the various parties involved, along with in-built data management tools and the aforementioned certification process. Access could easily be given to Elixir's partners where necessary, with data kept safe on Dassault's servers. Using a cloud platform meant that members of the team could work at any time, from any location, and that design tools could be accessed on an ad hoc basis rather than investing in fixed CAD 'seats'.

"We needed a tool that could articulate for all those people naturally," said Léopold-Léger. "I was a bit sceptical initially whether this was really possible, and about the data being on the cloud, but [Champenois] quickly convinced me because these tools are like we are all in the same building."

"With the data in the cloud, in the end it's more safety for us and it's more flexibility. We can work at home, we can work anywhere in the world... we're not using all the possibilities of the platform, but we are using a lot, and the good thing is that whenever we need something we just rent it for one or two months, or one year."

This agile approach will also extend across the entire production process, something that will allow for assembly in France. According to Elixir, the company is geared to be profitable with just 12 sales per year, so a target of 80 units could see the young trio flying high before too long. ©

Additional reporting by Stuart Nathan

"We are consuming – depending on the engine – around 14 litres per hour, compared with 40 litres per hour, at least with the old aircraft. It's a huge gain"

Cyril Champenois, Elixir





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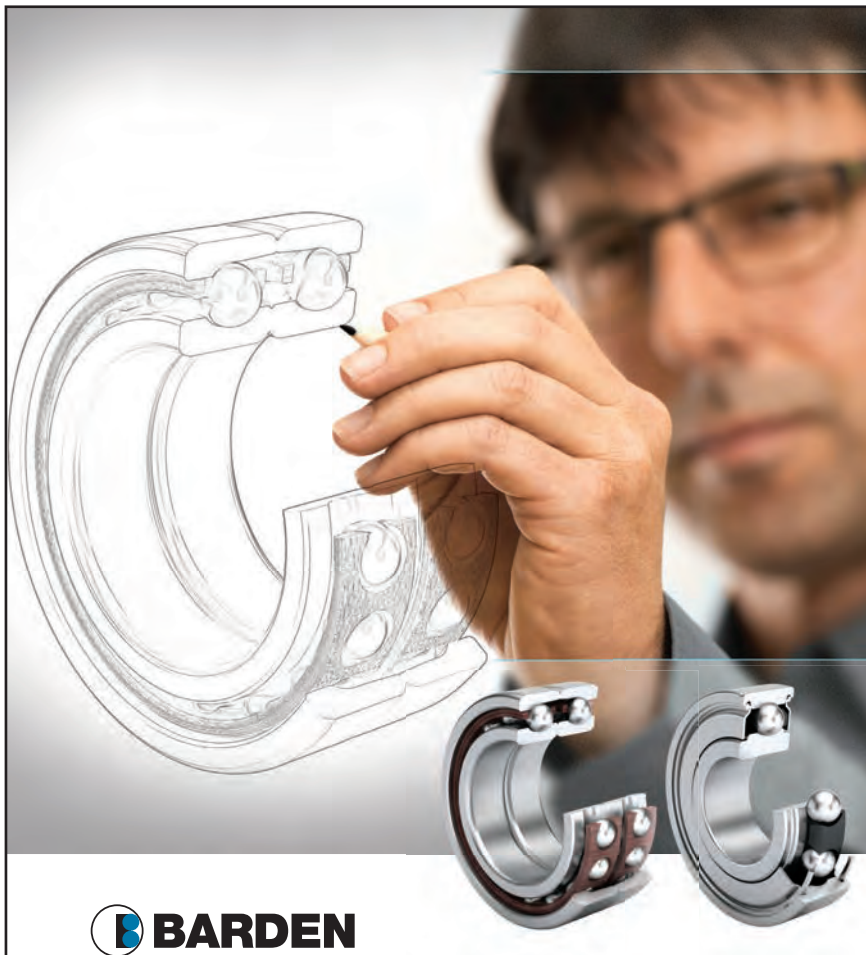


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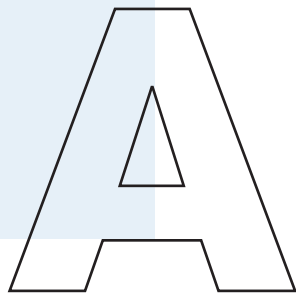
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# Plane savings on the deck

**New technology is helping to reduce the impact of aircraft during taxiing.** Jason Ford reports



As an airline passenger it's more normal to relax and think of your final destination rather than the ground-based procedures that got your flight into the air.

And why should you, given the journey you have made to the airport, the drudge of getting airside and the inevitable wait

among fellow travellers descending into shops, bars and restaurants prior to being called to a departure gate?

It is easy to overlook the fact that in its last financial year Gatwick Airport handled 255,711 flights, 127,833 of which were departures, and figures from Heathrow Airport report an average 1,293 flights per day, or 472,067 annually. Worldwide, there's a predicted 109 per cent increase in passenger aircraft by 2031, with demand for air travel increasing by around four to five per cent a year.

While the aviation industry makes a relatively modest contribution to greenhouse-gas emissions compared to other industries, comprising two per cent of the global

total, it is aware of its environmental responsibilities and the measures that will have to be in place in order to alleviate the burden it can place via emissions to the air and around airports through noise.

Keith Bushell, environmental affairs manager for Airbus, said the A320 neo is 20 per cent more fuel-efficient than the A320 series, and is satisfying the council of the International Civil Aviation Organization's 'Chapter' standards for noise.

"It is [also] around 17dB quieter than Chapter 4 and also meets, and

beats, Chapter 14 criteria as well," he said. "In London it has the QC [Quota Count] system based on the noise levels of aircraft and the A320neo is QC exempt for arrivals and QC exempt for departures, apart from maximum take-off weight."

In 2011 the European Commission's Flight Path 2050 report set out a number of targets, including a 75 per cent reduction in aircraft CO<sub>2</sub> emissions from a year 2000 baseline, NO<sub>x</sub> reductions of 90 per cent and a reduction in perceived noise from aircraft of 65 per cent, plus a requirement for emissions to be cut from the ground-based movement of aircraft.

A short- or medium-haul flight on an aircraft such as an A320 will see approximately 200kg of fuel consumed by the Auxiliary Power Unit (APU) and one main engine during the initial taxi to the runway. According to some estimates, around five million tonnes of fuel are used per year by the global short-haul fleet during taxiing alone.

TaxiBot is currently the only certified and operational aircraft taxiing system designed to take an aircraft to the runway with the aircraft's main engines turned off. Designed for narrow- and wide-bodied aircraft, the system from Israel Aerospace Industries is a towbar-less 800hp hybrid-electric aircraft tractor that is controlled by the pilot and is in use at Frankfurt Airport by Lufthansa.

While the use of TaxiBot has the potential to benefit fuel tanks and bottom-line costs associated with Lufthansa's fleet, easyJet is looking at reducing the costs associated with ground-based transportation by investigating a future in which fuel cells help to do the work of tugs, APU and main aircraft engines to deliver 100 per cent fuel savings associated with taxiing. Around four per cent of easyJet's total fuel consumption comes from taxiing and in 2012 it announced its support and involvement in trials of the Safran and Honeywell EGTS (electric green taxi system). >>

**01** The A320 neo is 20 per cent more efficient than current A320's

"Noise pollution would drop because we don't have all these APUs screaming away all over airports"

Ian Davies, easyJet





02

>> EGTS allows an aircraft to taxi via electric motors housed in its main wheels. The motors derive their power from the aircraft's APU and each wheel is fitted with an electromechanical actuator. In use, the system's power electronics and system controllers give pilots control of the aircraft during taxiing.

However, according to Ian Davies, easyJet's head of engineering and maintenance, the system had one fundamental snag.

"The reason we haven't adopted it is because it is quite heavy – 400kg in weight," he said. "A rule of thumb [is that] for every 100kg of weight we burn 3kg of fuel to carry that weight per hour."

When appropriate, easyJet taxis its short-haul Airbus aircraft on a single engine, which Davies said consumes approximately 320kg of fuel an hour.

"When you stack it up – the fuel-saving measures we were doing on single-engine taxis, and the saving we would get from electric green taxi – it didn't work out economically," he said. "To use electric green taxi we needed to increase the amount of generation of electrical power from the APU by three times the existing output, which wasn't conceived when first started the process, which was not to modify

anything on the aircraft, just put the taxi system on."

As part of easyJet's 20th anniversary in November 2015, the airline asked students at Cranfield University to consider air travel in 20 years' time, with one of those ideas involving the use of a hydrogen fuel cell stowed in the aircraft's hold to provide energy for procedures, including taxiing.

The airline, taking the idea forward with Safran and ITM Power, imagines 'a completely virtuous cycle' in which it creates its own hydrogen via renewable sources close to Gatwick.

"There are different ways in which we can make hydrogen," Davies said. "One of them is National Grid balancing, so what they do is take energy during the night that would otherwise have been lost and convert it into hydrogen. Effectively the hydrogen



03



04

**02** With EGTS, the APU powers motors in the main wheels

**03** EGTS International's A320 fitted with EGTS

**04** TaxiBot is put through its paces at Frankfurt Airport

becomes, for want of an analogy, the best storer of energy; it's like an accumulator for electricity and that is to play back into the National Grid, converting the hydrogen back into electricity to balance the grid during peak times.

"If we got around 1.5 hectares of land and we put a solar array in there... with air and wind – that's two wind generators and a solar array – we could create a 1MW station that would produce around 500kg of hydrogen completely cleanly every day. If we were to get this within 10 miles of Gatwick then we would only have one journey a day to where we could dispense the hydrogen into each fuel cell in each aircraft."

In July 2015, the Airports Commission published its Final Report on expanding airport capacity in Britain, with a recommendation that a legally binding 'noise envelope' puts limits on the level of noise created by an expanded Heathrow. Bushell is confident that measures such as landing via a steeper approach and continuous descent approaches will have a positive cumulative effect.

Davies is equally bullish about the potentially positive impact 'green taxiing' would have on the ground.

"The argument about pollution at Heathrow with the third runway could be influenced if people were to go and do this, particularly on narrow-body aircraft that are coming and landing [frequently]... and doing a lot of taxiing," he said. "Noise pollution would drop because we don't have all these APUs screaming away all over airports." ■





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# Hybrid moves on the buses

**Vantage Power's hybrid technology aims to breathe new life into the UK's ageing bus fleet.** Andrew Wade reports

A

lexander Schey has packed a lot into his 28 years. After leaving Imperial College London with a first in mechanical engineering, he embarked on a 26,000-mile journey to travel the Pan-American Highway. Schey and his colleagues from Racing Green Endurance were the

first to make the trip in an electric vehicle, travelling from Alaska to the southern tip of Argentina in their SRZero twin-motor supercar.

More recently, Schey has been named in *Forbes Magazine's* 30 under 30 in European Industry, primarily for his endeavours with Vantage Power, the company he co-founded with Toby Schulz in 2011. Vantage is currently developing a diesel-electric hybrid powertrain for UK buses. Although perhaps not quite as glamorous as traversing the Americas in an open-top supercar, its potential economic and environmental impact makes Vantage Power one of the most exciting engineering start-ups in the UK.

"At university I kind of fell in love with the whole idea of electric and hybrid-vehicle technology," Schey told *The Engineer*. "It was during Racing Green Endurance that we [Schey and Schulz] both realised we wanted to take what we had learnt into a business of some kind. So after that project we started Vantage Power, but we didn't really have a clear idea as to what we were going to do."

It was only after undertaking extensive market research that the pair discovered their niche. As a start-up with virtually no money they quickly figured out that the barriers to entry in the wider automotive sector were too great, and with no track record they wouldn't be taken seriously. Instead, they searched for the industry with the biggest requirement for hybrid technology.

"Buses are big, they're heavy, they're running 24 hours a day, so they use a lot of fuel," said Schey. "Couple that with the fact that buses – pretty much by definition – are operating almost exclusively in towns and cities, so they have the biggest impact on local quality of life, air pollution and things like that. Put those all together and you actually find out that the bus industry is the most ripe for change in this area."

"Although the industry is still very large, it's much more approachable, much smaller and connected than the huge global automotive companies where we'd have no chance of doing anything."

More research followed, with Schey and Schulz quickly identifying the after-sales market as Vantage Power's



"Although the bus industry is still very large, it's much more approachable, much smaller and connected than the huge global automotive companies"

potential sweet spot. New hybrid buses are expensive, and that segment would be out of reach until the company's technology was proven. Retrofitting would provide the perfect opportunity for Vantage to cut its teeth, while at the same time targeting a market exposed to increasing regulatory pressure.

"Buses have a huge amount of work done on them," Schey explained, "and midway through their life they will typically have a big upgrade, be it a gearbox or an engine. So some piece of technology would ultimately be retrofitted to that industry. It's quite a well-established concept... but nobody had gone the whole hog and said 'let's upgrade it to hybrid'."

After commercial calculations Schey and Schulz decided the idea was a good one, leaving them the task of designing and building the powertrain. Known as the B320 Hybrid Retrofit System, it features a four-cylinder 4.5L displacement diesel engine. This is used to keep the 125kW lithium-ion battery topped up, which in turn provides the power to the 210kW (283bhp) electric-drive motor. The energy-storage system means a bus can travel up to 4km without the help of the diesel engine.





**01** Vantage is currently in talks with numerous bus operators in the UK

**02** According to Schey, 2,000 London buses will be illegal to drive in 2020 under new regulations

During a retrofit the bus has its engine and gearbox removed, and the B320 is connected to the existing electronics, hydraulics, pneumatics and mounting points. So far, all design and testing has been carried out by Vantage Power at its Greenford base in West London, but the future heavy lifting will be undertaken by its partner Ensignbus, the UK's largest used-bus dealer.

"We have the facilities to actually do the retrofit ourselves, and indeed we do that for all our prototype work, but not for the larger-scale stuff," said Schey. "Ensign is way better suited than we are for that."

According to Schey, the retrofit process should require about 40 man hours, taking a small team about two or three days. Once complete, fuel consumption is reduced by around 40 per cent, which works out at about £15,000 per bus per year at current fuel prices.

The system, which comes with its own driveline and battery warranty, brings buses into line with Euro V emissions regulations. Schey wouldn't be drawn on the exact cost of the B320, but insists that it represents value for money.

"We expect to be able to retrofit four to five buses for the price of one new hybrid," he said. With the new Routemaster hybrids coming in at around £300,000, that would put a retrofit somewhere in the region of £70,000 – no small investment, but recoverable on fuel costs within five years while at the same time extending the life of buses that would otherwise be left behind by impending emissions directives.

Alongside the fuel gains, Schey also claimed that the other areas of performance have been improved, and that driver feedback so far has been universally positive. Speed off the mark is essential for any mode of transport that frequently stops, and the powertrain has provided some unanticipated benefits.

"One thing [the drivers] say is that when you're in a normal bus, you have okay acceleration off the line, but then the moment you shift out of first gear into second gear you lose a lot of momentum. The drivers hate that when, for example, they have to join fast-flowing traffic in a roundabout – they worry that they might not have the acceleration.

"With our system you just have full acceleration throughout your whole speed range. There are no breaks between gear changes. I would have thought that was

## CareerCV

### Alexander Schey Founder and CEO, Vantage Power

#### Education

**2009** BEng in mechanical engineering,  
Imperial College London

#### Career

Schey completed internships with Arup and Rolls-Royce while studying for his degree, working on heating, ventilation and air conditioning for an art museum and stress analysis.

**2009 – present** President and founder, Racing Green Endurance

**2012 – present** Ambassador for BIS '30 under 30' Make it in Great Britain campaign

**2011 – present** CEO of Vantage Power

Schey is a frequent speaker at schools, universities and museums on science and technology subjects and entrepreneurship.

a relatively small point at the beginning, but actually it's turned out to be a really key thing for them."

Vantage is currently in talks with numerous bus operators around the country and is manufacturing 10 'beta' engines to undergo trials with some of sector's main players. According to him, there are about 9,000 double-deckers in the UK between six and 12 years old, and this is Vantage's target market. The looming emissions regulations mean a large chunk of that 9,000 will have a major incentive to adopt the technology.

"Realistically, just due to the way we ramp up, we'll probably only have access to around 7,500 over the next few years, but crucially 2,000 of those are in London," said Schey.

"So 2,000 double-decker buses, in 2020, will still have half of their remaining life... but will be illegal to drive through central London due to the ultra-low emissions legislation coming in. Every single double-decker has to be hybrid or better. These are vehicles that were bought maybe two or three years ago, and will literally not be able to drive, and they'll still have a decent chunk of life left. So those 2,000 vehicles in London are real prime property for us."

Vantage is also eyeing up international expansion, as well as the possibility of a single-decker version of the B320, although the commercial incentive with single-deckers is not as strong.

"If it turned out to be economical to put it in a single-decker, we'd be all over that," said Schey. "In fact, we've had an interest from a single-decker operator. But because they're about 60-70 per cent of the mass of a double-decker they use, as a rule of thumb, 60-70 per cent of the fuel."

Further down the line there are loose plans for plug-in hybrids, dependent on both an improved charging infrastructure across the UK, as well as the success of the B320. The former will require major government investment and won't happen overnight, but the latter could be just around the corner. ☺



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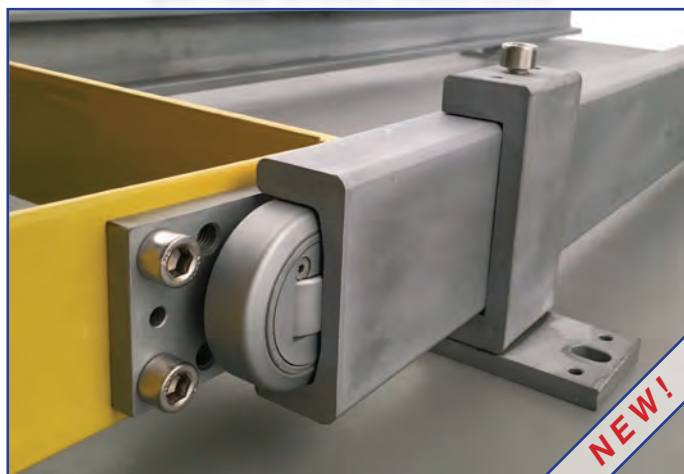
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# Making the most of the microbes

**Novelist Jon Wallace considers the science fiction implications of engineering stories that have caught his eye. This month: some unlikely heroes and villains in the form of bacteria**



allows us to strip our characters of law and order's protections, placing them in exciting future frontiers.

We normally follow a plucky group of survivors picking through a *Mary Celeste* world, fighting off the hostile infected: humanity returned to evolutionary struggle. Unlike post-nuclear war tales, we can offer a glimmer of hope to our characters – of a cure, that brings us back from the brink, and turns the lights back on.

Often enough, the disease becomes a character in its own right, given a title by its mad inventors, a face by its symptoms. It's a demon that possesses us, transforming us into grotesques, vampires, zombies. Here sci-fi is infected by horror and fantasy, losing any sense of scientific grounding; the fact that some Frankenstein created a monster in a test tube is regarded as 'science' enough.

Often these stories are pessimistic, playing on modern fears of something ugly lurking beneath the veneer of civilisation (*The Walking Dead*); of overconfident human science treading on God's toes (*The Stand*); or of nature's revenge on a globalised world (*Outbreak*). All are united by fear of the unseen, of microbiology as an invisible invader we cannot recognise until it has already occupied us. In an era of HIV and antibiotics, bacteria seem less threatening to writers, and often lose out to viruses as the ultimate antagonists – even as antibiotic resistance grows, even when bacteria have given us cholera, anthrax, leprosy and bubonic plague.

Should microorganisms play such a limited role in our fiction? The more you investigate the science, the more new story avenues present themselves – where bacteria offer intriguing possibilities beyond the narrow confines of lethal pandemics.

This month, for instance, *The Engineer* reported on new developments in bacteria-powered energy production; researchers in the US are using

h, microorganisms. Is there anything they can't do? For the writer seeking to destroy civilisation, microbiological agents such as viruses and bacteria have become a popular tool. The 'outbreak' scenario

cyanobacteria (a phylum that obtains energy using photosynthesis) to create 'bio-solar panels', which produce electricity, opening the way to advancements that could release bio-solar cell technology into practical applications.

Such applications are emerging all the time, offering a vision of a future where microorganisms



Why should microorganisms play such a limited role in our fiction?

**"Bacteria offer some intriguing possibilities moving beyond the narrow confines of lethal pandemics"**

Jon Wallace

solve our man-made problems; creating clean energy such as the bio-solar panels; bringing rain to drought-hit regions through bio-precipitation; cleaning up toxic waste through bioremediation. Bacteria seem to be crucial to our future development.

Space exploration could be fertile ground for bacteria fiction. Could it be that rather than manned

space travel to other worlds, we might first see bacterial astronauts? Bacteria are, after all, among the hardiest of organisms: flourishing in the deepest parts of the ocean, in acidic hot springs, in the Earth's crust; and in manned spacecraft. Would such organisms not be crucial to colonisation of space? A story could see dormant starships dispatched to a system boasting an Earth-like world. On reaching the system, the craft's bacteria are woken by the sun's rays, powering up the craft's systems, which fire bacterial seeding pods into the planet's atmosphere, making rain and fermenting new organisms, a genesis that makes mankind a new world in six days.

Perhaps the bacterial future will be on a more intimate scale: the human body contains at least as many bacteria as human cells, in our guts, in our orifices and on our skin. We are only beginning to understand how they influence our health, even our minds. Recent studies even suggest that gut bacteria have a powerful effect on our mood and cognitive function.

This being the case, might an informed chef not create a new psychological cuisine? We might follow the story of some gourmand who serves dishes laden with programmed mind-altering bacteria, offering a menu of upper mains and downer desserts. As he experiments and refines his recipes, he discovers that love itself is a bacterial infection. Sickened by a world torn by conflict, he begins dishing out food laden with highly infectious, programmed bacteria: erotic entrées and passion pastries that start a love epidemic, ending war (and the legal profession) overnight.

It's not the only profession that could be changed by bacterial engineering: HR managers might turn to seeding office keyboards with happy, healthy bacteria, programmed to infect workers and 'switch off' on leaving the office – making the workplace the only location where we are truly content.

However the future plays out, one thing seems certain; the more we understand bacteria as equal inhabitants of our world, as capable of good and bad effects as humans, the better we'll understand ourselves – and the more new, infectious stories we'll have to tell. ☺

**Jon Wallace is a science fiction author living and working in England. His new novel, *Steep/e*, is published in paperback. Check out his website [jonwallace.co](http://jonwallace.co)**

# Smart motors show some good sense

**A European project is developing motors that can interact with each other while also acting as eyes for the whole production line.** Helen Knight reports

**T**he rise of Industry 4.0 and smart production lines means sensors are increasingly being used in all areas of manufacturing. These sensors can provide engineers with exhaustive details on the health and operation of their production lines. But installing huge numbers of sensors on machinery and equipment can add considerable costs to an operation. A fault with a single sensor on the line can also lead to production downtime and financial losses.

To this end, Prof Matthias Nienhaus, a drive systems specialist at Saarland University in Germany, and his colleagues are developing smart motors that do not need external sensors. Instead the motors themselves act as sensors, allowing them to monitor whether they are running smoothly and detect any faults.

The motors are also capable of communicating and interacting with each other. In this way they could be used to form a network of smart motors, linked by an operating system, and capable of monitoring the entire production line.

Ultimately, the system could make it possible for one motor to automatically take over from another in the event of a failure.

By allowing production components to continuously monitor themselves for faults and signs of wear in this way, the researchers hope to make manufacturing more cost-effective and flexible. "We can see how a bearing is working, and whether there is a problem with the winding or with the coils, for example, and we can react to it to maintain the motor," he said.

Reducing the use of additional sensors can save a considerable amount of space and money, according to Nienhaus. This is particularly the case with smaller motors. "Relative to the amount you spend on a small motor, the [sensor] encoder is nearly the same cost," he said. "So if you want a motor that is able to measure

"If you want a motor that is able to measure positioning, then you have to invest in a sensor that costs roughly the same amount as the motor"

Matthias Nienhaus, Saarland University

positioning, then you have to invest in a sensor that costs roughly the same amount as the motor," added Nienhaus.

Using fewer sensors also reduces the complexity of the system, by cutting down on the number of cables and other equipment needed, he said.

To use the motor as a sensor, the researchers monitor the distribution of its magnetic field strength. As the electric current flows through the coils within the outer ring of the motor's rotating permanent magnets, a magnetic field is created.

By monitoring how the magnetic field changes as the motor rotates, the team can calculate the exact position of the rotor and is able to draw inferences about how it is performing.

The magnetic field is monitored by measuring the electrical signal from the motor. Any deviation in the magnetic field, caused, for example, by a fault altering

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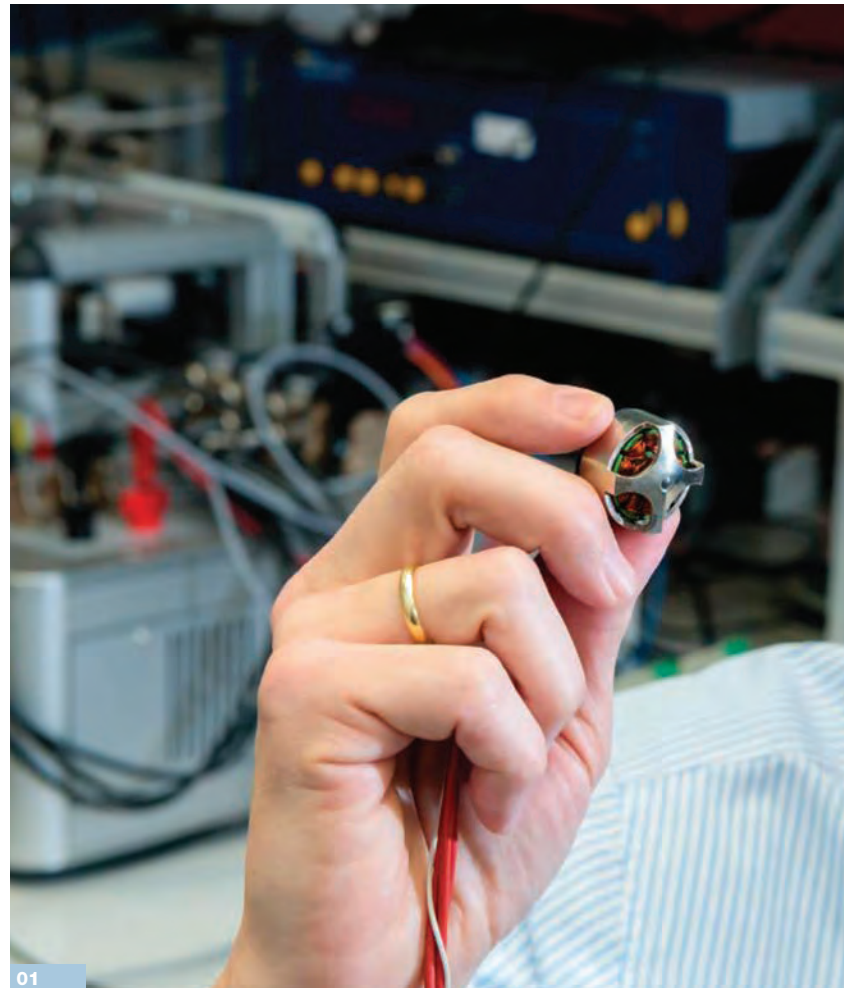
**01** Prof Matthias Nienhaus with one of his team's smart motors

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the normal operation of the motor, will alter the electrical signal, said Nienhaus. "If we change something in the motor, for example, if there is a hole in the magnet, then you can see it in the signal," he said. "It works like a finger print, so each motor has its own fingerprint."

By analysing these signal patterns the researchers can detect changes caused by malfunction or wear. This allows the researchers to very precisely pinpoint problems with the bearing, for example, or if the motor's mount assembly has not been well built, said Nienhaus.

The researchers are now developing mathematical models to simulate the different motor states, fault levels



01



"If we change something in the motor, there is a hole in the magnet, then you can see it in the signal. It works like a fingerprint for each motor"

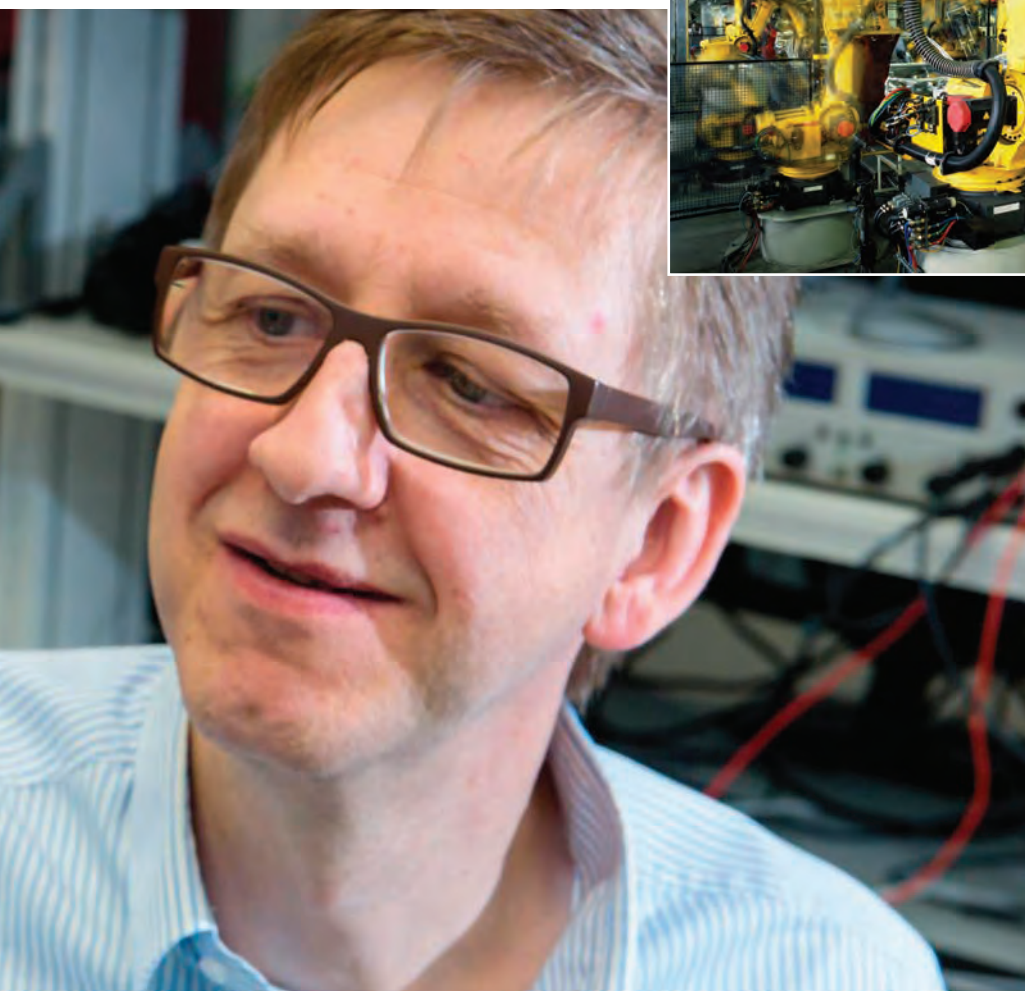
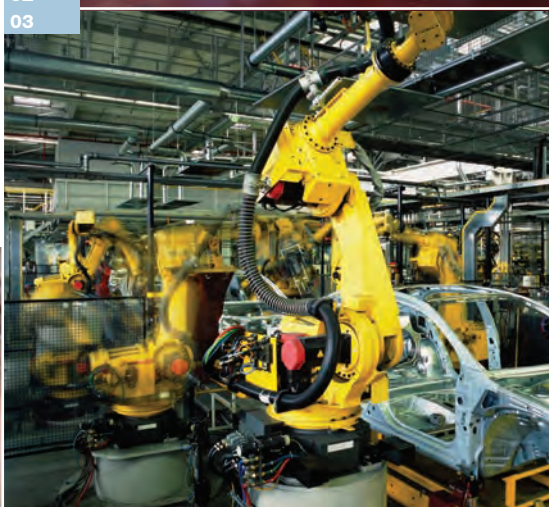
Matthias Nienhaus, Saarland University

and degrees of wear. These will be fed into a microcontroller, to allow it to continuously process the data coming out of the motor. Any faults can thus be responded to immediately.

As part of the project, known as Modular Sensor Systems For Real-time Process Control and Smart State Monitoring, Nienhaus and his colleagues are investigating which motor speed range generates the best data, and which type of motor is most suited to the application.

Alongside the team at Saarland University, the project also includes researchers at the Fraunhofer Institute for Microelectronic Circuits and Systems and at Kaiserslautern University of Technology, as well as companies such as Bosch, Festo, Sensitec, Lenord, Bauer and Company, Pollmeier and Canway Technology. The €3.1m (£2.4m) project is being funded by the German Federal Ministry of Education and Research (BMBF).

One potential application for the self-monitoring motors the team is investigating is in the development of smart conveyor belts for factories, distribution centres and airports. Each drive roller in the conveyor system could be fitted with



**02/03** Sensors are increasingly used to gather data on production lines

one of the sensor motors, which would allow it to continuously monitor its performance and health.

The smart rollers would also be able to communicate with one another, and their operating system, to allow them to respond automatically to changes or problems, said Nienhaus.

So, for example, if a fault appeared in one of the rollers, it could be instantly detected and the products, packages or luggage automatically directed along a different route.

"We would like to make a complete conveyor system, where each roll has a motor and an operating system, and via this operating system the individual rolls can talk to other rolls," said Nienhaus. "This would result in a very powerful and complex system where each roll is one cell, and all of the cells work together."

By analysing data on the roller's angular momentum, the system could even estimate the weight of the package moving over it, and determine if there is space inside for another item, he added.

"We would like to make the system very simple, and we are also working with a chip manufacturer, to put all of the electronics and software into a single chip," said Nienhaus. "That will be a very important step in making the technology cheap enough to be used in each roll."

The project, dubbed 'Rolle', is being funded by a €4.2m grant from the BMBF, and was presented at Hannover Messe in April. The team is planning to test the system at a large distribution centre. ©



# Techniques and coatings optimise performance

**Treatments can be applied to bearings that combat friction and corrosion.** Supplier: Barden Corporation

Products developed by The Barden Corporation are frequently designed to optimise performance through the addition of new design features or by

applying special techniques and coatings to components.

The role of surface engineering in rolling-bearing technology is

becoming increasingly important as bearings get progressively smaller, but are still required to run faster, at higher temperatures, carry higher loads and thus operate reliably for longer periods.

Advanced coatings and surface treatments can be applied to bearings that combat friction, prevent corrosion and reduce wear, even under the harshest operating conditions. The resulting benefits are higher power density, improved performance, more predictable/consistent bearing behaviour (particularly in harsh environments), lower running costs and longer service intervals.

Multi-layer sub-micron (sputtered) coatings, for example, can be employed to enhance the physical and tribological characteristics of bearing surfaces. The success

of such techniques relies on the avoidance of distinct layers by generating a graduated or diffused interface between different materials. Similarly, keying layers such as nickel or copper are frequently used to improve the adhesion of soft films to hard or passivated substrates.

Sub-micron coatings can be applied to the internal and external surfaces of bearing rings and rolling elements if required. For example, molybdenum disulphide ( $\text{MoS}_2$ ) or tungsten disulphide ( $\text{WS}_2$ ) can be sputter-coated to the surface of bearing components in order to make bearing behaviour more predictable in harsh environments.

In some high-speed applications, the ball separators or cages can be supplied in special polymer materials. These components are vacuum-impregnated with oil to increase the life of the bearing.

The special polymer material is able to retain the oil in a controlled manner when vacuum impregnated. Application examples include bearings for high-speed aircraft gyros.

Other special polymers can be provided for high-speed harsh environments where the bearings require high resistance to chemicals or thermal attack. ☐



# Low-cost robotics can increase productivity

**Kit has applications from automotive production to medical.** Supplier: Igus

German manufacturer Igus has introduced a direct-drive articulated joint kit known as Robolink D, which will complement its Robolink W wire-driven modular robotics kit.

Currently available in three joint sizes – 20, 30 and 50 – the new development is based on self-

lubricated PRT slewing ring bearings, with the joints driven by a worm gear drive and NEMA 17- or 23-stepper motor.

“Until now, the stepper motors were not placed in the robotic joint itself, but instead in a separate drive unit, driven by means of Bowden wires coupled to it,” said Robert Dumayne, Igus director.

“In order to carry higher loads with better precision, Robolink D is our second concept where the motors are integrated into the joints. The direct drive makes the Robolink articulated system tougher and more durable than before, opening up more opportunities for lean automation.”

The direct-drive articulated joint kit consists of Iglidur PRT slewing ring bearings, a worm gear and a plastic housing that can be optionally equipped with Igus stepper motors and connecting components, as well as limit switches for zero point definition.

The modular design of Robolink D is intended to provide manufacturers and engineers with low-cost robotics to increase productivity.

According to Igus, potential applications range from automotive production to medical technology.

“With Robolink D, it is possible to use the individual articulated joints as a construction kit to make an articulated arm with up to six degrees of freedom,” said Dumayne.

In addition to the articulated joints, plastic connection elements and aluminium connection tubes are also available. STEP files of the connecting parts are available free of charge, but the control elements are not included.

The designer is free to select their own control solution, with many options available, including stepper-motor control cards, PLCs or educational solutions such as Matlab, Labview and ROS. ☐







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# Halving aerator costs at the sewage treatment works

## Variable-speed drive gets to work on sewage aerator in Lincolnshire facility. Supplier: ABB

A sewage treatment works operated by Anglian Water has halved its aerator energy costs, reduced maintenance and cut ammonia to almost zero levels following the installation of an ABB variable-speed drive. The drive was installed on a 4kW sewage aerator at the Swallow unmanned treatment works in Lincolnshire.

Wayne Barley, northern energy and efficiency engineer for Anglian Water, said: "The vertical rotor of the aerator was set on a duty cycle of 20 minutes off, 20 minutes on. Working in this way, there were frequent sudden stops and starts that caused shock loads on the motor and gearbox, as well as needing frequent operation of the contactor to switch the motor on and off.

This sometimes led to electrical and mechanical failure of the aerator, causing interruptions to operations.

"The middle of the aerator has a tube to pull effluent from the bottom of the tank to the top of the tank, similar to an aquarium air lift, which ensures all the content is treated," explained Barley. "The old 20-minute duty cycle allowed detritus to settle at the bottom

of the tank during the off phase, causing the tube to block over time. We needed a solution that would solve these problems and hopefully also produce energy savings by matching sewage treatment more closely to demand."



Following a site survey an ABB machinery drive, ACS355, was recommended. The drive's internal timer outputs signals to switch the motor on and off and to alter the frequency to achieve different speeds at different times.

"We experimented with the timings and speeds so we could find the minimum that would still draw the effluent and aerate the sewage," said Barley. "We settled on four different time periods, during which the motor would be constantly on but working at different speeds to match the demand at those times.

"These changes mean the aerator motor achieved a minimum of 10 per cent reduction in speed even at peak times, while the ramping and soft start capability means we avoid shock loading to the motor and gearbox." A ramped start feature reduces the high load and torque placed on the motor gearbox and power train during start-up, and also prevents constant switching of the contactor and motor, which can lead to failure of equipment over time.

The original energy cost of the application was £762 per annum, but this fell to only £374 following the introduction of the ABB drive, a reduction of nearly 50 per cent. ☐

# Some important tricks for robotic reconnaissance

## Zippermast means tiny vehicles can raise camera sensors to see over obstacles. Supplier: EMS

Inspired by coiled metal tape measures, the Zippermast is the key to an important trick in the repertoire of the ZM series of robotic reconnaissance vehicles. The mast is an extending neck that allows the little caterpillar-tracked vehicles to raise camera sensors to see over obstacles. Consisting of three interlocked tapes that work according to the principles of the zip, the mast is raised and lowered by a motor from Faulhaber, according to Electro Mechanical Systems.

The smallest model of the ZM is just 15cm high, but this tiny casing holds a mast that can extend up to 4ft in height. The standard model is 25cm high with a mast that can go up to 8ft.

The developer of Zippermast, George Woodruff, designed the



system out of three tapes of spring-tempered, heart-treated stainless steel wrapped around coils and mounted at 120° to each other. A guiding spindle in the middle of the triangle has bevelled slots machine into it that grip the edges of the tapes, which have

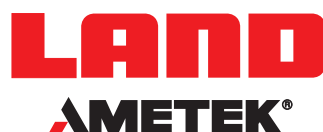
jagged edges that interlock with each other. When the spindle turns, the tapes extend. No locking mechanism is needed, and the mast can be raised to any height up to its maximum.

The motor that runs the spindle is essential to the operation of the robot.

It is frequently used under extreme conditions, often by the emergency services, so it needs a robust and long-lasting motor. It also has to achieve high performance in low volumes; it has to fit in a space with a diameter of 32mm. Andreas Eiler of Faulhaber decided to recommend a DC micromotor with a rated torque of 120nNm provided by compact but powerful rare-earth magnets.

The drive is delivered by a Faulhaber planetary gearhead with all-steel construction. The motor has a highly resistant polymer housing that meets IP68 dust- and waterproofing requirements and also resists corrosive chemicals, UV and IR. It can be used in sea buoys and Eiler said it could even be used in space. "The Zippermast can be used as a boom for small and medium-sized satellites antennas or optical devices, for example," he added. "In addition, we are working together with the company ODG-ARGO, which supplies robot vehicles to the NASA and CSA space agencies. We have just installed the Zippermast on one of the ARGO robots, which may be used for a planned Mars mission. I figure we have a good chance to be involved in one of these space projects." ☐





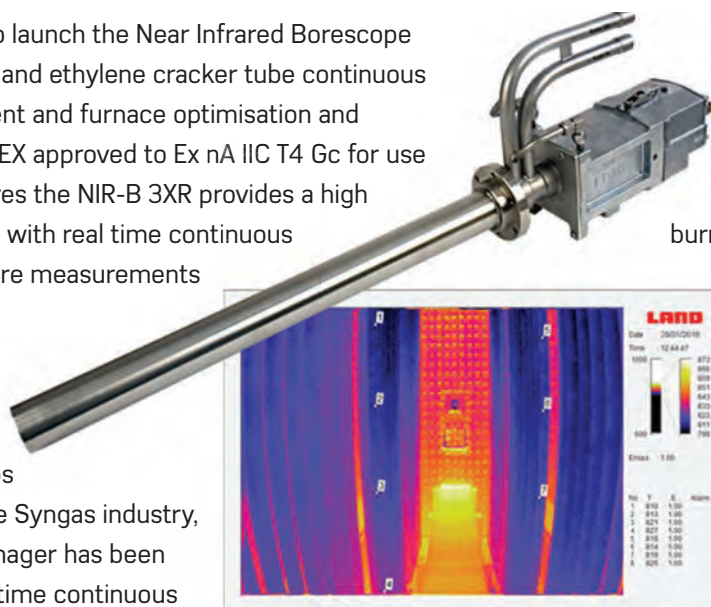
# Reformer tube temperature measurement and imaging

The latest thermal imager offering from AMETEK Land is designed for reformer and ethylene cracker tube skin continuous temperature measurement and furnace optimisation

AMETEK LAND is proud to launch the Near Infrared Borescope (NIR-B) 3XR for reformer and ethylene cracker tube continuous temperature measurement and furnace optimisation and monitoring. ATEX and IECEx approved to Ex nA IIC T4 Gc for use in Zone 2 Gas Atmospheres the NIR-B 3XR provides a high resolution thermal image with real time continuous high accuracy temperature measurements of both the tube skin and refractory surface.

Building on AMETEK LAND's long history with the high accuracy Cyclops portable pyrometer in the Syngas industry, the NIR-B 3XR thermal imager has been designed to provide real time continuous data monitoring of the reformer, improving data accuracy through automation and reducing personnel risk at the same time. The NIR-B 3XR uses the shortest wavelength possible to minimise errors associated with varying emissivity allowing highly accurate temperature measurement point data to be taken, stored and trended over the lifetime of the reformer or cracker.

The high resolution image combined with the wide angle field of view (90°) allows multiple reformer or cracker tubes in the lane to be imaged and measured simultaneously. With advanced digital communications the image and data can be viewed real time in the control room in the safe area.



The image also allows the user to monitor and optimise the performance of the furnace, easily identifying hot and cold areas within the reformer and any uneven heating due to unbalanced burners or gas mix can be visualised with corrections viewed in real time.

During start up phases any burners that are not operating correctly can be clearly identified and the effect of any impinging flames can be seen.

Working in partnership with leading Syngas catalyst manufacturers, global Syngas reformer operators and the reformer designers, AMETEK LAND has developed NIR-B 3XR to

provide an invaluable tool in prolonging reformer tube life time, optimising production throughput and reducing energy consumption. An additional benefit to using fixed thermal imaging is the opportunity to improve plant safety by removing the need for an operator or technician to be in the hazardous area on a regular basis.

Based on over 20 years' experience in high accuracy process thermal imaging AMETEK Land has a range of industry leading features in the image and data processing software platform that supports long term data trending allowing process optimisation to be achieved combined with potentially avoiding catastrophic failure.

# Manufacturers have it all safely in hand

**Advanced handheld probes are able to measure the parts on production lines that larger systems simply cannot reach.** Evelyn Adams reports

Working out the final tolerance between an Airbus engine and its enclosing nacelle is no easy task. The parts include thousands of tiny, precisely designed dimensions. Up until recently, engineers would measure each individual component on coordinate measuring machine (CMM) tables. But attempting to measure the intricate design of the entire engine system on the factory floor was almost impossible.

That is, however, until portable CMMs were introduced. Engineers at Pratt & Whitney's (P&W's) assembly operations in Middletown, Connecticut, have been using these handheld CMMs for a number of years to drive down costs and save time. Now, it seems even more manufacturers are turning to portable CMMs to take measurements. The trend is being driven by an improvement in the technical design of the units, which now feature even better accuracy and design.

"Handheld CMMs can make it easier to measure larger parts," said Frank Shevelow, a technician at Advance CNC Machining. "Some articulated arms, for instance, have a diameter reach of 9ft. They can also be more advantageous when there is a need to measure multiple axes at one time. They allow engineers to measure multiple aspects of a feature at one time, such as diameter and

concentricity of a bore... Some software will allow you to attach devices such as a laser scanner to scan parts and compare them to a CAD model."

At the Pratt & Whitney factory, engineers have been using CMMs known as Romer Absolute Arms from Singapore-based Hexagon Manufacturing Intelligence. "All crucial measurements can be taken while the engine remains securely within its engine build unit [EBU] on the assembly line," explains Zvonimir Kotnik, North America portable business unit manager at Hexagon Manufacturing Intelligence.

He added: "By using the CMM to replace the expensive custom-tooled gauges traditionally used to measure large cured parts, P&W engineers anticipate saving thousands of dollars per year in tooling costs, not to mention eliminating the costs of obsolescence when part designs are changed."

As well as being portable, handheld CMMs such as the Romer Absolute Arms have another major advantage. Engineers are able to switch from the special tube-measuring probe to a surface-measuring ball probe in a matter of seconds. This is particularly useful for tasks such as engine subassemblies, which can include a variety of different materials, such as sheet metal and tubing.

The latest generation of portable CMMs are significantly more advanced. For instance, in April, Creaform, a Canadian provider of portable 3D measurement solutions and engineering services, released its new portable CMM, dubbed the HandyProbe Next. The optical-based contact inspection solution claims to





**01** Hexagon Manufacturing Intelligence's  
Leica Absolute Scanner

**02** Creaform's HandyProbe Next  
portable CMM



address the increasing demands of rigorous quality control directly on manufacturers' production lines.

The HandyProbe Next features productivity and efficiency improvements in a more shop-floor-ready design for accurate part inspections, according to Creaform. It is aimed at quality-control experts who rely on portable tools to validate the size and shape of production tools, jigs, assemblies, sub-assemblies and final products. The device is claimed to be twice as accurate as similar machines.

It also uses a wireless probe that enables the instant capture of coordinates "Manufacturers are under increasing pressure to integrate more rigorous quality-control operations into their production processes, while still maintaining the same efficiency," said Daniel Brown, senior product manager at Creaform. "The HandyProbe Next delivers versatility, shop-floor accuracy and portability, unlike articulated arms or fixed CMMs. The solution comprehensively addresses quality issues that, if left unattended, can lead to unwanted production and

they can apply the right set-up for each section of the part without needing software adjustments.

"With the Leica Absolute Scanner LAS-20-8, we wanted to create an affordable handheld laser scanner that delivers results every time without complex set-ups or training needs," said Duncan Redgewell, vice-president, Hexagon Manufacturing Intelligence Portable Products. "Alongside the Leica T-Scan 5 – our high-end laser scanner for feature-rich inspections or use with robotic and automated systems – LAS-20-8 enables us to offer the right laser scanning solution for any large-volume measurement application."

Steve Young, an engineer at Exact Metrology said the biggest advantage of a portable CMM is driving down costs. "They do not require dedicated floor space or a dedicated temperature-controlled room," he added. "They are also portable so they can be taken to the problem rather than the other way around." He claimed that they are best suited to manufacturing engineering since they sometimes lack the right tools to solve problems on shop floor.

"A customer would, during weekend overtime hours, remove a tool from the shop floor and place it on a CMM, make all the adjustments and then reinstall it back on the shop floor, costing a lot of time and money," he said. "Now they just go out between shifts and check the measurements on the tool with a handheld."

Young said he believed the trend towards using handheld CMMs over more conventional table-based measurement will continue. "I think the technology will increase in accuracy in the coming years."®

part approval delays, fabrication shortcomings and unexpected costs."

Meanwhile, in February, Hexagon Manufacturing Intelligence released a new portable CMM laser scanner for large-volume inspection applications. Named the Leica Absolute Scanner LAS-20-8 portable 3D laser scanner, it is designed to make gathering complex data easier and quicker for shop-floor operators. Hexagon said the tool can be used for inspections of difficult surfaces, such as those that are shiny metallic or made from dark materials. The LAS-20-8 works for measurement volumes of up to 60m and has an IP50 rating that allows it to be taken almost anywhere in the workshop.

The scanner identifies itself to the tracker, enabling quick changes between scanning, probing and reflector measurements. A built-in guide light leads the operator to the optimum measurement position and haptic, acoustic and visual feedbacks. The laser intensity automatically adjusts to different surface types and operators can switch between pre-set measurement profiles using the main button of the scanner, so

"Manufacturers are under increasing pressure to integrate more rigorous quality-control operations into their production processes"

Daniel Brown, Creaform

# Air-gauging system aids shift into higher gear

**System allows company to overcome problems caused by aluminium alloy.** Supplier: Bowers Group

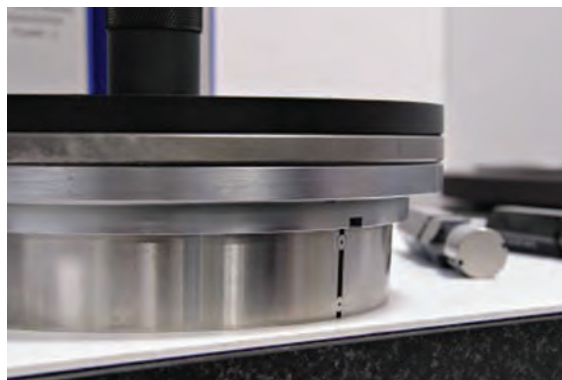
Bowers Group recently created a bespoke air-gauging system for actuator and flow-control specialist Rotork that allowed the company to overcome problems caused by the aluminium alloy it uses in a particular gearbox it manufactures. The method allows critical dimensions on the item to be measured without the need for any contact between the component and measuring equipment.

The gearbox has seven critical diameters that need to be verified to ensure that they make full contact with a mating part so that a flame-proof joint can be formed between the two components. Each diameter must be checked for roundness and dimension, with tolerances varying between 0.020mm and 0.050mm. However, the aluminium alloy is abrasive and tends to cold-weld to any part it comes into

contact with, which caused problems to the contact-gauging system Rotork used to make the measurements. Bowers has considerable experience with non-contact air gauging, hence the contact from Rotork.

Rotork's manufacturing centre uses Sylvac D300s digital displays, but Bowers did not have an air-gauging system compatible with this display, so undertook to develop a bespoke solution. In conjunction with

one of its suppliers, Bowers proposed an eight-channel air-gauging system that could be linked with the Sylvac digital displays. Early testing showed that the system would be stable, easy to calibrate and to use, and Rotork placed an order for two systems to be delivered to its machining partner HPC late last year. Paul Dennett, quality engineer at HPC, said: "The results are looking very good, even on the diameter 36.0mm bore, which only has a 0.020mm tolerance. I must also say that the gauging is much more shop-floor friendly than the old contact-style gauges." Bowers is now delivering a 10-channel system that works on a similar principle. ©



# Get your problems in better focus with point and click

**Multiple images with various focal depths are combined to create a single image.** Supplier: Fluke

A new thermal-imaging camera from Fluke is expected to improve measurement and inspection by allowing users to simply point and click without having to worry about focus.

The Ti450 Thermal Imager uses a feature called MultiSharp Focus, where multiple images with various focal depths are combined to create a single image. This results in a clear image with every part in focus, even from a target that was initially blurry.

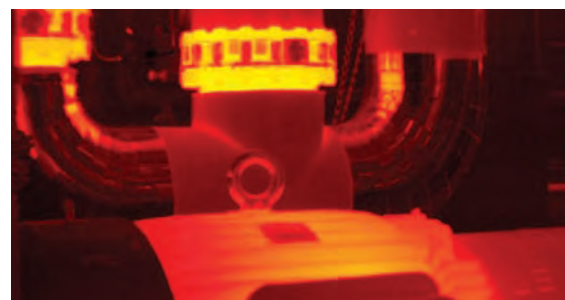
"This algorithm takes a series of images that are collected automatically and assembles them into one image that's in focus everywhere," said Jamie Reid, Fluke systems engineer.

"This makes the work of a thermographer a lot easier, because rather than trying to adjust focus on the fly, they're able to just point, pull the trigger, not have to worry about focusing, and be able to capture things at various focal depths in the image at the same time."

When the user pulls the trigger on the device, a built-in laser distance metre instantly calculates and displays the distance to the designated target, and the focus engine

immediately adjusts the focus. Multiple 640 x 480 images are then combined into a single image with the same resolution, displayed on a 3.5in LCD screen.

"We like this a lot for industrial substations," said Pete Bergstrom, head of firmware, software and systems engineering team at Fluke Thermography. "Also for mechanical situations where you're in tight quarters, you've got a motor that's driving some production line or a pump." ©





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# CMMs are taking a close interest in ejection seats

## Manufacturer of aircraft ejector seats upgrades its inspection capability. Supplier: Mitutoyo

UK-based Martin-Baker has delivered more than 70,000 ejection seats to 93 air forces throughout the world; and the company's products have saved over 7,450 aircrew lives. A combination of skilled staff, the best inspection and testing equipment, plus close relationships with suppliers of quality-control equipment, helps to ensure the production of the highest-quality safety-critical parts.

The mainstay of Martin-Baker's inspection function is its line-up of Mitutoyo CMMs; this relationship started with two Euro-C models back in 1997. The latest investment embraces four CMMs for the inspection department, situated in two environmentally controlled locations: the central inspection department in the main factory; and goods inwards. The first machines have benefited from

Mitutoyo hardware and software updates and were still performing well; but a decision was made to invest in the latest technology and the company's oldest CMMs have now been replaced with Mitutoyo's advanced Crysta Apex S9206 CMMs with scanning probe systems.

Quality manager Darren Smith said: "In light of the safety-critical nature of our ejection seats, we administer a stringent quality regime and our quality ethos permeates every aspect of all of our activities. All Martin-Baker staff fully appreciate that the ejection seat may represent a crew member's last chance to survive and that there can be no compromise on quality. Every facet of the safety system, from initiation, escape path clearance, ejection sequencing, stabilisation, life support and parachute descent, to

final rescue, must work perfectly to safeguard a life.

"As our production levels continue to rise, component throughput in our busy inspection and goods inward departments has grown accordingly. Therefore it helps that, when



compared to our older machines, besides having an enhanced accuracy specification, our new Crysta Apex S9206 CMMs perform quicker measuring routines. This is due to the employment of high-accuracy scanning systems that enable rapid data collection. In addition to the enhanced abilities of our new CNC CMMs and the outstanding performance and reliability of our older models, another reason for remaining loyal to Mitutoyo is the excellent service we have received from the company, in terms of training, support services and calibration. To allow our operators to take full advantage of our efficient new Mitutoyo CMMs, prior to installation we radically reorganised our environmentally controlled inspection and goods inward departments."

Martin-Baker also uses Mitutoyo's MCoSmos CMM offline programming software in order to maximise the measuring time of the CMMs. The software allows generation of measuring programs away from the CMM by using CAD models rather than physical parts.

"Whenever possible we use our new Crysta Apex S9206 CMMs, as their CNC operation automates measuring routines and provides both accuracy and speed," said Smith. ©

# Taking vision measurement onto the exhibition floor

## Non-contact vision measurement probe system for CMMs goes on show. Supplier: Renishaw

Renishaw took advantage of MACH 2016 to exhibit its extensive range of equipment, including the new non-contact vision measurement

probe system (RVP) for co-ordinate measuring machines (CMMs).

The new RVP for use with the Revo-2 5-axis measurement system

on CMMs is claimed to increase the multi-sensor capability of Revo-2 by adding non-contact inspection to the existing touch-trigger, high-speed tactile scanning and surface finish measurement capability of the system.

For certain applications, non-contact inspection provides advantages over traditional tactile probing techniques. Thin sheet-metal parts, components with large numbers of holes (as small as 0.5mm), and parts that are not suited to tactile measurement can now be fully inspected with the RVP system. According to Renishaw, this new innovation also gives marked improvements in throughput and CMM capability by utilising the 5-axis motion and infinite positioning provided by the Revo head.

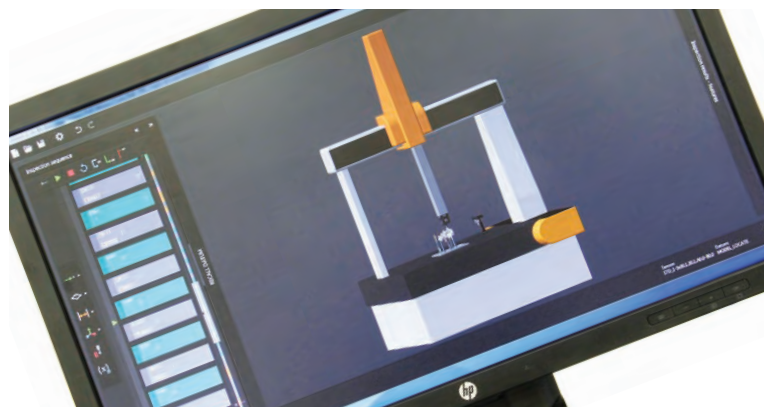
Furthermore, the company's Modus 2 metrology software suite brings new levels of efficiency to the programming and operation of CMMs. Based on the Modus platform, Modus 2 has been designed with usability in mind, including a simple interface and faster programming, resulting in high levels of productivity with or without a CAD model.

The user experience for Modus 2 is also designed to be identical whether the software is connected to a 'live' CMM or working in an offline environment where full simulation with speed control allows measurement sequence development and visualisation.

Further innovations include 'Off Surface' motion technology, intelligent measurement strategies, automatic reporting and an interactive virtual CMM environment.

Renishaw also exhibited its Sprint system at MACH, which offers high-speed, high-accuracy scanning to CNC machine tools.

Sprint records a constant stream of accurate 3D points across the part surface, and analyses this data in real time on the CNC machine-tool controller, to provide opportunities for automated in-process control. ©





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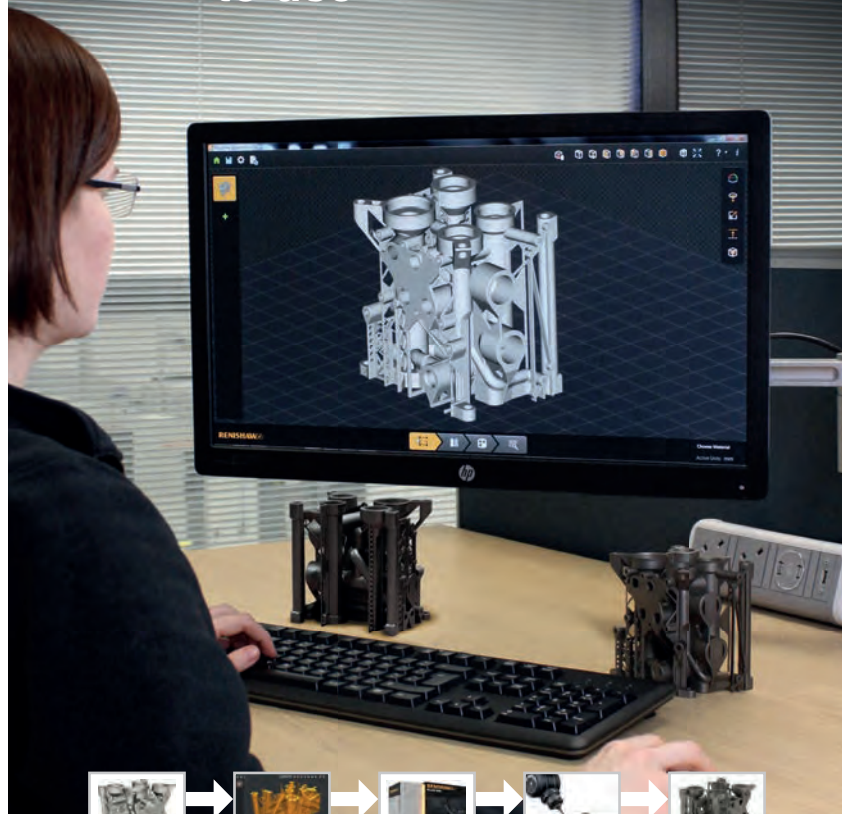


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# Additively produced metal parts take flight for Airbus

**Parts include printed titanium fuselage and engine pylon components.** Supplier: Alcoa



Following last year's US\$1bn deal to supply Airbus with multi-material fastening systems, Alcoa has announced that it will henceforth supply the airline giant with 3D-printed metal parts.

The parts include printed titanium fuselage and engine pylon components for Airbus commercial aircraft. Alcoa expects to deliver the first additive manufactured parts to Airbus in mid-2016.

"We are proud to partner with Airbus to help pave the way to the future of aerospace development and manufacturing," said Alcoa chairman and CEO Klaus Kleinfeld.

"The unique combination of our multi-material alloy development expertise, powder production capabilities, aerospace manufacturing strength and product qualification

know-how position us to lead in this exciting, emerging space."

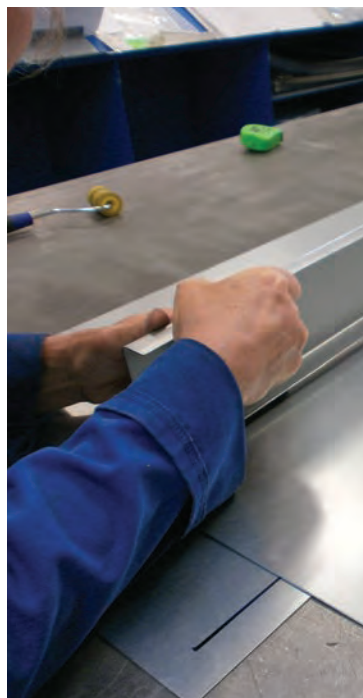
The agreement follows last year's acquisition by Alcoa of RTI International Metals (RTI) – now known as Alcoa Titanium & Engineered Products (ATEP) – which enhanced Alcoa's additive manufacturing capabilities to include 3D-printed titanium and specialty metals parts. These capabilities will be drawn on under the new Airbus deal, along with ATEP's titanium ingot melting and billetising, machining, finishing and inspection technologies.

Alcoa is also bolstering its additive manufacturing capabilities through a US\$60m investment in advanced 3D-printing materials and processes. This involves expansion of the company's Technical Centre near Pittsburgh, Pennsylvania.

Last year's US\$1bn deal with Airbus saw Alcoa awarded a contract to supply titanium, steel and nickel-based superalloy fastening systems for a range of Airbus aircraft, including the A350 XWB, A320neo, and A330.

"Our growing aerospace capabilities, technology strength and global, first-rate customer service continue to strengthen Alcoa's decades-long partnership with Airbus," said Kleinfeld. ©

# 'Constructive bonding' makes an entrance with double-sided tapes



**Range can cope with the differential thermal properties of substrates.** Supplier: Tesa

The ACX Plus range of double-sided tapes from Tesa represents the latest series of innovations from the company in the arena of "constructive bonding".

Constructive bonding is based on the viscoelastic properties of ACX Plus.

This characteristic enables the range to cope with differential thermal properties of substrates to be bonded. In addition, it allows ACX Plus to cope with uneven or irregular surfaces.

Quality double-sided tapes have always displayed many benefits in speed of application and cost-efficiency over mechanical fixings on close-fitting interfaces, Tesa said, but ACX Plus adds this new viscoelastic dimension to encompass a much wider range of applications, both indoors and out.

According to the manufacturer, the benefits of using a high-performance tape as against traditional mechanical methods or adhesives include:

- Quicker and easier application than comparison to riveting, screwing or welding, which speeds up manufacturing/assembly;
- A seamless finish, with no drill holes that may lead

to corrosion and better aesthetics;

- Equal distribution of the stress areas of the bond, so no weak points are created as is the case with rivets and screws;
- Corrosion prevention; and
- Compensating for different rates of thermal expansion and contraction of different substrates, as well as absorb shock and vibration.

Tesa 706x ACX Plus offers high adhesion – especially when used in conjunction with an adhesion promoter in the bonding of powder-coated materials that have a lower surface energy and are commonly known as being hard to bond through preventing the adhesive from wetting out the surface.

In addition, Tesa ACX Plus 707x can be used to bond panels before they are put through the powder-coating process, speeding up and simplifying the production process, with the advantage of avoiding colour-match issues on pre- and post-painted parts.

Tesa claimed that the ACX Plus range is the most effective double-sided tape product for constructive bonding currently available. ©



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# Lightweight vehicles drive new specialist adhesives

**Products are optimised for composite parts that incorporate metal components.** Supplier: Henkel

Earlier this year, at the JEC world composites show in Paris, adhesive specialist Henkel highlighted how the pressure to produce ever more lightweight vehicles is driving the development of a range of specialist adhesives, optimised for the production and assembly of composite parts, including hybrid concepts incorporating metal components.

One particularly notable example is Loctite MAX 2, a two-component polyurethane composite matrix resin system, which is now being used in the automotive industry, and enabled composites specialist Benteler-SGL to develop a glass-fibre-reinforced leaf spring that's now being used on the Volvo XC90.

Elsewhere, automakers are increasingly turning to fibre-reinforced plastics to replace steel, and this

creates a growing need to find effective ways to bond these types of mixed materials to one another.

For overcoming the different coefficients of thermal expansion (CTE) in modern, lightweight bodies,

the market needs an adhesive that offers both high strength and high elasticity at the same time.

In response to this demand, Henkel has developed a new adhesive known as Loctite UK 2015, which is based on

two-component polyurethane technology. According to the firm, this adhesive is ideally suited for use on structural body parts, regardless of whether they are made of fibre-reinforced plastics, e-coated steel or e-coated aluminium.

Henkel also introduced a new binder technology at the show, Loctite FRP 2000, which has excellent compatibility with polyurethane and epoxy matrix resins.

In the preforming process, only small amounts of the FRP 2000 binder are needed due to its high mechanical strength, and it is therefore well suited for use with complex-shaped parts. ☐



# Stock management is the key to growing business

**Fastener supplier offers a broader range of services to assist its customers.** Supplier: TFC

Many long-term customers recognised TFC as a reliable and technically competent fasteners supplier but were not aware of the broader range of services being offered since expansion plans were put in place back in 2007. These plans have

moved the company from a two-centre £7m business to an eight-centre pan-European £21m business that employs over 100 staff.

A recent example of TFC's growth success has been the introduction of a customer-tailored DLF operation

with one of the UK's leading ball-valve manufacturers, which was looking to significantly improve upon the system already in place.

Steve Teale, TFC's sales director, said: "TFC had an excellent relationship through the long-term

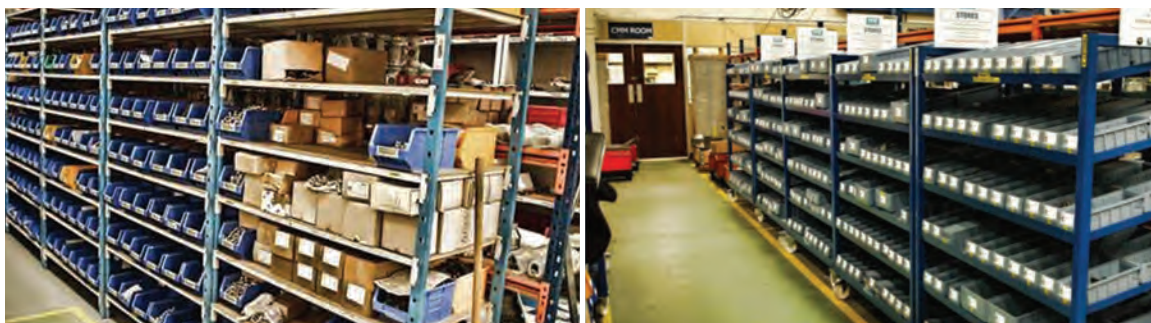
supply of a range of Smalley Spirolox rings and circlips.

"We identified an opportunity to further grow this relationship with cross-selling of other fastener products and services, specifically with our flexible Direct Line Feed solutions as the customer expressed concerns on its current service levels with its existing supplier.

"TFC's commercial team offered a competitively priced package that allowed our logistics team to carry out a routine site survey and to analyse the customer's current set-up. We soon identified signs of sub-standard service, double-bin stock-outs, untidy racking, poor labelling and we were advised of on-going price increases that were affecting their production schedules, and ultimately, the reputation of this manufacturer with its customers."

After completing the site survey, TFC's logistical team was then able to offer an improved stock-management system.

The new racking was introduced at TFC's investment, complete with new stock bins and clear 2D barcode labelling, which allowed the customer to track and reduce consumption and overheads. ☐





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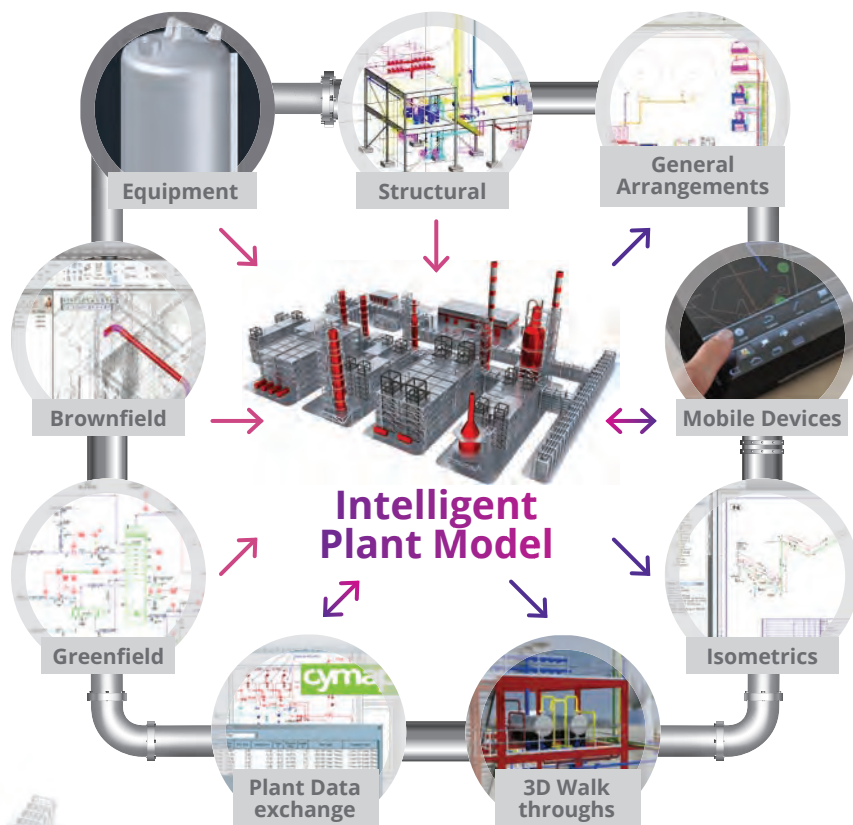
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# Weapons-grade energy savings

**The Ampthill site of Lockheed Martin is setting high standards for energy management.** Mike Farish reports

**T**ucked away just to the north of the small Bedfordshire town from which it takes its name the Ampthill site of Lockheed Martin UK is one of 21 locations across the country owned by the US multinational. It currently employs some 922 people in the design, development and production of various high-technology

systems in areas such as aerospace and defence.

Graham Harraway, operations director at Ampthill, explained that the 64-acre site is the only one in the UK that is wholly owned by the company and, since it was acquired a little over a decade ago, has had about £23m invested in it. He said that the site covers vehicle systems; mission support; and special projects. It is currently working on substantial projects for the turrets of the Scout SV and Warrior armoured vehicles used by the British Army.

At present, surprisingly few of those on site, only about 120, are involved in direct manufacturing or related support activities. Harraway explained that given that the current focus is on development work for the Scout and Warrior turrets there are some 449 engineering personnel in those initiatives. Those numbers will, though, rebalance as the two

contracts transition through to manufacturing – a flexibility aided by the fact that around a fifth of the development personnel involved are contractors rather than permanent employees.

Actual manufacturing activities include composites production, electronics installation, machining, grit-blasting and painting, as well as inspection routines using a coordinate measurement machine. The wide range of operations at the site is facilitated, Harraway added, by canny use of multi-skilling. Some of the CNC machinists, for instance, are also qualified wiring technicians.

But as with any manufacturing business, the bottom line of profitability depends on many factors, not least

**01** Developments of the turret for the Warrior armoured vehicle is a current major focus

the energy efficiency of its operations. Last year it became the first site operated by Lockheed Martin to gain the ISO50001 energy management standard. In fact, it is now described by the company as its 'greenest' site in the UK.

Harraway said that gaining the standard presented itself as an appropriate option for the company as it looked ahead to the time when current development projects would morph into necessarily more energy-intensive manufacturing. Moreover, the preponderance of defence-related work carried out at the site means that work there is already governed by a number of extremely demanding procedural standards common in that area. He mentioned, for instance, the AS9100 quality management standard.

As such, Harraway explained, there is already a lot of familiarity with measuring and managing. Moreover, he added that an initial assessment of what the standard could offer confirmed very importantly that it included an emphasis on continuous improvement that could be implemented in a structured manner.

Energy savings had, in any case, been perceptibly increasing in importance as a target area for improving efficiencies since 2010.

That was when the company carried out a structured improvement exercise in response to its recognition that it simply could not measure what its energy consumption actually was down at shopfloor level. "We knew what we were spending on electricity, but we didn't know what the key drivers were," Harraway explained. A very basic reason for that was that there was no sub-metering at all on the site; the only quantitative measurement of electricity usage was of the total amount consumed. But given the additional price volatility for heating oil one thing was clear: the site was spending too much money satisfying its energy needs.

Accordingly over the next few years, Ampthill was the location for a series of initiatives aimed at both assessing and beginning to tackle the causes of that situation. A start was made on introducing sub-metering, for instance, with some 20 monitoring points identified and kitted out appropriately. External consultants were used to analyse particular areas of energy consumption including IT servers, HVAC and lighting. The latter, by the way, came up with the rather astounding finding that nearly 1,200 different types of lighting unit were utilised at the site.

Moreover, all of this activity produced some tangible results. Oil consumption at the site, for example, was £364,000 in 2007 and only £66,000 in 2015.

But it was in October 2014 that the decision was taken to pursue an ISO50001 approach. The date is provided by Ian Martin, environmental safety and health manager. He said that although by then the site had stepped up its energy-related efficiency activities even further by formally auditing its energy consumption under the terms of the UK government's Energy Savings Opportunity Scheme (ESOS), it nevertheless realised that the scheme was limited in its potential, not least because it imposed no mandatory requirements for remedial action. "We wanted something that could take us to another level," he said.

Martin himself led the small team set up to spearhead the initiative. He said it comprised individuals from each of the five EESH (energy, environment, safety and health) zones into which the site is divided, plus a similar individual from a higher corporate level. Actually gaining the standard took

"As with any manufacturing business, the bottom line of profitability depends on many factors, not least the energy efficiency of its operations"





02

>> >> roughly six months starting from the pre-qualification audit in January 2015 through the achievement of Stage 1 in March and Stage 2 in June of that year.

An example Martin cited of the type of difference compliance with the standard makes is the requirement it imposes to take into account the energy-efficiency implications of all capital investment decisions. But the aspect he identified as particularly crucial is the demand it makes for energy-review procedures. These, Martin indicated, essentially involve a holistic analysis of energy consumption across all aspects of the organisation that in turn supports the formulation of appropriate monitoring and measurement plans to facilitate enhanced energy efficiency.

In practical terms, that meant a significant increase in the intensity of sub-metering at the site. Martin reported that the number of sub-meters used to monitor localised electricity

consumption has already gone up to 77. Areas currently sub-metered from the main incomer include all transformers and distribution boards, as well as individual items of equipment that have been identified as particularly energy intensive in their operation. The latter include, for instance, the hydroclave used in composites material production and also CNC machine tools. Moreover, this is a continuing process. Martin confirmed that by the middle of this year the number of sub-meters should reach a hundred.

All the data gathered in this way is

“We knew what we spent on electricity but not what the key drivers were”

Graham Harraway, Lockheed Martin



03

networked back to central energy monitoring point running a software system called SEEview that is, in fact, a Lockheed Martin product to provide a breakdown of energy consumption across the site. But, as Harraway explained, a hugely important implication of the availability of this data is that it will enable reduced energy consumption at the machine level by the relevant operator. “When we start to engage them with the metering so that they can appreciate when they are using the most energy they are the ones who will come up with the solutions,” he said.

It is only from around now onwards that the fact of the ISO50001 standard being gained will start to impact significantly on the day-to-day experience of most shopfloor personnel. This is not, of course, to say that environmental concerns and energy efficiency were not on the radar before. Harraway said that was manifested by, for instance, the prior existence of the five EESH zones, the ESOS work and an intensive recycling programme that in 2015 saw the site recycle 142 tons of non-hazardous waste out of the 163 tons it produced.

“We are adding to that,” Harraway observed. What employees will begin to notice increasingly from now on, therefore, is the amount of information about energy usage that will inform their teamworking and related target setting.

Nevertheless the standard is also manifested in more tangible ways simply by the adoption of various new types of energy-efficient hardware that are now found around the site. External lighting, for instance, that previously relied on halogen or sodium bulbs rated at 200-400W now utilises LED units rated at 16-18W.

Internal illumination for existing manufacturing areas is transitioning towards reliance on miniature fluorescent tubing complying with the ‘T5’ specification rather than the larger T12 and T8 types used previously. The former lighting units in one manufacturing building, for instance, were 60x400W high bay fittings. These were replaced with Tamline Hilux 380(T5) units that have an efficiency of 94.3 per cent and a luminous efficacy of 73.53lm/W. The cost saving is £3,500 per annum.

The ultimate objective, though, will be reliance entirely on LED units. On-off switching is also now increasingly effected by means of activity sensors rather than manual switches that can be left on needlessly. The state of the art for the site in all respects will be represented by a completely new £5.5m manufacturing facility specifically intended for the Scout SV and Warrior projects that is due to become operational in the summer of this year.

The process of gaining the standard was accomplished fairly quickly although Harraway and Martin concurred that doing so was not easy and more difficult than anticipated. As Martin explained, it is not a simple matter of following a set of instructions and actual implementation confronts those involved with nuances that require original thinking to be solved. Harraway said when the project started, energy-related thinking at Ampthill was at the building level but that this had to be driven down to a machine level.

In 2016 relevant site objectives include:

- not to exceed an annual figure of 5,200MWh for its electricity consumption;
- establish the energy that is required to manufacture a turret once the design has been frozen to allow setting of energy-efficiency objectives in 2017 for the Warrior and Scout programmes; and
- embed the energy management system aligned to the monitoring and measurement plan for each zone, so that it leads to appropriate objectives and targets for site energy consumption in 2017.

They also include ensuring the continuation of the site’s ISO50001 certification. The company said that it is now reviewing the work completed at Ampthill with a view to adopting the procedures it has pioneered elsewhere.®

02 Lockheed’s Ampthill site

03 The factory has achieved savings of £150,000 a year in energy usage





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# Stepping into a world of plastic

**The leading event for the design and moulding sectors of the plastics industry will have a host of major industry names in attendance**

**T**his year's PDM Event (14-15 June, Telford International Centre) will feature a free-to-attend conference covering injection moulding, rotational moulding, energy-efficient equipment and 3D mould tool design, while around the exhibition new machinery will be unveiled. The results of two new industry surveys – Best Places to Work in UK Plastics and Most Influential People in the UK Plastics – will also be announced.

On the exhibition floor visitors will have the opportunity to discuss projects with product design companies, rotational and blow-moulding machinery suppliers, toolmakers, rapid prototyping specialists, moulders and mouldmakers, masterbatch specialists, software suppliers and materials testing specialists. They can also bring along questions they may have relating to plastics design and moulding to the Plastics Consultancy Network's (PCN's) Plastics Surgery on stand E007, where PCN's consultants will be on hand to offer effective, creative and cost-effective advice and solutions.

Leading industry names who have booked stands include Meusburger, Branson Ultrasonics, Zimmer Group, Piovan, Plastrubition, Hasco Internorm, Plastech Solutions, Telesonics, Ewikon and Thermoplay.

New exhibitors include Connect 2 Cleanrooms (offering mouldshop solutions to prevent contamination); Staubli Connectors (hydraulic and electrical connectors); CRC Industries (global supplier of chemical products including purge agents and mould lubricants); Plunkett Associates (low-volume prototyping); BOC (industrial gases and cleaning solutions); and Petlon Polymers Ltd (polymer compounding and recovery).

*"Visitors will have the opportunity to discuss projects with product design companies"*

According to the event organiser, notable exhibits on show this year include Renmar's range of 17 Marse hopper loaders, Arburg's new Golden Electric 100-tonne machine. The Rubber & Plastics Research Association (RAPRA) will also be on hand to explain the benefits of membership, while any company in need of assistance can access the impartial specialist support from its Polymer Helpdesk twice, free of charge. This service aims to match

Many leading companies have booked stands at this year's event

the requirements of industry to leading polymer scientists and engineers that will provide a solution.

For many visitors, the free conference programme will be one of the main attractions. A topic that will loom large on day one of the conference is injection moulding. Martin Neff, team manager Technology Consulting – Plastics Freeforming, will give Arburg's perspective on freeformer additive manufacturing versus conventional additive manufacturing and Murdoch Crawford, category director, Plastipak, will provide an overview of SprayPET technology developments. Moulding experts from British Plastics Federation (BPF), Engel, Helix Polymer Technology, Stratasys, Arburg and Amtek Plastics will all participate in a panel discussion on recent innovations, and an industry attorney will advise on patenting strategies in injection moulding, explaining how costs and risks should be evaluated.

Rotomoulding will then become the focus, with a session on alternative materials presented by Matrix Polymers, and advice on preventing 'creep' – a cause of plastic product failure – presented by Dr Nick Henwood, rotational moulding expert, Rotomotive.

Other key sessions on day one include a session on Industry 4.0 (an industrial revolution in automation, data exchange and market trends), and an overview of energy-efficient equipment, which has been designed to show delegates the real savings that can be achieved by updating or replacing existing machinery.

Day two opens with a number of new perspectives on design, including a presentation showing what can be achieved when design is used as a tool for integrating different processes, led by Les Stokes, director, LA Design.

Technological developments covered in the conference include 3D CAD software for the automation of routine operations and Preview – a predictive system to recommend injection mould set-up with process optimisation in wireless sensor networks. The session on Preview will be presented by Dr Paul Shipton, consultancy director, Smithers Rapra.

This year's event will also see the full integration of the Plastics Recycling Expo (PRE), an exhibition and conference aimed specifically at the plastics recycling industry. In the PRE Conference, speakers will explore how to keep plastics recovery facilities viable in the current economic environment, value chains in the circular economy and how to increase the use of recycled content in cars. ☐





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# In the zone for subcontracting

**With more than 400 exhibitors and a clutch of new initiatives, Subcon looks set to become even more valuable for its visitors**

N

ow in its 40th year, Subcon, the UK's showcase for the contract and subcontract manufacturing supply chain, returns to the NEC, Birmingham, from 7 to 9 June, with more than 400 exhibitors and new initiatives to make the event even more valuable to visitors and exhibitors alike.

New at Subcon 2016 are dedicated zones, making it easier to find key suppliers. As well as the composites and materials zone there are also specific areas focused on contract electronics manufacture, manufacturing software, turned parts

(in association with the British Turned Parts Manufacturers Association), castings (in association with the Cast Metals Federation) and Surface Engineering (in association with the Institute of Metal Finishing).

In the international supplier zone there will be pavilions featuring subcontractors from The Czech Republic, Spain, Italy, Portugal, Latvia, Turkey, India and China.

Popular features launched at last year's Subcon are also back on the agenda. The Advisory Drop-In Centre gives SMEs access to expert advice on the critical areas for business success, including skills, innovation, exporting and access to finance, while the free-to-attend industry reception provides an ideal opportunity

to network over drinks and canapés.

In addition, select buyer visitors who attend Subcon 2016 will be invited to become part of the Buyer Programme, enabling them to search and select exhibitors based on the sectors they serve, services and approved accreditations and pre-book meetings. The personalised diary system will ensure buyers have a productive time at the show, ensuring meetings with the right suppliers.

Complementing these customer-focused activities, an insightful and eclectic conference will look at some of today's hottest technology trends and their impact on supply chains.

Free to attend for all registered visitors to the show, the conference will cover a broad sweep of topics, from supply-chain development issues, to technological challenges, sustainability, automation and late payments.

Keynote sessions include a presentation from Mike Healy, vice-president space systems and CIS procurement, Airbus Defence & Space, who will look at supply-chain trends and opportunities for satellite systems.

This is a fast-moving area, and as new paradigms come into play they bring major technology and cost implications – and significant opportunities for suppliers.

As Healy explained: "The supply chain represents typically 60-70 per cent of the total cost of a satellite. Historically, the supply-chain challenge focused on absolute reliability driven by a conservative approach to quality assurance and testing. The advent of 'new space' constellations such as OneWeb is driving a more innovative approach to achieve a 50 times reduction in price while maintaining high reliability. A new supply chain is being developed based on the opportunities, and risks, of this new business model."

Other keynote speakers include Dave Atkinson, UK head of manufacturing, SME commercial banking, Lloyds Bank, who will talk on investing to drive productivity and Jon Sumner of Lambert Engineering on taking automation to the next level with Industry 4.0.

Among the other topics covered are the commercialisation of composite materials for the mass market, precision metrology, additive manufacturing in supply chains, remanufacturing as a driver for sustainability, collaborative robots and SME engagement in major defence programmes. ©

**To see the full conference programme and register to visit Subcon 2016, visit [www.subconshow.co.uk](http://www.subconshow.co.uk)**



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**01/02** Select buyer visitors will be invited to become part of the Buyer Programme

"Features launched at last year's Subcon are back on the agenda"



## We asked a selection of Subcon's speakers what they'll be talking about at the show and about the broader challenges facing industry



● **Norman Housden, director, Optimatrix. Wednesday 8 June: SME engagement in major defence programmes**

### Q Why should visitors attend your session?

**A** For many smaller businesses the defence sector has often been too difficult to enter, however, with the changes in the administrative process and the recognition that SMEs are often more agile and can, therefore, deliver innovation sooner, now is the right time to reconsider competing in this sector.

### Q What is the biggest challenge facing the industry this year?

**A** Uncertainty. While the debate continues about staying in or leaving the EU we will be faced with a reduced appetite for long-term commitment, especially where import and export is involved. Working closely with our customers and suppliers to maintain stability whatever the referendum outcome is critical. Whatever happens in the vote the impact will not happen overnight, so hold fast to the existing terms of trade and establish a plan to negotiate the impact of any changes.

### Q And what is the most exciting opportunity?

**A** Uncertainty. Without doubt those companies that manage the uncertainty described above most successfully will be the most competitive and able to win more business than those who simply await the result and then try to react.

### Q Will it be more beneficial to the future of the UK manufacturing industry if Britain leaves or stays in the EU?

**A** The view that I take is that the UK has a strong capability in manufacturing and innovation and, whatever the outcome, there will be both winners and losers at a business level. However, the UK will adapt to the result and continue to build on its strengths.

### Q Why are you looking forward to speaking at/attending Subcon and why is this event so important for the industry?

**A** For the UK to rebalance its economy it is essential that the manufacturing sector becomes more competitive and reaches markets that have not previously been viewed as achievable, both internally and in export. I believe that the defence sector is now becoming more open for smaller businesses.

● **Neil Burns, director, Croft Additive Manufacturing. Thursday 9 June: Bespoke manufacturing and SME growth**

### Q Sum up your session in one sentence

**A** Exploring how newer and more conventional manufacturing methods can be used together to develop increasingly creative and innovative solutions.

### Q Why is it a must-attend for Subcon visitors?

**A** With the global additive manufacturing market estimated to reach US\$80bn by 2018, it's something we must all take heed of. Understanding its benefits, and how it can be incorporated into more traditional practices, will be a crucial thing to understand as the manufacturing industry develops in coming years.

### Q Why are you looking forward to speaking at/attending Subcon and why is this event so important for the industry?

**A** As an industry event, Subcon is one that allows businesses to share feelings and developments, and demonstrate advances in all aspects of the workplace.

● **Jon Sumner, associate sales director, Lambert Engineering. Thursday 9 June: Keynote address – Taking automation to the next level in the form of Industry 4.0**

“We believe that being in the EU has helped us win business”

Jon Sumner, Lambert Engineering

### Q What will Subcon visitors learn about at your session?

**A** Industry 4.0 and productivity are two of the biggest opportunities and challenges facing UK manufacturing today, and my presentation will give an insight into how to plan for the fourth industrial revolution and improve operational performance.

### Q What is the biggest challenge facing industry this year?

**A** Uncertainty. It casts doubt on purchasing decisions, slows investment and can delay new projects and innovation from being progressed. Never a good combination for a manufacturing business that has ambitious expansion plans.

The EU referendum is looming ominously on the horizon and nobody truly knows how it will affect UK manufacturing if we do decide to come out.

### Q And what is the most exciting opportunity?

**A** There is still a lot more we can do to build on this 'Made in Britain' movement and that is exciting for us. Consumers in the new superpowers love products made in the UK and, to a certain degree, this has been reflected in purchasing decisions and inward investment, where a lot of work has been reshored.

### Q What's your view on a possible Brexit from the EU?

**A** There has been a lot of conjecture from both sides, yet not a great deal of facts making their way to the surface of the discussion. From a Lambert point of view, we believe that being in the EU has helped us to win business overseas and, when you are breaking into some of the big European countries, it can be very difficult to break the domestic stranglehold. Anything that adds another barrier to that challenge would not be welcome.

### Q Why are you looking forward to Subcon?

**A** Subcon always delivers the largest collection of subcontractors in the UK, in one place over a short period of time. You just can't replicate that. It's one of the industrial events you always look for on the calendar.

● **Carl Hitchens, head of machining and metrology, Nuclear AMRC. Tuesday 7 June: Expanding the role of metrology for precision engineering**

### Q Sum up your session in one sentence.

**A** On-machine inspection is a technology that has the potential to provide real benefits in the manufacturing process, especially for large components. The infrastructure and investment required to provide efficient and effective handling equipment, and a coordinate measuring machine of sufficient measuring volume require significant capital investment. Investment that could be spent on increased manufacturing capability and capacity.

### Q What is the biggest challenge facing the industry this year?

**A** Supply chain. I see a great future for UK manufacturing. The challenge will be to transition through the current difficult market conditions and keep the UK supply chain in good shape, so that it can respond when the demand grows. Companies need to keep investing in capability and skills.

### Q And what is the most exciting opportunity?

In the nuclear industry, small modular reactors (SMRs) are a real opportunity for the UK supply chain. The technology of the SMR is at the scale that can be delivered by UK manufactures. ©

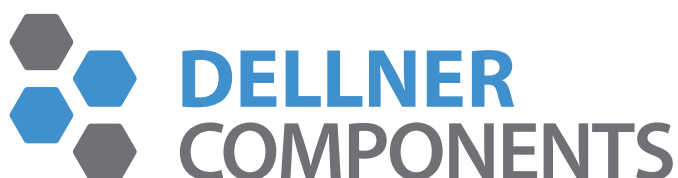




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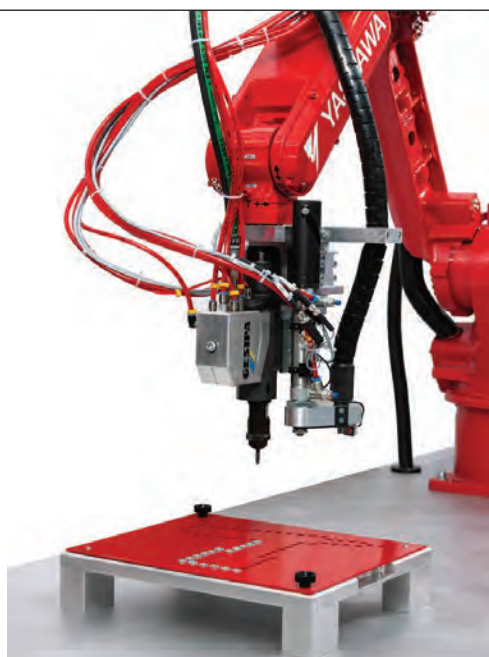
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# Step on the right side of the tracks

**With so many large projects underway, now is an ideal time to start a career in the rail industry.**

Evelyn Adams reports

**T**he railways in Britain are undergoing a transformation unlike anything seen in their history. Crossrail – London's huge new railway – is now entering its final stages of construction. Meanwhile, HS2 is set to form the core of what will be one of the largest infrastructure projects in Europe. Alongside this, Chancellor

George Osborne has recently indicated he will continue investing in rail by announcing plans to bring forward spending on the HS3 high-speed rail line, the trans-Pennine tunnel and Crossrail 2.

Overall, the rail sector contributes £7bn a year to the UK economy while employing more than 85,000 people – and that number is expected to increase dramatically. HS2 alone

will create around 25,000 jobs during construction and 3,000 jobs when in operation. From now until 2019, the government expects to spend over £38bn to run and improve the rail network, and this investment is expected to create 10,000 new engineering jobs. "Quite simply, the prospects for the industry are more exciting than they have been for generations," said Baroness Susan Kramer, the former minister of state for transport.

All this investment is being driven by a growth in activity. Rail journeys have doubled in the past 20 years to around 3.2 billion a year and significant future growth in freight and passenger traffic is expected. With so many projects underway, now is an ideal time to start an engineering career in the rail industry. As well as the increase in investment by the government, the UK is now home to two train manufacturers with big plans for the future: Hitachi Rail, which is making the UK's next generation of Intercity trains; and Bombardier, which is manufacturing the trains for

Crossrail at its historic plant in Derby. Both firms are recruiting throughout the UK.

"In Newton Aycliffe, we are continuing to recruit and build our skilled workforce, actively employing and supporting aspiring engineers through a monitored, professional development programme accredited with the IMechE," said James Clark, a representative for Hitachi Rail. "The programme allows our staff to become Incorporated and Chartered Engineers over four years. We already have a number of individuals following the scheme at the moment and we have plans to recruit more this year."

"As we progress on various projects across the UK, we are working in close collaboration with our Japanese colleagues, optimising the ongoing knowledge transfer process to ensure the highest level of quality. Across our business, new team members are joining every week, recruited from a variety of backgrounds with relevant transferable skills. The north east is thriving for technical, engineering and manufacturing skills at the minute."

Bombardier, meanwhile, has a contract to build 65 new trains for its Crossrail line, which is set to open in 2018, connecting Reading in the west with Shenfield in Essex in the east. The new lightweight Crossrail trains will be built with an emphasis on energy efficiency and use of intelligent on-train energy management systems. This contract has created 340 new jobs at its manufacturing plant at Derby, where the new trains are being constructed. Bombardier is also supplying London Underground with 191 new air-con trains for the Metropolitan, Hammersmith & City, Circle and District lines, as well as extra carriages for London Overground, increasing trains from four to five cars in length.

Clark said engineers need to be multi-skilled to succeed in the industry. In rail vehicle and signalling engineering specifically, there is always a need for people with a good mix of analytical and vocational skills. For more design-based roles, recruiters are looking for mechanical and electrical graduate engineers who can demonstrate they have a strong grasp of the fundamental engineering principles, together with experience in the use of computer-aided design, analysis and the ability to present and communicate their findings.

Hitachi said that as the drive for train and system improvements increases, there will be more demand for skills in material development, design and assembly techniques underpinned with research and development. Clark said it's wise



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for anyone considering a career in this area to begin investing in these skills now. "On top of these traditional skills, we believe an eye for continuous improvement is a key skill for engineers to have now," he said. "Get as much hands-on experience as you can, with an engineering education if possible."

While there will always be a need for traditional engineering skill sets, Ben Dunlop, Atkins' director of digital railways, points out that there are some areas of railway engineering that will see a transition towards more connected environments. These roles will use internet-based protocols and telecommunications networks to join the infrastructure and the operational railway. "This is in part what the Digital Railway vision is about, increasing the effectiveness of railway operation while increasing capacity," he said. "It's a big vision and a really exciting one too."

To future rail engineers, Dunlop advises them to look beyond what you can see today, and consider the opportunities that an increasingly connected environment

can offer engineering and operations in the railway sector. "Railways are complex systems that have engineering running through their core," he said. "Whether it is a new-build project such as Crossrail central or a major enhancement to an existing one such as the Thameslink programme, they require the brightest and the best brains to solve the technical and logistical challenges they offer in an efficient and cost-effective way. For the industry to really take advantage of them we need to have people who are not afraid to push the boundaries and challenge convention. If you think that might be you then the railway industry is definitely a career worth considering."®

"This is in part what the Digital Railway vision is about, increasing the effectiveness of railway operation while increasing capacity"

Ben Dunlop, Atkins

**01** Britain's railway network is currently undergoing a major transformation

**02** The railway sector now contributes around £7bn a year to the UK economy

**03** Crossrail, London's huge new railway, is entering the final stages of construction



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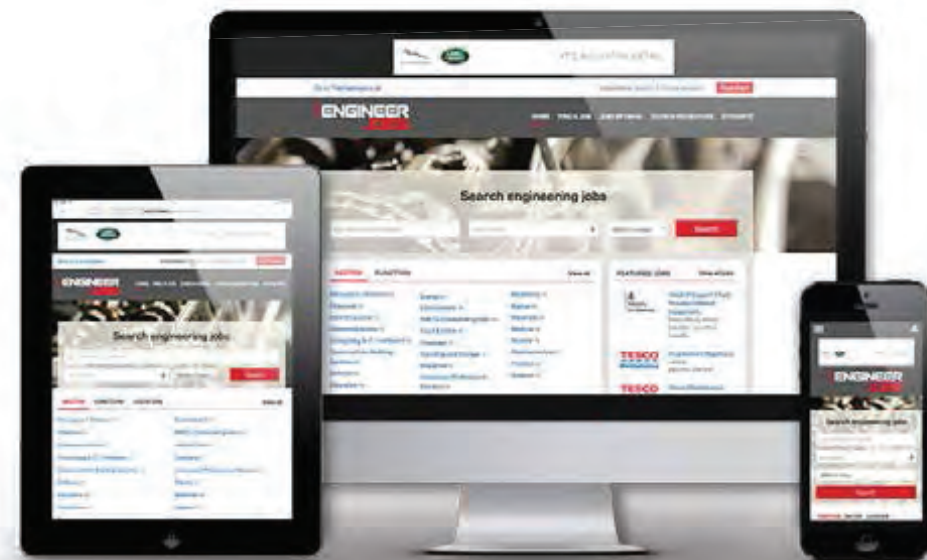


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1915

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# Dark day for trains

**A sombre look back at Gretna Green, the worst rail disaster that the UK has ever suffered**

This month *The Engineer* looks back to a very dark day in British history, and the worst rail disaster the UK has ever suffered. On 22 May 1915, five separate trains were involved in a devastating crash at the Quintinshill signal box near Gretna Green in Dumfriesshire, Scotland. The collisions and subsequent fire resulted in the loss of at least 226 lives, although a definitive number of victims has never been established.

"The Gretna disaster establishes a record in that it is the greatest railway accident since communication by rail was established," *The Engineer* wrote in the days following the disaster. "There has never been anything like it as regards numbers of casualties in this country or the United States, the total in this accident alone being as many as those killed in the United Kingdom during the last 10 years."

The Quintinshill signal box overlooked the Caledonian Main Line linking Glasgow and Carlisle, now part of the West Coast Main Line. As well as northbound and southbound tracks, passing loops for both main lines were also situated at this point. On the morning of the crash, both loops were occupied; the southbound loop with an empty coal wagon, the northbound with a goods train that had left Carlisle at 04.50.

Just before 06.30, a local train travelling north from Carlisle was shunted across to the southbound line in order to allow a London-to-Glasgow sleeper express to overtake it. Although not an ideal manoeuvre, this wasn't considered a dangerous thing to do as long as proper procedures were observed. Unfortunately, a personnel change at the signal box – compounded by a litany of rule breaches – led to a southbound troop train being given the all-clear to proceed, despite the section of track being occupied by the shunted local train.

The resulting crash officially claimed the lives of 215 soldiers, mainly from the Leith Battalion of the Royal Scots headed for Gallipoli. "Added to the prominence given to this disaster by the number of

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"There has never been anything like the Gretna disaster as regards numbers of casualties in this country or the United States"

*The Engineer*

victims and the manner in which they were killed, there is the pathetic fact of over 200 gallant Scottish Territorials, who were on their way to fight for their King and country, in which work they were willing to lay down their lives."

With the roll-list of the regiment destroyed in the ensuing fire, the precise number of casualties could never be confirmed with confidence. It's believed that the majority of deaths occurred not from the initial collision, but when the Glasgow-bound express for which the local train had been shunted came hurtling into the wreckage just a minute later.

"The first collision must have killed many in the troop train," wrote our predecessors, "but the greater number were, we think, killed by the down (northbound) express – not only as a consequence of its running into the debris, but because those who alighted from the troop train on the 'off' side were caught like rats in a trap on the down loop."

Alongside the dead soldiers were three railway employees and at least nine passengers, including four victims believed to be children but whose bodies were never identified or claimed. The cause of the



incident was found to be neglect of the rules by the two signalmen, and both were subsequently charged with manslaughter in England, then convicted of the equivalent charge of culpable homicide after trial in Scotland.

Perhaps the most damning fact to emerge from the entire incident was this: despite all the confusion of the occupied loops, the shunted train, and the shift change (which were by no means extraordinary circumstances), the signalman who gave the green light to the troop train had an unobstructed view just yards away of the stationary local train that occupied the tracks. According to this publication, simple measures could have been taken to avoid this fundamental human error.

"We may say, in conclusion, that there is a remedy against such oversight as happened in this case, and that is to track-circuit the lines. Had the up line been track-circuited, the signal for the troop train could not have been lowered. Such safeguards are, however, only used in places where a signalman's view is indifferent. In this case the view could not be improved." AW ©

## Word of the issue

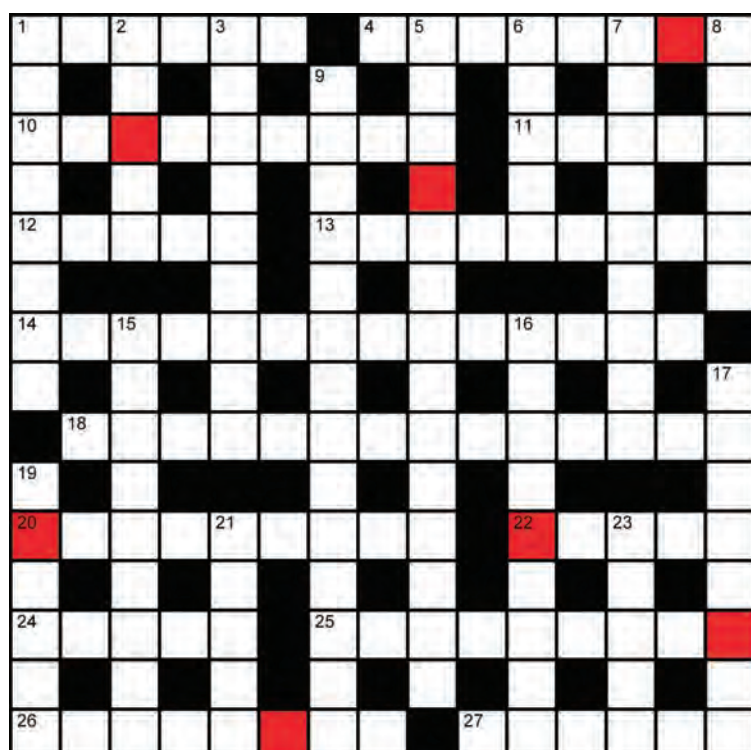
### Anthony Poulton-Smith explores the origins of the word 'cable'

In the modern era a word with several uses: aside from the electrical cable, we still hear of a telegraphic cable and have since 1883, this just four short years after the first mention of a cable car, and also in connection with an anchor. Note the nautical term correctly is a rope with a circumference of 10in or greater. Unrecorded in England before the late 12th century, 'cable' came to our shores with the Norman French cable and ultimately from Medieval Latin capulum. All these used in the sense of 'lasso, halter' and in particular as a 'rope for cattle'. The word has much earlier and quite different usage, for 'cable' shares an etymology with the very different 'capable' and could be seen to be an abbreviation. England may not have seen 'capable' before 1560 but the French capable and Late Latin capabilis had been used for centuries, with differing usage of 'receptive, the ability to grasp or hold'.

# Big picture



Ground tests have begun on the world's largest commercial aircraft engine. GE Aviation's GE9X is a 100,000-pound thrust-class engine that is going through its paces at the company's Peebles Test Operations facility in Ohio prior to initial deployment on Boeing's new 777X aircraft.



## Prize crossword

**When completed** rearrange the highlighted squares to spell out the positively charged dense centre of an atom. 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 To cause inconvenience to (3,3)
- 4 Increases proportionally (6,2)
- 10 Shaped imprecisely without finishing (5-4)
- 11 A sharp vibrating sound (5)
- 12 Unit of magnetic flux density (5)
- 13 Experiencing intense pain (9)
- 14 Complex state involving beliefs and feelings (6,8)
- 18 Succeeds by luck (4,3,7)
- 20 Visual tiredness caused by prolonged close work (9)
- 22 Violent commotion or disturbance (5)
- 24 Substance that exerts some force or effect (5)
- 25 Pulley on a shaft that presses against a guide belt (4,5)
- 26 Large cooking oven (3,5)
- 27 Avoid something unpleasant (6)

### Down

- 1 For less than the standard number of hours (4-4)
- 2 A framework of beams (5)
- 3 Violent disturbances (9)
- 5 Area in a city with large modern buildings (8,6)
- 6 Metric unit of capacity (5)
- 7 Got going or set in motion (7,2)
- 8 An Asian temple (6)
- 9 System used to warm a building (7,7)
- 15 Making no sound (9)
- 16 Puts aside for later (5,4)
- 17 Event that arouses action (8)
- 19 Suspend again (6)
- 21 With four parts (5)
- 23 Last letter of the Greek alphabet (5)

April's highlighted solution was rendering. Winner: **Julian Gable**



Awards Entry Deadline 31st May 2016

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