160 years of innovation
theengineer.co.uk
September 2016

the ENGINEER

FIRST FOR TECHNOLOGY & INNOVATION

Plane sailing

Engineering an assault on the world's oldest trophy

160 YEARS OF ENGINEERING & INNOVATION · 160 the ENGINEER

Can you dig it?

JCB's chief innovation officer discusses the company's brand-new machine »28

Manufacturing talk

Lord Bhattacharyya on Brexit, steel and future opportunities for the UK »32

Green sky

The technologies that are set to make civil aviation more efficient »55

»66

Careers feature

A demand for technical skills means opportunities are opening up in the renewables sector

Shorten your development time with speed and accuracy.

3D CAD online ordering can mean same-day manufacturing!

Our **CNC turning** and **milling** use a range of engineering-grade plastics and metals, including soft metals and steel. Our quick turnaround times mean that you won't lose valuable development time. Get 1 to 200+ parts in 3 days or less.

3D PRINTING | CNC MACHINING | INJECTION MOULDING

proto labs®

Real Parts. Really Fast.®

Order online anytime | Free design analysis

Rhys Wilkinson
Account Manager

protolabs.co.uk
+44 (0) 1952 683047
customerservice@protolabs.co.uk

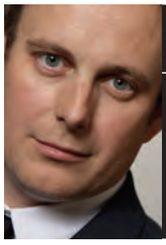
this**issue**

Volume 297
Issue No.7879
Established 1856

news

opinion

features



our**opinion**

Going with the flow

In recent years, many have claimed that the once-famed flow of technology from top-flight motorsport to the wider automotive world – the so-called 'race-to-road' phenomenon – has slowed to a trickle.

But while it's possibly true that there are fewer direct technology spin-offs today from competitions such as Formula One, the substantial flow of skills and expertise from the sector is often overlooked.

We saw a particularly high-profile example of this earlier in the summer, where the astonishing Olympic medal success of team GB's track cyclists arguably owed as much to the exacting technical focus of a team led by former Jaguar and Red Bull Formula One principal Tony Purnell as it did to the cyclists themselves.

In this issue we take a look at another sport benefiting from the refined focus of Formula One engineering: sailing's America's Cup – the world's oldest sporting trophy and an event that, in recent years, has evolved into something of a showcase for cutting-edge technology.

Bristling with sensors, flying above the waves on advanced hydrofoils and propelled by giant 'wings', today's America's Cup yachts have more in common with fighter jets than with the lumbering mono-hull vessels that have dominated much of the sport's history.

And in this issue's cover story (p22) we take a look at the role that engineers are playing in Land Rover BAR's bold effort to wrestle the trophy from its current holders and bring it back to Britain.

> "While there are now fewer direct spin-offs, the flow of expertise from Formula One is overlooked"

As team CEO and former McLaren racing boss Martin Whitmarsh explains, it's a highly collaborative effort bringing together a multitude of industrial partners and underpinned by a fascinating relationship between Whitmarsh and the team's leader, sailing legend Ben Ainslie.

Staying on the subject of collaboration, we're delighted to announce the winners of *The Engineer*'s inaugural Collaborate To Innovate awards. You can see the full list of winners in this issue (p79) and find out much more about their projects at our special Collaborate to Innovate conference on 17 November at Coventry's Manufacturing Technology Centre.

Visit conferences.theengineer.co.uk to find out more.

Jon Excell Editor
jon.excell@centaurmedia.com

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

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

Direct dial 020 7970 followed by extension listed Advertising fax 020 7970 4190 **Editor** Jon Excell (4437) jon.excell@centaurmedia.com **Features editor** Stuart Nathan (4125) stuart.nathan@centaurmedia.com **Senior reporter** Andrew Wade (4893) andrew.wade@centaurmedia.com **News editor** Jason Ford (4442) jason.ford@centaurmedia.com **Senior art editor** Phil Gibson (4135) philip.gibson@centaurmedia.com **Recruitment advertisement manager** Ben Cogger (4187) ben.cogger@centaurmedia.com **Account manager** Sarah O'Shea (4160) sarah.oshea@centaurmedia.com **Senior sales executive** Jason Padam (4677) **Sales executive** Kennedy Ogbanufe (4811) **Commercial director** Sonal Dalgliesh (4487) sonal.dalgliesh@centaurmedia.com **Commercial manager** Peter York (4942) **Business development manager** James Rushford (4487) **Production** Lyndon White, Wendy Goodbun (4807) te.production@centaurmedia.com **Publisher** Simon Lodge (4849) simon.lodge@centaurmedia.com **Subscriptions & Customer Services** tecirc@centaurmedia.com

CENTAUR MEDIA

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

OMEGA®

Your One-Stop Shop for Process Measurement and Control Products

- 100,000 products online
- Easy online ordering
- Same day shipping on instock items
- Full technical support

6 Channel Data Logger

RDXL6SD handheld temperature data logger with 4 type J, K, T, E, R, S or N thermocouple inputs and 2 3-wire Pt100 RTD inputs

Thermo-Hygrometer

RH700 measures humidity, moisture, temperature and pressure values

Pressure Products

Includes switches, load cells, strain gauges, controllers, recorders, dataloggers, transducers, and much more

Temperature Probes and Assemblies

For all environments and applications

omega.co.uk

Temperature | Pressure | Automation | Flow | DAS | pH | Heaters

0800 488 488
sales@omega.co.uk

Readmoreonline

Automotive
Volvo and Uber join forces on driverless taxi plan

Civil & structural
Metamaterials could lessen earthquake effects

Defence & security
How the sector helped Team GB cyclists to pedal to success

Electronics & communications
Princeton develops 25-core chip for servers

Energy & environment
Low-cost battery has potential for grid storage

Manufacturing
Security must be top of manufacturing agenda

Medical & healthcare
Taking ultrasound to the molecular level

Policy & business
Brexit: Treasury pledges to underwrite Horizon 2020 projects

Rail & marine
Keeping reliability and quality on track for the rail industry

Skills & careers
Addressing the manufacturing skills gap in a post-Brexit Britain

For news and jobs theengineer.co.uk

MANUFACTURING

Demonstration of additive ambition

Technology demonstrators interest aerospace and automotive companies

JASON FORD REPORTS

Stratasys has broken cover on technology demonstrators designed to realise large, additively manufactured (AM) parts and facilitate composite components without incurring the penalties associated with producing such components.

According to the company, the Infinite-Build 3D Demonstrator and Robotic Composite 3D Demonstrator build on Stratasys' expertise in industrial fused deposition modelling (FDM) 3D printing to help manufacturers design and build parts with credible structural integrity but at a fraction of the time and cost.

Common to both demonstrators is an approach to FDM extrusion that increases throughput and repeatability. Both use a worm drive filament extruder that winds filament through the print head to increase the sort of flow pressure that is required for composite extrusion.

The Infinite-Build 3D Demonstrator is designed to address requirements of aerospace, automotive and other industries for large lightweight, thermoplastic parts with repeatable mechanical properties.

To do so, the traditional 3D printer concept has been turned on its side to realise an approach to building parts that prints on a vertical plane, to produce components that can be measured in feet.

According to Richard Garrity, president of Stratasys Americas, the system has utility across jigs and fixtures, tooling and production parts.

"When you can convert jigs and fixtures into a thermoplastic material, you can produce them on demand, literally overnight," he said. "They are personalised – customised to a given worker or to a given process."

Boeing, which has approximately 30,000 AM parts installed in its commercial and defence platforms, helped define the requirements and specifications for the Infinite-Build 3D Demonstrator and is currently using one to further explore the production of low-volume, lightweight parts.

Ford Motor Company is also investigating automotive manufacturing applications for this demonstrator and will evaluate the new technology.

Furthermore, Ford and Stratasys will work together to test and develop new applications for automotive-grade 3D-printed materials that were not previously possible due to limited size.

Dr Ellen Lee, technical leader, additive manufacturing research at Ford Motor Company, said: "What we've been doing in the past – prototyping, design verification and looking at quick iterations for designs – has helped us to be more efficient and reduce our cycle times.

"Now, we're looking at more functional applications. This is because additive manufacturing gives us… design freedoms that allow us to [further] reduce our cycle times.

"Some tools can take months to make. Now, if we can reduce that to days for a printed tool, we can start to look at reducing or eliminating the time associated with making prototype tooling and eventually production tooling."

Stratasys' Robotic Composite 3D Demonstrator, developed in conjunction with Siemens, removes steps such as manual lay-up and curing in an autoclave to produce composite parts in 3D.

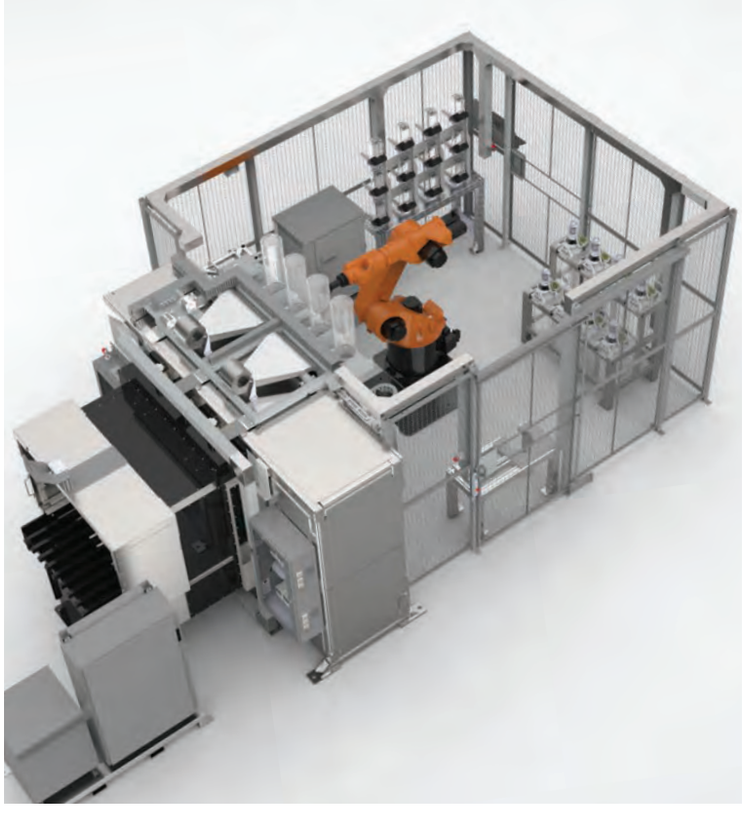
Garrity added that the traditional composite process could be difficult in terms of scaling, and rendering the types of detail that were often required in parts.

By comparison, the Robotic Composite 3D Demonstrator delivers 3D printing by using an eight-axis motion system (a six-axis robot with a two-axis rotary positioner) that enables precise, directional material placement for strength, while also reducing the need for support structures and eradicating layer transitions.

"We're not in the business of inventing a specific output," said Ilan Levin, Stratasys CEO.

"What we are trying to do is identify applications and deliver upon those applications as best we can, and provide as much value as we can."

Infinite Build machine



AEROSPACE

Drones come to the rescue

UAV carries a thermal camera that can locate people at sea and assess spills

ANDREW WADE REPORTS

Equipment can be swapped on to the drone to suit the mission, such as a self-inflating buoy

Total is developing a drone with capabilities to assist in search and rescue, environmental protection and rig safety.

The unmanned aerial vehicle (UAV) is the brainchild of Fabien Farge, an emergency physician employed with Total in Angola. Known as HELPER (Human Environment and Life Protection Emergency Response), the drone carries a thermal camera that can be used to locate people at sea, as well as assess the scale of leaks and spills.

Equipment can be swapped on to the drone to suit the mission, including a self-inflating buoy that can be dropped during rescue efforts, a tracking device to monitor slicks in real time using Google Earth, and a radio device to communicate with fishing crews and drifting boats near rigs.

"The drone carries all the equipment it needs for a [specific] mission, but the camera is useful for all missions," Farge said.

HELPER is based on a UAV platform developed by pilot and drone manufacturer Gérald Dumartin, who helped bring the concept to fruition.

"We started with one of his regular drones and added a bit of electronics," Farge said. "The first tests went great, but we realised we needed a much more 'professional' drone, and that did not exist on the market.

"So we created it with the help of two local engineers… David and Anthony Gavend. They worked on the algorithms necessary for the drone to fly in the most autonomous way."

The UAV is undergoing search and rescue testing in Biscarrosse, southwest France, with local lifeguards putting it through its paces.

The next phase will see HELPER deployed to a rig site in Angola, where all its mission capabilities will be tested.

"In Angola, it will be tested on a Total offshore site for different applications," said Farge. "For example, we could test environmental protection; in the event of a leak, the drone's thermal camera can assess the situation and determine its scale; in the event of a man at sea, we can use the same specifics as the ones being tested in Biscarrosse; and with an intrusion around the site, we can try to engage a radio contact."

Farge added that French firefighters were also interested in HELPER, as they could potentially use the UAV to monitor large fires.

"This drone can find many other uses to access more quickly, and more cheaply, dangerous areas or places where there are problems, and bring in real-time information to operating teams," he said.

"It's real progress in efficiency, cost reduction, and safety and protection."

AWARDS

Winners take centre stage at awards

The Engineer launches new awards in London

JON EXCELL REPORTS

Collaborative engineering projects ranging from the design and construction of the UK's largest-ever warship to the use of 3D printing technology for surgical implants were among the winners announced at *The Engineer*'s new engineering awards in London on 7 September.

Judged by a panel of leading UK engineers, winning entries had to demonstrate that they were innovative, collaborative and likely to have an impact in their particular field of application.

The event provided a fascinating snapshot of some of the trends and technologies that are defining modern engineering.

For instance, many of this year's winners have worked closely with specialists from other disciplines. One striking example was the Healthcare award, whose winner – the ADEPT project – had seen engineers working closely with surgeons to adapt 3D printing technology for the operating theatre.

Other themes to come to fore were connectivity, with the winner here demonstrating advances in human-software interaction; energy efficiency, which showcased some fundamental breakthroughs in the world of smart buildings; and transportation, which celebrated advances in materials for jet engines.

There was also acknowledgement for one of the UK's biggest engineering projects, with the Aircraft Carrier Alliance taking home the Defence trophy for the UK's new Queen Elizabeth-class aircraft carriers.

Finally, the awards also celebrated the next generation of engineers – and handed out two special trophies to teams from Watford Grammar School for Boys and Future Tech Studio.

Commenting on the awards, Prof Tom Rodden, deputy CEO of the EPSRC and a member of the C2I judging panel, said: "These awards illustrate the strength, breadth and depth of collaboration between academia and industry in engineering, and the impact they have on society and the economy."

For a full list of the winners, please turn to page 79

Newsinbrief

Team up for fuel cells

General Motors and the US Army are collaborating on a military vehicle powered by hydrogen fuel cells. The venture facilitates technology transfer between the two, with GM providing access to its consumer-driven automotive technology in exchange for the military's feedback on non-standard fuel-cell applications. The vehicle, which is based on a Chevrolet Colorado, is set to be unveiled this autumn.

Giving consent

The world's largest offshore windfarm, Hornsea Project Two, has received development consent. The windfarm is predicted to create up to 1,960 construction jobs and 580 operational and maintenance jobs. If built to full capacity, the investment would total around £6bn. Located 89km off the Yorkshire coast, the windfarm will comprise up to 300 wind turbines and will connect to the grid at North Killingholme in north Lincolnshire.

Sky-high production

Monthly figures from SMMT show that UK car production is at its highest since 2000, with more than one million cars built so far this year. Over three-quarters of the cars built in 2016 will be exported. Greg Clark, business and energy secretary, said: "Our automotive sector continues to go from strength to strength thanks to our highly skilled workforce and long-term investment in new technology and innovation."

Concepts for autonomy

CNH Industrial has revealed concept autonomous tractor technology with a cabless Case IH Magnum and a New Holland T8 NH tractor that retains its cab. Both models are designed to enable fully remote deployment, monitoring and control.

INNOVATE FASTER

WITH FIELD-DEPLOYED 5G PROOF-OF-CONCEPT SYSTEMS

In the race to design next-generation wireless technologies, research teams must rely on platforms and tools that accelerate their productivity. Using the NI software defined radio platform and LabVIEW Communications, leading researchers are innovating faster and building 5G proof-of-concept systems to demonstrate new technologies first.

Accelerate your innovation at ni.com/5g

LabVIEW Communications System Design Software, USRP-2943R SDR Hardware

NATIONAL INSTRUMENTS™

TRANSPORT

Wireless network goes on the rails

Inexpensive track sensors could guarantee safety at level crossings

ANDREW WADE/JASON FORD REPORTS

A study from Huddersfield University's Institute of Railway Research (IRR) has concluded that wireless sensors at level crossings could both improve safety and reduce costs.

Following extensive testing at the university's rail research labs, the DfT-funded project established that networks of inexpensive track sensors could be powered by the vibrations generated by approaching trains. The IRR said that the technology is already in place across the oil and gas industry, and has also been used in some safety-critical applications such as medical devices.

> "If one sensor fails, the others talk to one another and create another network for the information to travel"
>
> Dr Coen Van Gulijk, Huddersfield University

The new level-crossing system would have inbuilt fail-safety owing to the multiple nodes on the network, with damaged sensors being bypassed to create new routes for the data to travel. According to Dr Coen Van Gulijk, the IRR's professor in railway safety, the fail-safe mechanisms for existing systems make them costly and difficult to install.

"These detectors are expensive because they are made to be fail-safe," he said. "But we have shown that we can use many cheap sensors and still guarantee fail safety."

"If one sensor fails, the others talk to one another and create another network, creating another route for the information to travel."

Research fellow Dr Farouk Balouchi added that the number of sensors could vary depending on implementation.

"On a basic configuration, five sensors can detect and monitor the train and track bed; on a more complex implementation there can be a lot more [sensors] depending on the strike-in and strike-out timing and monitoring requirements," he said.

Van Gulijk and his colleagues believe the savings could be substantial. They claim some of the safety systems for the UK's 6,600 gazetted level crossings cost as much as £500,000, with many also requiring high maintenance costs. A wireless network in a similar location could cost as little as £20,000, according to the IRR.

What's more, the IRR said the sensors could be installed quickly, with no wiring that would be vulnerable to theft or disruption by wildlife such as rodents, and would also have the additional benefit of monitoring the track condition.

Now that the system's feasibility has been demonstrated, the IRR is looking for industrial partners to bring the technology to market.

Wireless sensors can monitor track conditions

AEROSPACE

Airlander 10 crashes out

Prototype airship sustains damage at front of flight deck on heavy landing

Airlander 10 had an inauspicious end to its second test flight with a 'heavy landing' at its base in Cardington, Bedfordshire on 24 August 2016.

The prototype aircraft had flown for 100 minutes and completed its schedule before returning to Cardington.

Hybrid Air Vehicles, the company responsible for Airlander 10, said the 92m-long airship "experienced a heavy landing and the front of the flight deck sustained some damage". Pilots and ground crew were unharmed.

Media reports suggested the crash landing had been caused after Airlander struck a power line. Hybrid Air Vehicles confirmed that a mooring line attached to Airlander did come into contact with a power line outside the airfield, but that the event did not contribute to the heavy landing.

"Airlander sustained damage on landing during today's flight. No damage was sustained mid-air or as a result of a telegraph pole as reported," the company said. **JF**

ENERGY

Optimised WECs create shock waves

PowerPod II generates 50% more electrical power

JASON FORD REPORTS

A technology optimisation project with 42 Technology could see Trident Energy's linear generator employed in a range of wave energy converter (WEC) devices.

The redesigned concept – PowerPod II – is said to represent a major advance for Trident Energy's WaveDrive project, which is developing a generic power take-off (PTO) system for use in a range of WECs.

The new PowerPod II concept is based on a single generic design that can be adapted for use in different types of WECs and tidal energy devices. The new concept is similar in size to its predecessor but it generates 50 per cent more electrical power on each stroke.

Furthermore, the device's magnetic stack configuration has been optimised to allow the linear generator to operate horizontally, widening the available options for installation and operation. Improvements to the seal design for 'in-sea' operation, plus a more robust bearing solution, have been implemented to further increase reliability and cut maintenance cycles.

Alan Mackay, project lead at 42 Technology, said: "Trident Energy requested the optimisation of the design… to include marinisation of the basic sub-assemblies of the generator hardware and electrical infrastructure.

"This was achieved by using encapsulation at various stages of the manufacture, with the final assembly being significantly more robust and having at least two barriers to water ingress.

"Similarly, the bearing solution previously employed for the prototype used materials that were not compatible for a salt-water environment… 42 Technology revised the design to use a lightly loaded primary bearing, using… sealed bearings and marine-grade materials, for low-friction normal operation.

He added higher lateral loads are managed by a secondary polymer bearing solution, which comes into service if the armature is outside a designed concentricity tolerance with the magnet stack.

When High Speed Precision Control is Crucial

Industry leading dynamic Servo solutions for continuous and pulse duty applications

Visit www.emersonindustrial.com/automation

Control Techniques™
Leroy-Somer™

ELECTRONICS

Electricity that returns to Earth

Modified bacteria produces smallest-ever nanowires, sensitive to pH

STUART NATHAN REPORTS

Bacteria naturally found in the soil may be a source of electrically conductive nanowires that could be used in compact electronic devices, sensors and even devices that could generate alternative fuels from natural sources, new research shows.

The wires, which are produced by genetic modification, are smaller than those made by industry using current methods. Moreover, they do not require harsh chemical processes or pollutants in their manufacture.

The research was carried out at the University of Massachusetts Amherst, sponsored by the US Office of Naval Research, and led by Dr Derek Lovley. The team started with a microbe called Geobacter sulferreducens, which produces conducting fibres made from proteins that connect the bacterium to particles of iron oxide in the ground that support its growth. The current that it carries is too small to be useful for technology but is still measurable.

The conductivity of fibres is believed to stem from their structure, where the amino acids that make up the proteins are arranged so that their unsaturated regions with free electrons line up. To improve the conductivity, Lovley's team genetically modified the bacteria to replace the natural amino acids with tryptophan, an amino acid commonly found in the proteins that make up muscle fibres and are highly efficient at transporting electrons.

"We arranged the amino acids to produce a synthetic nanowire that we thought might be more conductive," said Lovley. "We hoped that Geobacter would still produce nanowires and it might double their conductivity."

The nanowires produced by the modified bacteria were 2,000 times as conductive as the unmodified nanowires. With a diameter of 1.5nm, they were 1,000 times smaller than the best materials that can currently be made using industrial nanotechnology, which tend to be about one billionth of a metre in diameter.

> "We arranged the amino acids to produce a synthetic nanowire that we thought might be more conductive"
>
> Dr Derek Lovley
> University of Massachusetts

The nanowires are also sensitive to changes in pH and could be used in medical sensors that could be implanted, for example, in the heart or kidneys.

Bacteria with electrical potential

AUTOMOTIVE

Self-drive cars by 2021

Ford is investing in four start-up companies for help in producing its first fully autonomous vehicle

Fully autonomous cars built without a steering wheel or accelerator or brake pedals will be on the road by 2021, according to Ford.

The manufacturer is stepping up investment and collaboration with four start-ups to bring ride-hailing or ride-sharing services to market. Its first fully autonomous vehicle will be a Society of Automotive Engineers-rated level 4-capable vehicle that will be available in high volumes.

Ford is bringing its plans to fruition by investing in Californian companies Velodyne and Civil Maps, which will, respectively, investigate a cheaper means of mass producing LiDAR sensors and develop high-resolution 3D-mapping capabilities.

Furthermore, Ford has acquired SAIPS, an Israeli computer vision and machine-learning company, and made an exclusive licensing agreement with Nirenberg Neuroscience, a machine-vision company founded by Dr Sheila Nirenberg, who cracked the neural code between the eye and the brain. **JF**

Autonomous Ford Fusion

MATERIALS

Researchers strike gold with electrical waste

Gold-retrieval method does not use toxic chemicals

JASON FORD REPORTS

Researchers at Edinburgh University have developed a means of retrieving gold from electrical waste including old mobile phones, televisions and PCs.

The precious metal is a key component of the printed circuit boards inside these electrical devices and up to 7 per cent of all the world's gold is believed to be contained within them.

Current methods for extracting gold from old gadgets are inefficient and can be hazardous to health because they often use toxic chemicals such as cyanide, researchers say.

Now, Edinburgh scientists have developed a simple extraction method that does not use toxic chemicals and recovers gold more effectively than current methods. The finding could help salvage some of the estimated 300 tonnes of gold used in electronics each year.

To extract the gold, printed circuit boards are first placed in a mild acid, which dissolves all of their metal parts. An oily toluene solvent containing the team's primary amide is then added, which extracts gold selectively from the mixture of other metals.

According to Prof Jason Love from Edinburgh University's School of Chemistry, gold is retrieved from the chemical mixture by using water.

"After separation of the oily phase from the acid phase, washing the oily phase with water transfers the gold into the water phase for electrowinning," he said via email.

"We have to do this a couple of times to ensure complete phase transfer, but each wash step is very quick [– just minutes]."

So far, 85 per cent of gold contained on old circuit boards is extracted on the first pass and Prof Love added that industry repeats these extractions several times to ensure the complete recovery of the desired metal.

300 tonnes of gold is estimated to be used in electronics each year

Something big is on the horizon

it's the UK's **only** national sensors show

and over 80 market-leading suppliers will be there

FREE Entry

FREE WIFI

FREE PARKING when you stay after 3pm

FREE seminar programme

Don't miss it

Register now

www.sensorsandinstrumentation.co.uk

Sensors & Instrumentation

for Test, Measurement & Control

28th & 29th September 2016 - NEC Birmingham

Incorporating the Machine Building, Automation & IIoT Zone

@SensorsShow

MEDIA PARTNERS

Automation – Practical Solutions for Manufacturing Efficiency

ConnectingIndustry.com

Industrial Technology

IEN Europe

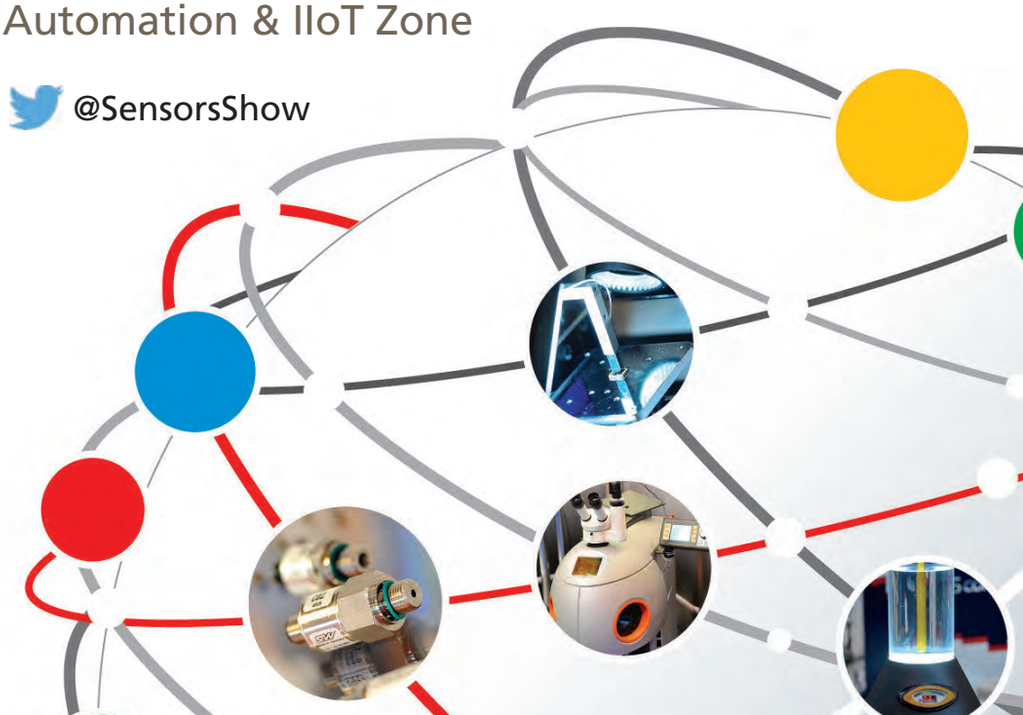
Instrumentation – Test | Measurement | Control

Industrial Plant and Equipment

PI UK – PROFIBUS • PROFINET

Sensorland.com

Manufacturing SMART FACTORY EXPO



ELECTRONICS

Get in vogue with 'nano-corduroy'

Wrinkled graphene sheets have potential to conduct electricity

STUART NATHAN REPORTS

Researchers in the US believe bacteria could be the key to turning graphene into a useful semiconductor.

Graphene is a good conductor of electricity, but because of its two-dimensional atomic structure a sheet of graphene tends to conduct electricity randomly across its whole surface, which is not useful, particularly in electronics; this depends on digital signals, which are either conducting electricity across a defined gap or not at all.

One way to influence the way that graphene conducts electricity is to shape the sheet, which is the research focus of Vikas Berry's laboratory at the University of Illinois in Chicago. One line of research that might prove fruitful is focusing on wrinkling graphene sheets in defined ways, with the help of bacteria.

Wrinkling a graphene sheet creates ridges and channels along which electrons can travel as the resistance is lower along the channel than across the rippled surface, but it has proven difficult to control how the ridges form.

Berry's team has found a way to do this in a way similar to vacuum-moulding, using bacteria as a mould. The team used a rod-shaped bacterium called Bacillus subtilis, which has two useful properties: first, it can be induced to line up in an ordered array by using electrostatics; and second, when dehydrated the surface of the bacteria wrinkle, forming ridges along the axis of the rod-shaped structure about 33nm apart.

The team produced an array of the bacteria in a nutrient solution on a silicon chip with electrodes at either end, draped a sheet of graphene on top, then cooked the graphene and chip in a vacuum chamber at 250°C.

This dried out the nutrient solution, wrinkling the bacteria and pulling the graphene sheet down onto the wrinkles to create what Berry calls 'nano-corduroy'. This is in effect an entirely new allotrope of carbon, he noted; a series of half-nanotubes. "The structure is different and the fundamental electronics properties are new." Potentially, the technique could be used to form the bacteria into the shapes of electronic circuitry and then impress these shapes into graphene.

> "The structure is different and the electronics properties are new"
>
> Vikas Berry, University of Illinois

The team describes the research in the journal *ACS Nano*.

Rod-shaped bacterium has been used to wrinkle graphene sheets

AUTOMOTIVE

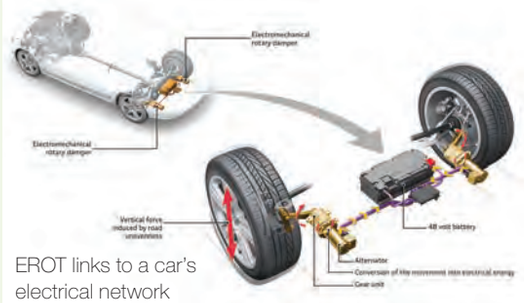
Fuel efficiency in hybrids

Audi eROT system replaces hydraulic dampers

A new system under development by Audi promises to enable further improvements in fuel efficiency in its hybrid vehicles.

It will do this by using the vibrations normally absorbed by a car's suspension system to generate electrical energy. The system, dubbed eROT (electromechanical rotary dampers), will also improve the car's ride. The system aims to replace hydraulic dampers. In these, the up-and-down motion of the wheels as they pass over bumps in the road is converted into heat as the increasing pressure in the hydraulic cylinders warms up the working fluid.

The eROT system is an active electrical system linked to the car's 48V electrical network. It absorbs suspension movement via a lever fixed to the wheel carrier mechanism at one end, and to a series of gears at the other. When the lever moves, its motion is transferred via the gears to an electric motor configured as a dynamo and connected to the car's lithium-ion battery. **SN**



EROT links to a car's electrical network

ROBOTICS

Rise of the self-learning machines

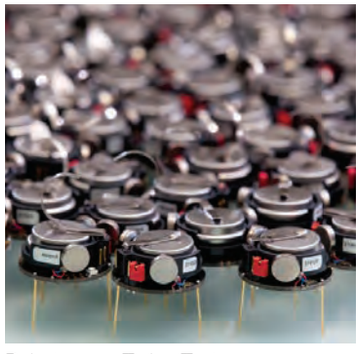
Robots analyse artificial and natural systems

ANDREW WADE REPORTS

Researchers from Sheffield University have created a robot swarm capable of learning how other systems work, and whose learned behaviour can pass a Turing Test.

The study could enable machines to analyse and predict artificial and natural systems, including human behaviour. Known as Turing Learning, the approach requires no prior machine knowledge, and involves rewarding behaviour that is analogous to that desired, and that can fool the 'interrogator' in a Turing Test.

"Our study uses the Turing Test to reveal how a given system – not necessarily a human – works," said Sheffield University's Dr Roderich Gross. "We put a swarm of robots under surveillance and wanted to find out which rules caused their movements. To do so, we put a second swarm – made of learning robots – under surveillance too. The movements of all the robots were recorded, and the motion data shown to interrogators."



Robots pass Turing Test

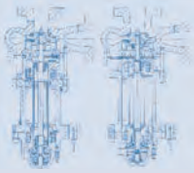
The interrogators were self-learning computer programs whose task was to distinguish between the swarms. The programs were rewarded when they correctly identified counterfeit data, and the learning swarm was rewarded when it fooled the interrogating program. According to Gross, the advantage is that humans no longer need to show machines what to look for.

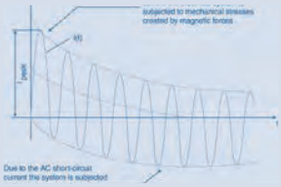
"Imagine you want a robot to paint like Picasso," he said. "Conventional machine-learning algorithms would rate the robot's paintings for how closely they resembled a Picasso. But someone would have to tell the algorithms what is considered similar to a Picasso to begin with."

Turing Learning, however, would simply reward painting that fooled the interrogators, simultaneously learning how to interrogate and how to paint. According to the researchers, the approach could be used to detect abnormalities in behaviour.

EIT ENGINEERING INSTITUTE OF TECHNOLOGY

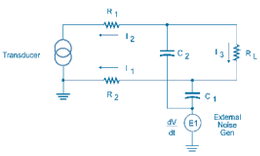
Advertisement feature





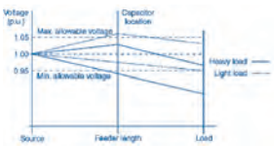
How you can better Balance a Shameful Engineering Equation in your Business

Engineering education and training = disappointment, frustration and a negative impact on the bottom line



"It is over a hundred years since the first report was produced, highlighting the failure of technical and engineering education in the UK."

United Kingdom. Secretaries of State for Education and for Business, Innovation and Skills.
Report of the Independent Panel on Technical Education, April 2016.



It is saddening that irrelevant content is being thrust at these budding engineers and technicians: how to program an obsolete microchip, how to program in redundant languages or to do battle with arcane (albeit interesting) mathematical concepts – all of little use to industry.

Some students may enjoy the mental gymnastics involved in Cauchy Integrals or calculating the damping of the needle movement of a galvanometer. When bagging that first engineering job, however, the insignificance of it all becomes clear.

There is an argument that is regularly expounded: theory, relevant to industry or not, is good, it teaches you to think! Is this not merely a convenience – much of what we learn has a short shelf life, particularly with technology moving apace – this argument excuses colleges and universities from the effort and the expense required to continually improve and replace obsolete content with practical job-focused resources.

The result is inevitable: frustration and distress for both the employer and employee when the qualification fails to drive the productivity you desperately need in your firm.

Solutions to Improving your Engineering Bottom Line

1. Provide good engineering education in high schools.
2. Although there are outstanding lecturers who produce extremely capable graduates, it would be great to:
   - Make industry experience a prerequisite for university and college instructors and lecturers. (Improved pay and conditions would ensure the finest are found).
   - Encourage academics to work in industry to acquire real, hands-on experience.
3. Send experienced engineers back to schools and universities to share their expertise and invite undergraduate students to complete internships in engineering departments. This will boost engineering capability from both ends.
4. Measure university and college engineering departments; promote those with a zeal for outstanding teaching, to encourage hands-on learning relevant to industry and to encourage others to step up.
5. Drive the entrepreneurial dimension of engineering education; a focus on astute business expertise and excellent communication skills are vital.
6. Teach engineering students to think and to search effectively for knowledge; to locate it, test it for quality and truth, apply it and then store it.
7. Encourage undergraduates to embrace the concept of flexibility in their career paths. Industry demands it. The days of an engineering graduate remaining with a company forever are gone. But even if he/she does stay, the company may be involved in manufacturing today, but be involved in design and product development tomorrow.
8. Instil a love of learning into students, to ensure that their pursuit of knowledge is life-long.

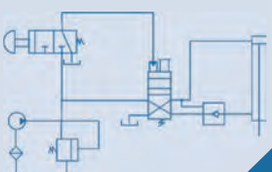
Some interesting ideas, but how can YOU better balance the equation?
How can you lift your team's performance?
How can you increase your productivity?
How can you boost the bottom line?

Here are a few suggestions on harnessing these training solutions with the online opportunities of the 'cloud'

1. Content designed with rigour by industry specialists.
2. Experts sourced from industry and from around the world to present via live, interactive, online webinar sessions to engineers and technicians based at single or multiple sites, simultaneously. This means big savings on travel costs and time.
3. Hands-on training for your staff by logging into remote laboratories and simulation software. Further skill consolidation occurring between webinar sessions, on site.

This training and education can be found in a vast array of topics ranging from instrumentation, automation and process control, to electrical power system protection, safety systems and wiring rules. You and your staff can access this training and much more online at your premises via the **Engineering Institute of Technology (EIT).**

EIT's students working full time



FREE

Courtesy of EIT and its sister training company, IDC Technologies, all readers receive **FREE access to the "Swiss Army Knife" of Videos on Engineering Skills.** Over 70 videos and 15 hours of special technical content in various engineering fields, including: Civil, Chemical, Mechanical, Electrical, and Industrial Automation.
Don't miss out! Visit: www.eit.edu.au/the-engineer to register today.

AEROSPACE

Aircraft repair could take off

Cranfield University project could revolutionise aircraft maintenance

JASON FORD REPORTS

Cranfield University and consortium partners have completed a three-year FP7 project to improve aircraft maintenance and repair processes by integrating health management capabilities with additive manufacturing (AM).

A total of 12 partners took part in the three-year RepAIR project, which focused on on-site maintenance and repair of aircraft by integrated direct digital manufacturing.

Suresh Perinpanayagam, lecturer in the Integrated Vehicle Health Management (IVHM) Centre at Cranfield University, explained that airline maintenance is mainly reactive or preventive, with many components part of a Line Replaceable Unit (LRU). If a failure occurs, the entire LRU is replaced and the unit is sent to the hub to be inspected, repaired and installed in another aircraft.

"The capability to repair a component using AM can allow for a completely different scenario where parts are repaired or manufactured while the aircraft is on the ground, just requiring a certified metal 3D printer," he said. "There are fewer delays and problems with the availability of aircraft. It reduces the need for keeping a stock of all the parts."

Perinpanayagam added that the health monitoring system proposed in RepAIR detects a failure in the planetary transmission that connects turbine and generator by using a complex physics-based model for which no additional sensors are needed. The advantage of this system is that certification is simplified because no additional hardware is required.

"The health monitoring system accesses data already available in the aircraft [speed, load, temperature] and calculates the friction," he said. "A failure alarm is triggered by a friction threshold, and a critical failure alarm is triggered if a higher threshold is reached. The system communicates the failure status [healthy, alarm, critical] along with the friction estimation and an identifier of the faulty component [flight, plane, component tag].

"The information is sent to the CAMO [Continuous Airworthiness Management Organisation] and the pilot. The CAMO may decide to trigger a repair work order using AM or other repair procedure. The pilot can act to minimise the damage by modifying the operational conditions of the transmission or disconnecting it if a critical alarm is triggered."

The RepAIR system team is now looking for industry partners.

> "The capability to repair a component using AM can allow a completely different scenario"
>
> Prof Suresh Perinpanayagam
> Cranfield University

The FP7 project integrated health management with additive manufacturing

MATERIALS

Riding the lightning

A new composite material uses shape memory alloy and carbon-fibre-reinforced plastic

Qinetiq has introduced a composite material that protects aircraft against high-impact and lightning strikes.

The technology introduces a shape memory alloy (SMA) into a carbon-fibre-reinforced plastic.

The SMA wire selection, geometry and architecture, plus the weaving process, ensures that the high specific properties of the carbon-fibre composite are maintained, while the SMA provides an enhanced ability to absorb energy before structural penetration.

Results showed the SMA technology would have significant benefits for protecting against the high-impact damage from a bird strike or debris that can be thrown into the underside of an aircraft from a runway. It found that the inclusion of 10 per cent by volume SMA resulted in a structure more than three times stronger than baseline carbon-fibre composites. The material has also been tested against the highest lightning strike threat level. **JF**

ADDITIVE

3D printer on a humanitarian mission

Adapted 3D printer needs no mains power or laptop

JASON FORD REPORTS

Engineering students at Leicester University have produced a portable 3D printer that can print objects, including cutlery and a set of teeth.

The development, by fourth-year Mechanical Engineering students, has the potential to place 3D printing into areas requiring humanitarian relief.

To make the device, the team made various mechanical modifications to a functional desktop 3D printer to make it portable enough to collapse into a suitcase with a handle and wheels.

The students adapted the printer for use without mains power, laptop or PC and have used it to print various items, including the mechanism that was used to fold the printer into its portable container. The printer is housed in two laminate foam layers within an MDF suitcase to protect it from transport damages and moisture.

Student Jay Vinda said that in order to produce a part the printer must be fed instructions in the form of G-code.

"Luckily, it is possible to produce the instructions in G-code format from an STL file by using Slic3r," said Vinda. "STL files can be downloaded directly from Thingiverse or 3D models can be saved as a .stl file on Solidworks. Slic3r will convert the 3D model into a set of instructions on a layer-by-layer basis and save this as a G-code file, which can then be saved onto an SD card. The SD card can be read by the 3D printer using the LCD screen that comes with the printer."

Vinda added that the printer has so far been used to print PLA, but can support ABS, PET, HIPS, and Nylon.

Safety in your hands.

Strong, light, intelligent and great under pressure.

The DPI620 Genii IS Multifunction Calibrator

The new Druck DPI620 Genii IS multifunction calibrator combines best-in-class performance with ATEX and IECEx approvals for use in hazardous areas. Robust and weather-proof, the Genii IS puts you in control of all your pressure, electrical, temperature and frequency testing, with flexibility and accuracy giving you elite performance wherever you need it.

Packed with performance enhancing features, the Genii IS operates as a 3 in 1 calibrator, test meter and HART/Foundation Fieldbus communicator in hazardous zones where explosive gas and air mixtures can occur. Incorporating tool-free battery management with interchangeable battery packs, easy-to-use touch-swipe screen and daylight readable display as well as being the smallest and lightest calibrator of its type.

When it comes to having all your calibration needs covered, stay safe, and stay ahead with the DPI620 Genii IS.

www.gemeasurement.com

Long life battery.
Easily interchangeable.

Pressure generation station.
For stand-alone operation.

Seeking a definite sense of continuity

The UK is currently paying a heavy price for a lack of long-term commitment and strategic insight into its nuclear programme

Almost half of *Engineer* readers think that a UK-developed small modular reactor (SMR) would be a better option than the current deal to build and operate a new nuclear power station at Hinkley Point, according to the conclusion of a recent poll on the website. Don't we all! Had we but started this great programme around 1990, the world would indeed be our mollusc of choice. Only practicality and hard facts stand between this UK-centric wonderworld and reality.

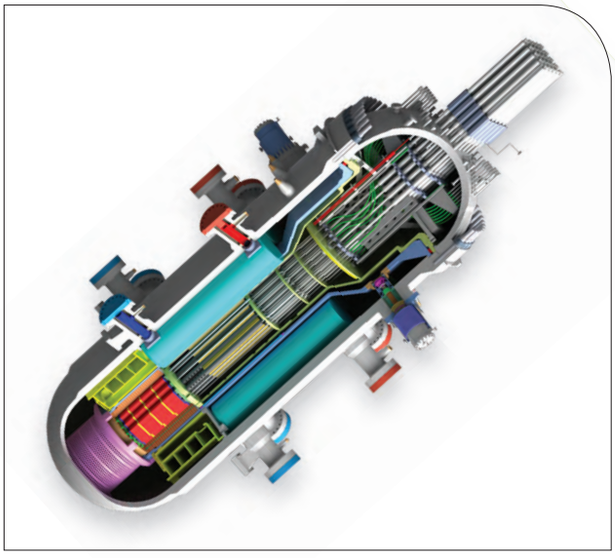
Any nuclear reactor project takes a long time and continuity of purpose. UK nuclear policy has been the very inverse of this – in 2003 we announced a 'no-nuclear' energy policy, sold Westinghouse and its AP1000 in 2005, were thinking we might need some nuclear by 2006, and by 2008 were going hell-for-leather for 16GWe of new nuclear by 2025.

This timescale now meant existing, foreign-designed, reactors would be necessary but, even so, 12 or so reactors would surely give British industry the incentive to tool up and get involved. Strangely enough, 12 or so reactors of at least three different types doesn't add up to the same opportunity.

So what haven't we tried and messed up yet? How about SMRs rolling off the production line like washing machines? And there's the rub. SMRs eschew the classic economies of scale that drive the size of light-water reactors (of which pressurised water reactors [PWRs] such as the AP1000 and Areva's EPR are a subset) upwards – conjecturally until they are so big you can no longer build them – and replace this with economies of number: in other words, make a large number of small reactors in a factory setting and simply transport them to the desired site. This makes a lot of sense, but the key is in the words 'a large number'.

Developing reactors is not cheap and tooling up a factory to make them is also expensive. Moreover, the factory has to be commissioned and worked up to speed, so by the time the first true production SMR comes rolling off the line a lot of money will have been spent. And this will need to be offset by sales before anyone starts making money. The process makes very good sense for Volkswagen Golfs, as you've got a pretty shrewd assessment before you start that the market is there – and it's the requisite large number.

So for our UK SMR what sort of numbers would we need? Well, best estimates for getting even the most developed of the existing (foreign-designed) SMRs 'on the bars' in the UK are around 2030, and if you transferred the whole of the 16GWe programme to, say, 250MWe small modular PWRs, then you would need 60. That's the right sort of amount for economies of number, but it would require a total strategic focus for a UK programme and the unequivocal backing of a single SMR horse. Everything from the last 70 years of the UK nuclear industry (Magnox – 10 stations, nine designs; AGR – seven stations, four designs; PWR – one station, one design, and very different from the standard model) tells you this isn't likely to happen. Of course, if you want a British design, add at least five years to the timescale, and worry that this will miss the prime energy need by over a decade.



Are small modular reactors the future of nuclear? *Image: American Nuclear Society*

> "Nothing in the last 70 years of UK nuclear power engenders any great expectation that we will have a strategy"
> Gregg Butler

Advanced designs are what we need. Which is the point where we find out that an advanced system marches at the speed of its lowest technology readiness level. For example, molten salt fast reactors might indeed be as cheap as chips and safe as houses, but they tend to need things such as online reprocessing, and they need to pump hot salt reliably for years – an interesting materials challenge and one never demonstrated. Regulators want evidence, flowsheets and demonstrable evidence. And comments that it worked okay in the US in 1983 in a slightly different form will not cut the mustard.

So what are we to do? Get on with the current Department for Business, Energy & Industrial Strategy (BEIS) competition, choose a single small modular pressurised water reactor design that can have a lot of UK manufacture, and announce a programme of, say, 20 of them after the current 16GWe of big ones. This would be enough of a home market to get the economies of number; getting the price low enough to access the world market. As a variant, you could also back one or two advanced systems at a low TRL level as a longer-term hedge. But do we have a clear idea why the programme is being supported, what future it is aimed at, what its success factors look like, and an unwavering long-term commitment? Unfortunately, this is called having a strategy and nothing in the last 70 years of UK nuclear power engenders a great deal of expectation that this will be the case.

Gregg Butler is head of strategic assessment at the Dalton Nuclear Institute, Manchester University

MAUCHER JENKINS

ALTOGETHER STRONGER

Leading intellectual property firms, **RGC Jenkins & Co** in the UK and **Maucher Börjes Jenkins** in Germany, have combined to become **Maucher Jenkins**, with offices in London, Farnham, Munich, Freiburg, Basel and Beijing.

This merger of two successful and financially robust European IP firms means that **Maucher Jenkins** stands out as one of the leading and most innovative global IP practices.

A team of talented attorneys act directly before the UKIPO, German PTO, EPO, EUIPO and WIPO on behalf of worldwide clients in a wide range of technologies, covering all IP matters including patents, trade marks, registered designs, oppositions, renewals and portfolio management. The firm's growing litigation practice handles disputes in the European, English and German courts.

Whatever your situation, **Maucher Jenkins** will help you to fight your corner or gain the protection you need to develop your ideas into commercial reality.

www.maucherjenkins.com

LONDON
26 Caxton Street
London SW1H 0RJ, GB
T. +44 (0) 20 7931 7141

FARNHAM
Broadmede House
Weydon Lane
Farnham, Surrey GU9 8QT, GB
T. +44 (0)20 7931 7141

MUNICH
Martiusstrasse 5
80802 Munich
Germany
T. +49 (0)89 340 77 26-0

FREIBURG
Urachstrasse 23
79102 Freiburg
Germany
T. +49 (0)761 79 174-0

BASEL
Aeschenvorstadt 71
CH-4051 Basel
Switzerland
T. +41 61 225 44 90

BEIJING
A-1002, Huibin Building
No. 8 Beichendong Street
Chaoyang District
Beijing 100101, China
T. +86 (0)10 8498 9052

Mailbox

Thehottopic

Education, education, education

Our poll on how best to boost the skills of students entering the profession sparked a heated debate

Industry involvement is absolutely crucial. The Sainsbury Review is about to change everything. I believe we need to ensure that schools are able to continue to offer workshop-based hand-skills development in Key Stage 4 (14-16 education). I hear too many employers complain that learners hold a qualification, but, for example, 'don't know how to change a hacksaw blade'. Schools need to prepare learners for the options they have at 16, which from 2019 will be either academic, or technical and professional (i.e. further) education. I fear there is little incentive left for schools to invest in the tools, the workshops, and the various engineering-specific kits that might help attract learners into the profession.
Matt Simmons

Make it law that manufacturing companies over a certain size have to take on engineering apprentices at 16-18 years old for an indentured period. We would soon have the required numbers of skilled trades people that the country needs within a six-year period. Also, the most academic people do not always make the best tradespeople so let's not get hung up on having A-levels as a starting point for engineering education.
Martin Cunningham

Standard education is really only geared up (no pun intended) to provide a general background and basic skills. In the old days, technology did not develop very rapidly and therefore schools and colleges could produce people who could go straight into work. With the modern pace of technological change, the education system will never be able to move fast enough or have enough funding to do this anymore. Therefore it is more important for industry to step up and give people the specialist and bespoke training based on a good general education. Their reluctance to invest in their future engineers holds them back.
Nick Cole

I became aware that sixth-form colleges often demand a B grade or better at GCSE maths to allow you to take physics at A-level; they demand a B grade at physics; and that you take maths at A-level as well. In my view this filters out lots of potential engineers and scientists at too early an age and does not give young people the chance to recover in the sixth-form years.
Mike Daintree

If each of us moaning about schools not preparing students as we need taught at a junior engineering club at a primary school, we'd have less right to moan. Also, giving up on the unfounded whining about pay and status would help enormously. Who wants to join a profession of bleating whingers?
Mike West

Get in contact with the local schools. Possibly those where the kids of your engineers go. Invite classes to visit your company and give a presentation of what you do. If you want people to go to sea, either make them want to leave you at all cost, or instil in them a longing for the sea.
Ralf Mueller

As various people have identified, getting a degree is expensive. As has also been identified, there is a widening skills gap, and there are constant calls from the large engineering organisations to widen participation. What seems obvious if that these large organisations, put some serious money into funding individuals through university, this would quickly increase the quantity and quality of engineering students. This would then feed down into more young people taking relevant A-levels and GCSEs. It won't happen of course, because the short-term costs would be too high and the long-term gain to difficult to quantify for the accountants.
Jason Cox

Inyouropinion

Driverless dream

Ford has announced a set of plans to develop fully autonomous cars, but many readers are still lukewarm on autonomy

Driverless and steering-wheel-less cars are wonderful things. Except for occasions where a wheel and a human brain is needed. Yesterday in London the cab I was in had to back up because of an oncoming large vehicle that could not reverse due to traffic behind it. My cabbie had to get the car behind to move back. What will the fully autonomous Ford car do in that particular situation I wonder?
John B

Responses to traffic lights, emergency vehicles coming up behind in traffic queues, pedestrians on crossings (or not), level crossings (especially ungated ones), temporary speed restrictions on motorways, icy conditions, punctured tyres, lane discipline at complicated junctions – the list of problematic issues for autonomous cars goes on. Computers were once called TOMs, short for Totally Obedient Morons, and there's a good reason for that – no human-designed machine has ever been perfect and foolproof. Oh, and whose fault is it in a road-traffic accident? The occupants, the owner, the manufacturer, the programmer of the TOM? No thank you Mr Ford, Mr Tesla, Mr Google, Mr Apple or anyone else who wants to put such an unpredictable hazard on the road?
Geoff Hill

This is a bit like electric vehicles – full of promise but never really deliver. I sometimes think it is technology for technology's sake.
Allan Rhodes

I am surprised at some of the comments I am seeing here assuming that all are from engineers. The automation of driving is just a part of the huge structural shift we are now experiencing in our society as robots and automation free us from more and more monotonous tasks. While I am sure there will be more issues and even fatalities with this technology it will save far more lives than it endangers. We have already accepted this technology in so many other parts of our lives.
Peter Blackburn

I share Peter Blackburn's disappointment with the replies – driverless cars have been navigating real-world situations for a while now and have clocked up a huge number of miles, pulling up small examples where someone shouting 'move back' is required really feels like small-minded stuff. I would think that the readership of a publication such as *The Engineer* would be forward looking and excited about the historic shift we're about to experience. I think it's inevitable we will end

Thesecretengineer

Our anonymous blogger considers how best to deal with the dreaded 'ideas man/woman'

I remember hearing a joke regarding one of my colleagues when I joined the engineering fraternity in the dim-and-distant past.

Apparently this particular bright spark had come up with a stunning new tweak on a design then in development and, when asked by his incredulous peers how such a thing would be achieved, had replied: "Don't ask me, I'm just the ideas man."

Ever since then I have been on the look out for the 'ideas man' (or, of course, 'ideas woman') and found examples everywhere that I've worked. All workplaces seemingly have them.

Invariably the suggestions that they make will be hugely ambitious and impractical. Invariably, these suggestions will be made in an off-hand way, not only as if the idea is obvious to anyone if only they had the wit to see it but also belying the highly complex subtleties of implementation.

I have yet to determine whether such extravagant ideas come from people because they have an ingrained superiority complex regarding their own creative abilities or because they are secretly frustrated design engineers.

If the ideas man or woman is on the same rung of the ladder as myself, or below, then I find a surprised raising of the eyebrows and barely stifled guffaw is sufficient to inform them of the error of their ways.

If they persist, then heavy sarcasm is brought to bear. Something along the lines of: "Yes, and if we put a rotor on the top and fly it upside you can cut the grass with it as well." Possibly followed by: "… you imbecilic amoeba."

If the ideas man is higher up the ladder then the sarcasm must be eschewed, or at least disguised. Unfavourably comparing the boss's IQ to that of plankton is, when all is said and done, not a terribly wise career move.

I have found that the higher-ranking ideas man also tends to bring an additional peril with him. Pearls of wisdom such as: "If we make it a nuclear-powered widget then the glow will also make it easier to find in the dark" will often be followed by "that shouldn't take you long" or, even worse, "you should have that done in a couple of hours". I was once given a "half-day job" that took two weeks of hard work to complete.

So just how does one handle this most thorny of problems? I find that letting the dust settle first is always helpful. Listing the obvious failings while their tail is up and their eyes shine with the inner light of divine inspiration is an entirely pointless exercise. Once they have convinced themselves that this is the perfect solution/ultimately desirable and achievable option then the senior ideas man tends to be like a particularly tenacious terrier with a rat.

I promise to go away and look into it instead, then list all the problems and go back fully armed the next day. If I am absolutely certain of my ground then I have not been beyond introducing a seemingly inescapable fatal flaw to the worked-up scheme, leaving the instigator to find this on their own. They get a sense of achievement through spotting it and I get what I know is the right result – basically everyone wins.

Sometimes, very occasionally, the ideas man does hit on something worthwhile. I admit to a small demon whispering in my ear on such occasions that I should "bury it, as it will only encourage them into thinking that the near-random aspect of being right some of the time is in fact proof of their innate genius".

However, we are not employed to make life easy for ourselves or to deny others their moments of glory. So, instead, I embrace it and congratulate them on their insight. I cannot help but think that those in other disciplines have very little idea about these hoops that we in design have to jump through on a day-to-day basis.

up with driverless cars and the roads will be a lot safer for them. It presents some amazing opportunities for rethinking cities even as the cars could wait in designated off-site areas and come to collect people as required, removing all the congestion of parked cars from the roads. Credit to Ford, I suspect it is just getting out ahead of Musk as I foresee that Tesla will be announcing a big step-up in the autonomous system for the Model 3 very soon.

MJL

Join the debate theengineer.co.uk

Looking for the hidden engineers

Families and school groups are set to discover engineering feats in museums and exhibitions that go relatively unnoticed

On my travels this summer I was struck by the ever-increasing role of engineering in the world of fine art and, indeed, other 21st century cultural pursuits, so much of which goes largely unseen.

This was particularly apparent during a visit to The Hague's Mauritshuis, which thanks to a two-year refurbishment brings together design and engineering to create a beautiful, high-tech exhibition space. The structure of the house is retained, a new modern and open space created underground, which effortlessly connects to buildings across the road. The redevelopment is of a high standard and, as you would expect, key environmental elements such as the temperature and light in the galleries are carefully controlled. Those lights aren't LED but halogen – such is the pace of change that this already feels somewhat behind the times.

But how many of the visitors to this gallery and others like it across the globe see what is happening behind the scenes to optimise the visitor experience and the preservation of the exhibits? As families reflect on summer highlights, will any consider the engineering behind the exhibitions and theatre productions they've seen, the open-air screening and festivals they've enjoyed and even the thrills of theme-park rides or encounters with animatronic dinosaurs?

"As families reflect on summer highlights, will any consider the engineering behind the exhibitions and theatre productions they've seen?"

Paul Jackson

Mauritshuis currently hosts a temporary exhibition by contemporary artist Vik Muniz. Entitled Verso, it shows what is behind the painting – the elements that we visitors don't usually glimpse. In many cases you see the various stickers that represent loans to other galleries. However, looking behind the *Mona Lisa* offers something intriguing – a piece of kit that monitors an existing crack and will (through a fully automated system) send out an alert should said crack increase by even a micron.

There are masterpieces of engineering behind much of what we see at museums here in the UK, we just don't look for them. We're hoping that in teaming up with attractions for Tomorrow's Engineers Week (7–11 November), more families and school groups visiting them will discover the engineering behind the exhibits and activities. We hope they will be inspired to think more about the work those 'hidden' engineers do and to think where they might develop their own skills.

In fact, we're looking to put some of the engineers whose amazing work goes unseen (or is easily taken for granted) front and centre during the week. The image of engineering needs a make-over and we want to use real engineers in real jobs to help challenge and change perceptions of the industry. Part of that is about showing the hidden engineering all around us, so do join us if you can give any insights into what you do. You don't have to create a 37-piece gingerbread showstopper but if you'd like to make a video to show off your engineering skills we'd love to hear from you.

Paul Jackson
Chief executive EngineeringUK

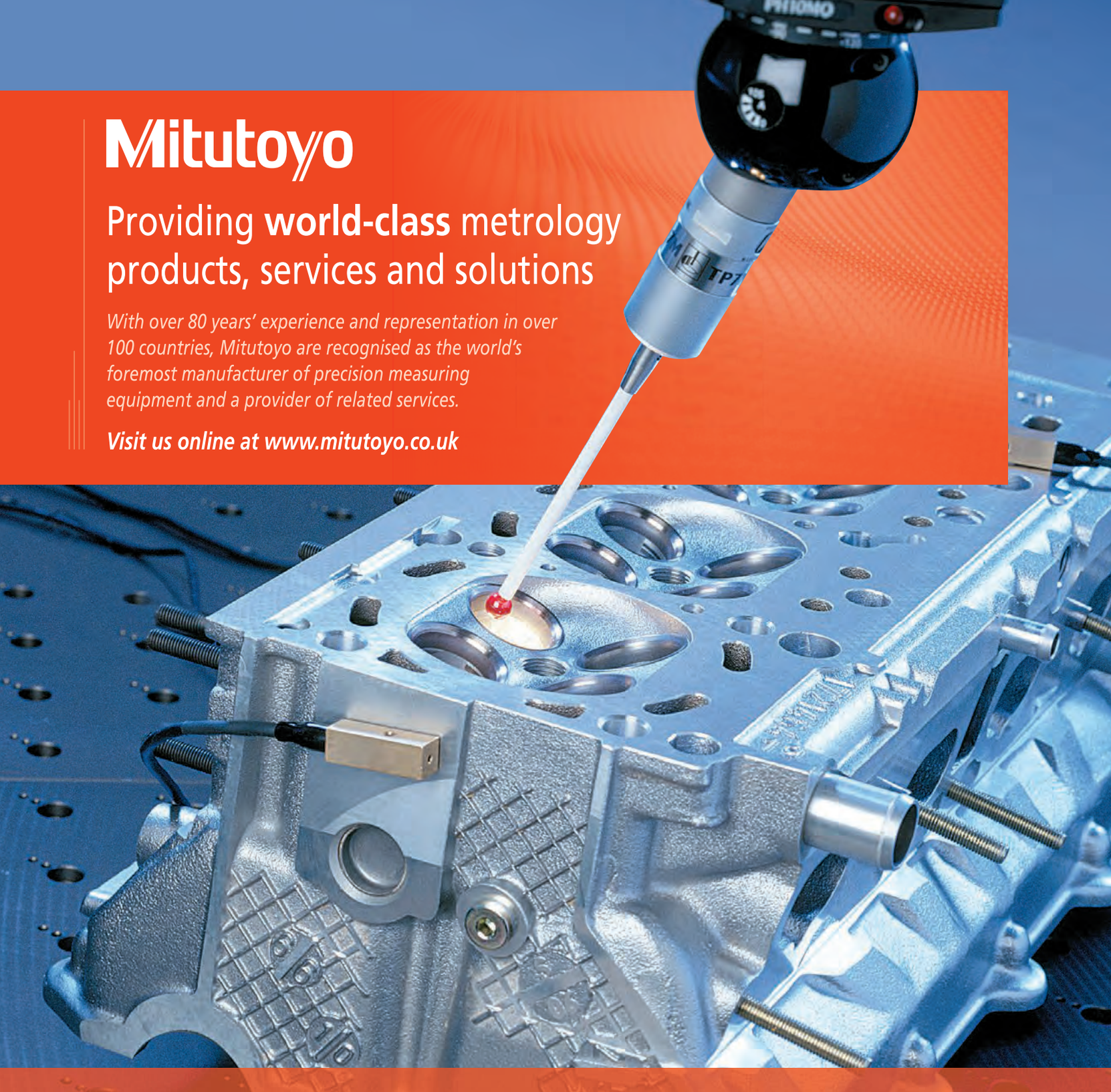
The refurbishment at the Mauritshuis brings design and engineering together *Image: Mauritshuis*

Mitutoyo

Providing **world-class** metrology products, services and solutions

With over 80 years' experience and representation in over 100 countries, Mitutoyo are recognised as the world's foremost manufacturer of precision measuring equipment and a provider of related services.

Visit us online at www.mitutoyo.co.uk



City & Guilds Approved Centre

EXCLUSIVE DIMENSIONAL METROLOGY QUALIFICATION

Mitutoyo alongside City & Guilds exclusively offer the first National Qualification in Dimensional Metrology

Find out more, or book your place at *www.mitutoyo.co.uk/education*

Flying on the water

A crack technical team led by a veteran of Formula One is helping Olympic sailing legend Ben Ainslie mount a challenge for sport's oldest trophy. Jon Excell reports

If you're interested in boats there are few more fascinating places to while away the hours than Portsmouth harbour: where an endless flotilla of superyachts, passenger ferries, towering warships and even the occasional hovercraft form what's surely the UK's most varied and dynamic maritime landscape.

But of all the vessels that head in and out of this historic port there is perhaps one that catches the eye more than any other: its futuristic curves, giant fibreglass sail, elegant hydrofoils, and energetic crew marking it out as something special.

For Portsmouth is the home of Land Rover BAR (Ben Ainslie Racing), the company set up by the four times Olympic sailing champion with the specific intention of bringing sailing's most prestigious trophy – the America's Cup – back to Britain. And the boat currently under development at the team's sparkling new HQ is one of the most advanced, high-tech racing vessels ever to be built in the UK.

If Ainslie succeeds, it won't be his first taste of cup success. In 2013, he was parachuted in to Oracle Team USA's flagging campaign, and has been widely credited with masterminding one of the event's great turnarounds: with Ainslie as skipper, Oracle turned an 8-1 deficit into a 9-8 victory.

But talking to *The Engineer* earlier this summer, Ainslie explained how this triumph only sharpened his desire to mount a proper British challenge for the trophy. "It started here in around 1851, an American boat won it, took it back to New York harbour renamed it the America's Cup and we've never seen it since. It's very important to us to right that wrong in our maritime sporting history. If we could bring the cup home it would be one of the greatest achievements in British sport."

01 Huge crowds cheer on the team during racing in Portsmouth

With this in mind, he has pulled together a crack technical team of engineers from a multitude of disciplines – led by Formula One (F1) veteran and former McLaren Group CEO Martin Whitmarsh – that he hopes will not only wrestle the iconic trophy from its current owners, but also mimic the success of firms such as McLaren and use sporting triumph as a springboard for wider industrial success.

A complex competition (see box, p24), The America's Cup has long been one of sailing's most captivating spectacles but, over the last decade, radical changes to the rules have seen it evolve into one of sailing's most dramatic and high-tech competitions.

As recently as 2007, competitors raced far out at sea in big mono-hull vessels typically weighing around 25 tonnes, and rarely exceeding speeds of around 10 knots. But a change in regulations for the 34th Cycle of the America's

02

03

"It started here in around 1851, an American boat won it, took it back to New York, renamed it the America's Cup and we've never seen it since"

Ben Ainslie

04

Cup, which came to its conclusion in September 2013, saw the introduction of advanced hydrofoiling catamarans that fly at up to three times the speed of the wind on advanced L-shaped hydrofoils (or daggerboards).

According to Ainslie, these changes have revolutionised the sport: "They're the most incredible boats to be on; they're so physical but the reward for getting up on the foils, tearing round at close to 60mph and doing these foiling tacks and gybes it's just awesome. As sailors we love it and for spectators it really, really works."

Piloting a so-called 'foiling multihull' around the twists and turns of an America's Cup course is no mean feat. During sailing, the aerofoil (or wing) – a giant 23.7m-tall fibre-glass structure – provides astonishing amounts of thrust but in doing so provides an unwanted heeling force that threatens to capsize the vessel. The hydrofoils resist this side force and create the lift.

The crew's job is to ensure that, in the constantly changing conditions of the ocean these competing forces are carefully balanced. They do this chiefly by changing the angle of attack of the hydrofoils and adjusting the wing and the flaps to generate just the right amount of thrust without capsizing the boat.

All of this is backed up by the efforts of the muscle-bound 'grinders': specialist crew members whose prime purpose is to operate hand-powered cranks that charge the hydraulic systems used to power the wing and foils.

The preliminary stage of the competition – the so-called Luis Vuitton America's World Cup Series – is already under way. And for these races, which are aimed at narrowing down the field to find a challenger for next year's big show-down in Bermuda, all of the teams are racing a standard boat: a 45ft foiling catamaran known as the AC45.

02 The crew communicate with each other using bone-conduction technology

03 Fibre-glass 'daggerboards' support the full weight of the vessel

04 The boat's wing is 27.3m high and weighs just 340kg

But in tandem with this the team is refining and building the considerably more advanced AC-class race boat that it hopes will eventually win the America's Cup in Bermuda in 2017. And while the AC45 is capable of an impressive turn of speed, the AC-class vessel currently under development is estimated to be almost 2.5 times as powerful: capable of flying at around 85kph, and at up to three times the speed of the wind.

While many elements of the boat's design are carefully regulated there are areas of design freedom – notably in the design of the hydrofoils, aerofoils (wing) and control systems. And it's here that the engineering team hopes to squeeze out the kind of marginal gains that have come to define other high-tech racing sports. "The control of the wing, the flying shape of the wing, the dagger boards, the rudders, they're the things that really make a difference to these boats and they're still completely open," explained team CEO Martin Whitmarsh.

Much of the effort has been focused on the design of the hydrofoils and ensuring that the need for speed is carefully balanced with the requirement for controllability. **>>**

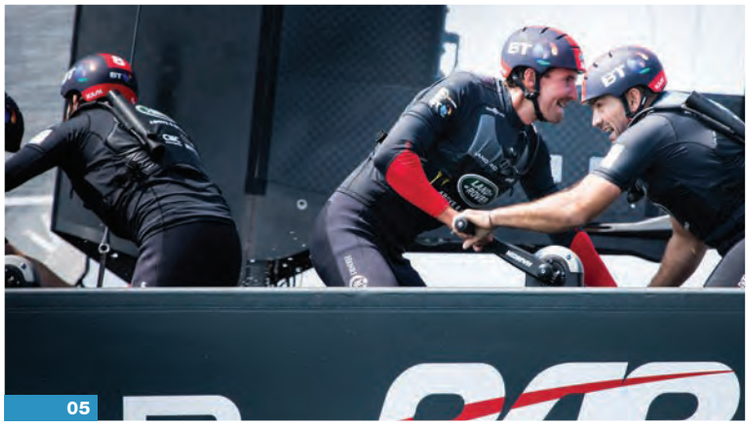
>> "We can design foils that are quicker in a straight line," explained the team's design manager Simon Schofield, "but it's about striking a balance between controllability and speed now."

In contrast to the lengthy courses that have dominated the America's Cup in the past, today's finals are hectic, high speed and relatively short affairs. The Sound of Bermuda, where the final will be contested in 2017, is a tight course, where 90 per cent of the time the boat will be accelerating or decelerating and any mistake could be costly. "If you come off your foils in a gybe… and land in the water that's [the equivalent to] 10 or 15 boat lengths, and in some races if you touch down once in a gybe you lose the race," said Schofield. "It's a balance between having the quickest possible foil and one that can get around the course. The boundaries are very narrow; you've only got a minute and a half between manoeuvres – it's much more of an acceleration game than a speed game."

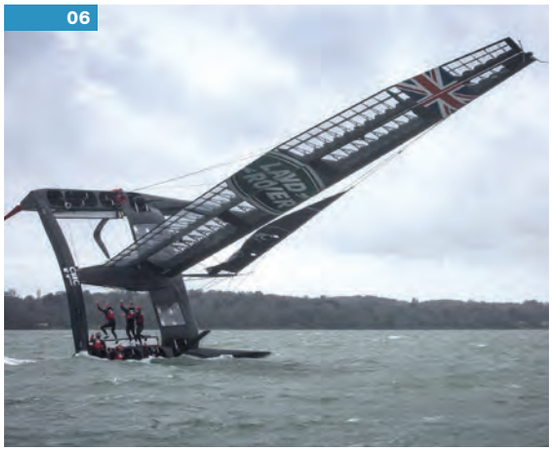
05 'Grinders' charge up the boat's hydraulic power systems

06 The boat almost capsizes during training

07 'Flying' on the foils in Portsmouth's historic harbour



05



06

07

Indepth

A cup with a long history and a complicated format

The America's Cup has a long history and a complicated format. Although six teams are competing in its current iteration, the 35th, which culminates in 2017, the final race will be between the current holder of the trophy and a qualifying challenger.

The world's oldest international sporting trophy, the history of the America's Cup goes back to 1851, making it slightly older than even *The Engineer*. In its entire history, only four teams have won: the US, Australia, New Zealand and Switzerland.

Selecting the qualifier to challenge for the trophy is a competition itself, known as the Louis Vuitton America's Cup World Series. This consists of a series of regattas of six races held over a weekend in international locations. The 2017 competition in fact began last year in Portsmouth, Gothenburg and Bermuda. Further races took place earlier this year in Muscat, New York and Chicago, plus a second regatta in Portsmouth. Still to come are races in Toulon and Fukuoka, Japan.

Teams accumulate points during these regattas in a league system.

The regattas, which take place in a round-robin format, will yield four top challengers who will compete in a play-off – a match-racing semi-final and final in Bermuda to be held in May and June 2017. The winner of this will compete against the holder in a final pair of races in late June.

During testing, data on the performance of these critical components is gathered from the thousands of fibre-optic sensors embedded throughout the boat, and fed back live to the engineering team. But some of the most critical information is provided by the sailors themselves.

It's a dynamic that Whitmarsh remembers well from his days in F1: "I think it's quite amazing when you're dealing with the best racing drivers or sailors in the world, the feeling that they have. If there's something wrong – a vibration, a noise, a tone, a feeling, a steering load feedback – these guys are so supersensitive.

"When I started my career as an engineer I was initially incredibly dismissive of drivers but increasingly I've found myself having to tell engineers to listen to the driver. I find the whole dynamic very important."

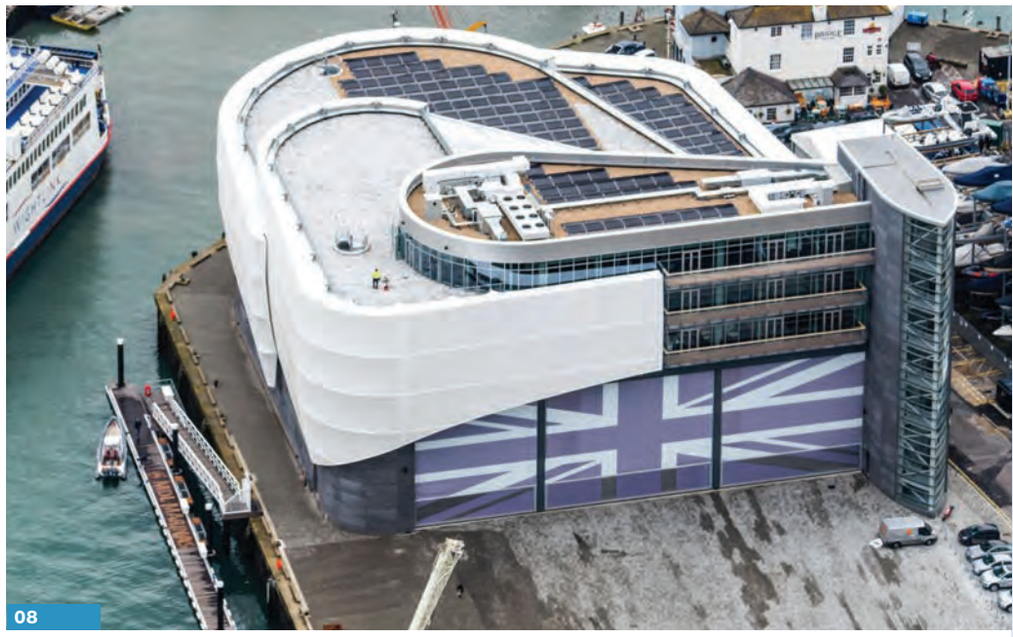
> "When you're collaborating across a very rapid design cycle, having the right info up to date with everybody sharing it is really important"
>
> Robin Hancock, Siemens

For Schofield, this feedback is a critical part of the design process that helps bring the engineers back down to earth. "The crew will often come back and say it's too unstable," he said. "We're only designing for the ideal world – you've got to be careful that you don't design something that is quick but so spiky in its performance that you drop off a cliff."

As well as the relationship between crew and the engineers, the team also works closely with a number of key industrial partners – including Jaguar Land Rover, BT, BAE Systems, Siemens, and Renishaw – through its Technical Innovation Group (TIG). "We're quite a small organisation; the TIG allows us to reach out to much larger technical organisations looking for areas of expertise that we don't have," commented Whitmarsh. **>>**

"At McLaren we realised we've got a machine here that attracts really bright, ambitious, creative people. It promotes invention and it creates IP"

Martin Whitmarsh, McLaren


08

>> One particularly notable example of industry involvement is the work the team has done with Land Rover – its main technical partner – on the boat's 78.6ft wing. Around the same size as Boeing 757, this huge carbon-fibre structure is covered in a thin Clysar film that deforms under the load of wind, thereby modifying the flow of air over the wing and affecting its performance.

In an effort to understand this in greater detail, and to actually determine the final flying shape of the wing, the team deployed tools originally developed by main technical partner JLR for designing the roofs of convertible cars.

Another important relationship is with industrial giant Siemens, which has supplied an end-to-end suite of software tools that has enabled the team to create a true digital twin of the real-life boat.

According to Siemens Industry Software vice-president Robin Hancock, there's absolutely no lag between the boat and the model, and he reckons it represents a new level of sophistication for the America's Cup. "When you're collaborating across a very rapid design cycle, having the right info up to date with everybody sharing it is really important. This is the first team to have that."

Elsewhere, one particularly unusual development has seen engineers at BAE Systems adapt a battlefield communication technology based on bone conduction to help the crew communicate more effectively with each other.

This prototype headset creates physical vibrations from an audio signal, which travel through facial bones into the inner ear, where the vibrations are translated into nerve impulse signals sent to the brain. The device enables users to keep both their ears free so external sounds can be heard, while providing the ability to communicate clearly with crew mates despite the harsh and noisy conditions.

Ainslie, Whitmarsh and the Land Rover BAR team appear supremely confident that this focus on innovation will bring the America's Cup back home. But beyond this, they hope it could lay the foundations for wider industrial success: that a triumph in Bermuda next year could set the team up as an internationally recognised hotbed of maritime innovation.

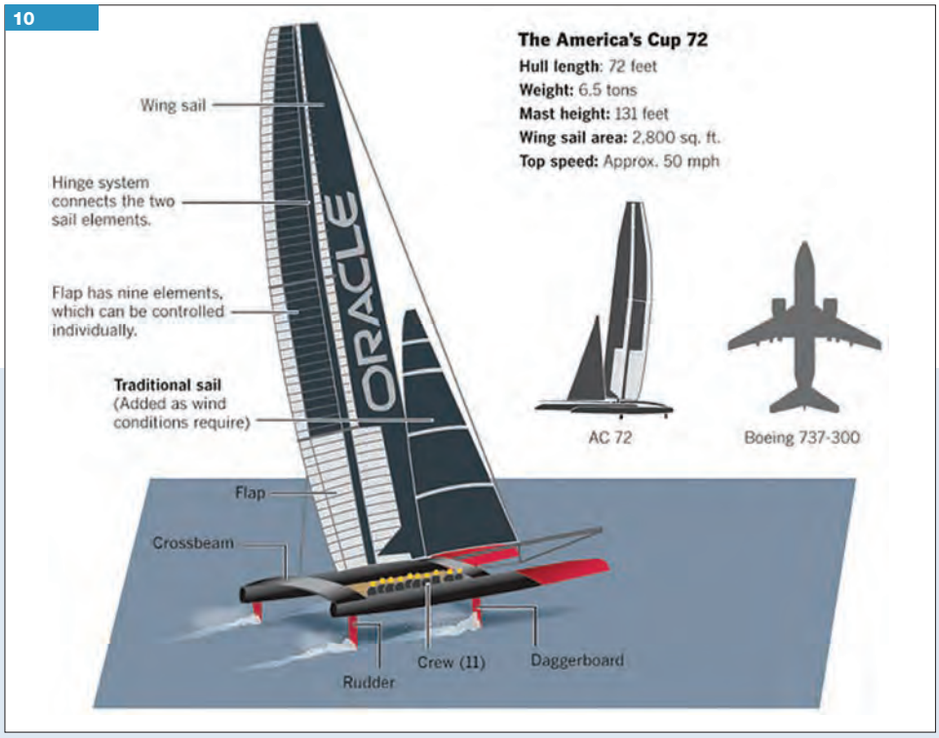
"Racing is such a fantastic environment to drive endeavour and creativity," said Whitmarsh. "[At McLaren]

08 Land Rover BAR's dramatic HQ

09 Ainslie (far left) at the helm

we realised we've got a machine here that attracts really bright, ambitious, competitive people. It promotes invention, it creates IP and enables us to grow capability, so we took that from a motor-racing business with about 80 people to a business of about 3,500 people and a series of technology businesses that had been grown off the back of that. We're very focused on trying to win the America's Cup – that's where our brand is going to be grown – but it's clear to me that the marine sector is a number of years behind aero and motorsport with regards to control systems, hydraulics, simulation, analysis. I think there's an incredible opportunity to go out and do those things."

10



Indepth

Stuart Nathan explores sailing and flying synergies

Land Rover BAR isn't alone in looking to industry to help provide a competitive edge. Indeed, the current holder of the America's Cup, Oracle Team USA, has been working closely with aerospace giant Airbus on a host of innovations.

Speaking at Airbus's recent Innovation Days event in Hamburg, Charles Champion, executive vice-president for engineering, commented that the synergies between sailing and flying are greater than ever.

One of the biggest of these is in materials, he said.

The skeleton of an America's Cup boat for the 2017 races is made from carbon composite, as are increasing amounts of Airbus's aircraft; notably the A350 series, whose wings are entirely made from composite; the wing structure is very similar to the sail wing of the yacht.

Champion said: "The use of aeronautical technology increases the boat's performance. There are many similar challenges, these include flight qualities, aerodynamics, lightweight materials, instrumentation systems, and the fact that they are tested in the air or at sea."

According to Champion, diversity of projects is one of the keys to delivering innovation at Airbus. By helping to deliver a step change to the sailing world, with its technologies, competencies, methods and tools, the company's engineers gain a new perspective on their work that helps to unlock new views on how they can be used in its civil and military aerospace centres of excellence.

Some of the main areas where Airbus technology has come in useful include aerodynamic foil design and testing, hydraulics, yacht aerodynamics, 3D printing and MEMS pressure sensors.

Perhaps the most striking features of the America's Cup boat are its dagger boards – the aerofoils that the boat rises up on at speed. Airbus found that the ideal shape was very similar to the upturned winglets it currently uses on the tips of the wings of the A350 aircraft. Like the winglets, the dagger boards have to bear extremely large loads; whereas on the wing they help to diffuse the vortices of air that form during flight, on the boat they are to support the weight of the entire craft, the force of wave impacts and the stresses incurred when the boat manoeuvres.

To ensure that the basic winglet structure was up to the job, the Airbus team performed two component tests at its Hamburg manufacturing facility to validate the rigidity of the structure against the strength that was required. In the process of this work, the team found that different manufacturing processes might be possible to make the winglets for the aircraft; these are now being validated.

The aerospace company's expertise in computational fluid dynamics (CFD) was also important to the project. The data gathered during the boat design process helps the team to design a global sailing simulator, which Champion said is precisely equivalent to an aeronautical flight simulator. In the case of the boat, simulation was even more challenging because as well as the aerodynamics of the part of the boat that is out of the water it had to take into account the hydrodynamics of submerged portions: the hull sections and dagger boards.

Variables taken into account include the yacht speed, the cavitation (formation of bubbles in the water owing to the low pressure in the wake of the hydrofoil), and the hydroelectricity or deformation of the dagger board structure caused by water pressure.

Another function where aerospace technology has contributed is in sensing the strength of the wind. In conventional boats this can be done by careful and practised observation of the fabric sail, but obviously this can't be done in a boat with no sail. Instead, Airbus provided aerodynamic pressure sensors similar to those it is now introducing onto its aircraft wings; these use MEMS devices to provide an accurate reading of air speed without having to pierce the composite structure. The leading edge of the boat's vertical aerofoil carries eight strips of sensors, which have a variety of potential applications.

Airbus has also contributed a 3D-printed component to the Oracle boat. This component, the forward organiser, has a complex geometry and is made from aluminium. By making it with additive layer manufacturing, Airbus achieved a weight reduction of 57 per cent, reduced the production lead time and increased the component strength.

Digging the urban style

JCB hopes its new compact wheeled excavator can reshape the future of urban construction. Andrew Wade reports

An invitation to visit JCB's headquarters is no doubt the stuff of many a childhood dream. The company's iconic machinery has been a mainstay of UK construction for decades, and the brand has even transcended industry to attain a dictionary entry; JCB has long been a recognised term for any machine with a shovel at the front and a digger at the rear.

Founded in 1945, the privately owned company is one of British manufacturing's real success stories, and today has 22 plants across four continents generating a total of £2.5bn in annual sales. Three years ago it celebrated the production of its one-millionth machine – apparently enough diggers to stretch from the UK to Australia.

But JCB's proud heritage belies a drive for innovation that enables it to compete on a global level. Its continued expansion has occurred largely in the absence of acquisition, relying instead on in-house creativity. It was the latest fruits of this innovation that prompted *The Engineer*'s recent visit to JCB's Rocester HQ.

Developed in secrecy over three years under the codename 'Project 710', the Hydradig is a compact wheeled excavator that JCB believes can reshape urban construction. Building work in cities is taking place in increasingly congested environments, with a growing demand for agile, multi-tasking machinery that can still deliver grunt. JCB has designed the Hydradig to meet that demand.

"This was about creating a completely new machine, a new piece of construction equipment that didn't exist before," JCB's chief innovation officer Tim Burnhope explained.

"When we talked to customers, they told us there are five areas where they find these type of machines don't have the true capability of what we need for today's environment."

The five areas identified by JCB were visibility, stability, mobility, manoeuvrability, and serviceability. According to Burnhope, machines in the 10-tonne sector would traditionally only excel in one or two of these areas. The challenge for JCB would be to design a new construction vehicle that was outstanding in all departments.

"Why can't we have a machine that drives like a backhoe loader?" said Burnhope. "We should be able to do 40kph. Why can't we have four-wheel steer? Why can't we turn in half the turning circle? And why can't we service it from the ground?"

But delivering improved performance in all areas would not be easy, as the challenges facing JCB were interlinked and often conflicting. Boosting stability generally means adding bulk, which, in turn, often hampers visibility and mobility. Individual teams were assigned one area to focus on and told to ignore everything else; the rub would come later when trying to merge the various solutions.

Improved visibility came with the help of a brand-new cab that provides 360° views. The operator can see all four wheels, as well as within 1m of the Hydradig's footprint at ground level.

"Visibility from the cab was the main customer consideration because of on-site safety concerns," said Burnhope. "In an urban environment, not to be able to see around a small machine is a real challenge." **>>**

01 A newly designed cab gives the operator 360° views


02


03


04

> "Stability was probably the biggest challenge. Working on how to get the perfect 50/50 weight distribution across the axles for speed"
>
> Tim Burnhope, JCB

02 JCB lowered the centre of gravity on the Hydradig

03 A range of attachments allows multi-tasking

04 The Hydradig offers a reduced tailswing

05 With its mass lowered, Hydradig can lift up to 1,000kg

>> In order to remove as much obstruction from the new cab as possible, the driveline and hydraulic pump were mounted lower in the chassis. This also helped the designers solve other key issues around stability and mobility. By significantly lowering the machine's centre of gravity, JCB could kill multiple birds with one stone. But arranging the pieces of the puzzle closer to the ground was not straightforward.

"Stability was probably the biggest challenge," said Burnhope. "Working on how we got perfect 50/50 weight distribution across the axles for speed, but at the same time bringing the whole mass down. Compared to a traditional machine, we've brought down the centre of gravity by three quarters of a metre. That was an incredible breakthrough."

The industry trend had been for smaller machines on site, but the size of building components had remained the same. Essentially, more weight was required from a smaller footprint. Some machines would use bigger counterweights to increase lifting capacity, but the extra bulk could make them unwieldy, as well as too big to operate in a single carriageway.

"The challenge at the time was that we believed the size of the counterweight we needed to lift 1,000kg would hurt the visibility," Burnhope explained. "So what we needed to do was to cleverly shape that, and come up with different densities. It was literally a spreadsheet with all of those values, and then the constant tweaking to get to that 1,000kg… the answer in the end meant we could lift 1,000kg over the side rather than 500kg, and we could do it with a zero tailswing."

To enhance mobility, JCB's engineers took design principles from its Loadall Telehandler. Adapting the Loadall drivetrain for the Hydradig would allow the new vehicle to reach speeds of 40kph on roads. The 50/50 weight distribution, combined with a repositioned slew ring, meant the Hydradig also wasn't prone to the 'nodding' other diggers often experience at speed.

"It's a stepless hydrostatic transmission," said Burnhope. "Just press and go, straight to 40kph, with tremendous weight distribution, so it just drives like a high-speed backhoe or Loadall."

For safe on-site operations, speed can be limited to 20kph. Manoeuvrability comes via three standard steering modes: two-wheel, four-wheel, and crab steering. An optional reverse steering mode also allows the operator to use the three standard modes while the cab is facing in either direction. JCB said the Hydradig has a tailswing of just 120mm, 29 per cent less than any of its competitors.

The final piece of the puzzle was serviceability, but bringing the drivetrain and hydraulics so close to the ground also helped tick this box. Working on machinery at height is inherently dangerous, but on bigger machines 'boxing ring' safety systems could be used to prevent falls. However, the systems weren't suitable for servicing smaller equipment.

"Health and safety don't want anyone working at height these days, they want them on the ground," said Burnhope.

With service access at ground level, JCB had completed its five-card trick, addressing the interdependent problems it set out to solve. In a global market that the company's own CEO recently described as "uncertain and fragile", JCB sees the Hydradig as a potentially game-changing addition to its portfolio and a driver of future growth.

Burnhope said: "It's got all these degrees of freedom that we've never experienced before… it can use forks, it can work with a bucket at any angle, it can lift, it can carry, it can grab… we've designed it to run with a trailer."

JCB has clearly invested major time and resource into the Hydradig's development, and company chairman Lord Bamford recently hailed its successful launch. But it has a long journey ahead if it's to be spoken of in the same breath as JCB's famous backhoe loaders, and become an enduring part of the company's legacy. What I do know is that I've been promised a spin at the JCB test quarry, and both my inner child and its corresponding adult are very much looking forward to it.


05

The grand pragmatist

The founder of Warwick Manufacturing Group is focused on more longer-term goals than the UK's membership of the EU. Will Stirling reports

A minute into the interview with Lord Kumar Bhattacharyya, it is evident that he believes Britain's decision to leave the European Union is not the Armageddon for engineering and industry that many people feared.

The chair and founder of Warwick Manufacturing Group (WMG) speaks with the near blasé assuredness of someone who has witnessed huge change in Britain and who is focused on goals that are even more long term than our membership of a supranational bloc. "The world is much bigger today. How do we explore other markets? India is one of the biggest investors in the world. There is a lot of love for the UK in India," said the eminent engineer and pro-Remainer. "You have to get on with it. I am a pragmatist," he added, pointing out that EU competition laws have complicated and delayed decisions by some multinationals to invest in Britain.

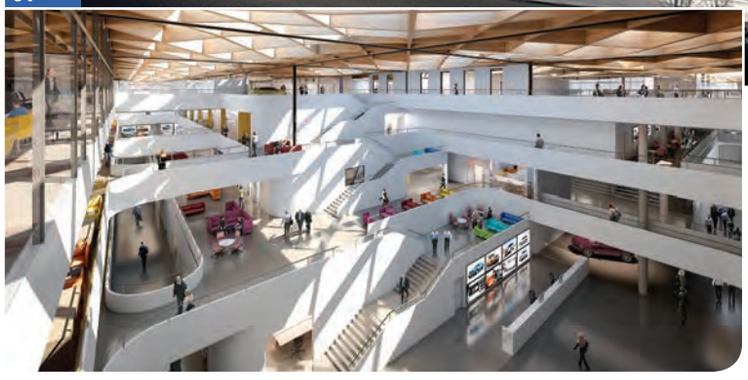
He should know about Indian opportunities. From ordinary beginnings as a graduate apprentice at Lucas Industries in the 1960s through to founding WMG in 1980 and receiving a knighthood for services to engineering and industry in 2003, Lord Bhattacharyya has worked closely with Indian companies to create Anglo-Indian ventures, most notably brokering the takeover of Jaguar and Land Rover by Indian industrial giant Tata Motors in 2008.

His vision for the UK has always been ambitious, rooted in long termism and the crucial role of investment. "I brought steel here," he said without hyperbola, referencing Tata. "The reason why it is in trouble is lack of investment," in reference to the precarious future of UK steelmaking since Tata Steel announced in May it would sell the loss-making Port Talbot steelworks. A friend of former Tata chairman Ratan Tata, Bhattacharyya said that he is developing the strategy for Tata Steel to remain here.

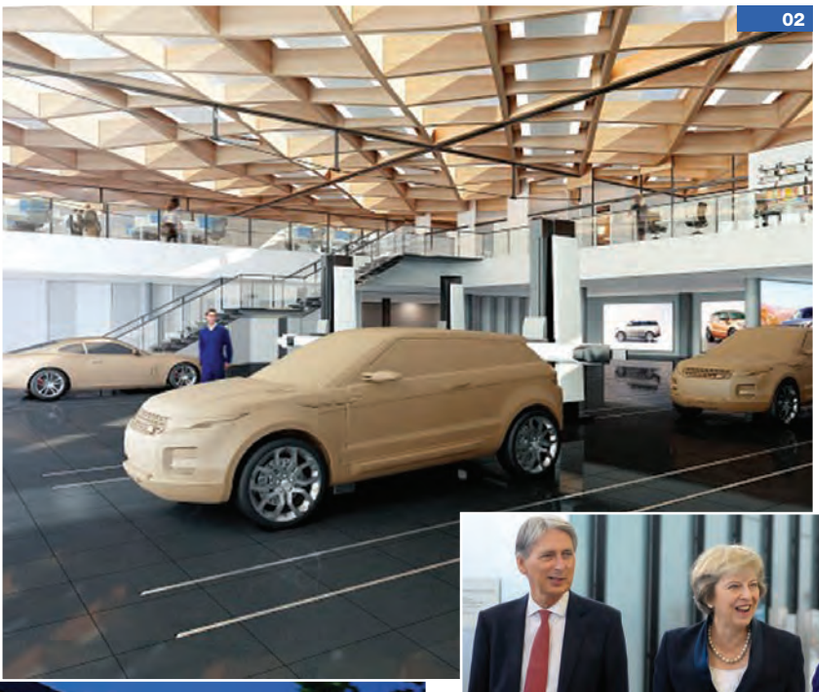
But won't multinationals now question their commitment to existing and future investment in the UK since Brexit? Consider Siemens UK's managing director Juergen Maier's comments in late June about "reviewing Siemens' future investment" in facilities such as the offshore wind turbine factory in Hull. And might many companies linked to WMG's expensive research facilities, such as the National Automotive Innovation Centre, get cold feet at this uncertain time? "I don't think so at all," said Bhattacharyya. "They come here mainly for technological purposes. They are not coming here for short-term financial benefit, mainly for science and technology, and once they develop this they benefit. They are not particularly worried about where Britain lies, as long as they can be a part of [the success]. And geographically we are still a close market."

He added: "I am sure that when the deals are done, it won't be as black and white as people think, because all countries have got bilateral relationships and agreements with industrial companies, and agreements on [their] science base."

This grounded view of business fundamentals is reflected in the Warwick Manufacturing Group. With turnover of £150m and nearly 500 employees, it is home to a big range of engineering research, but one sector dominates: automotive. WMG's biggest investment to date, in build now, is the National Automotive Innovation System (NAIC). The numbers are big: £150m for the building, rising to £300m when accounting for investment in capex and people. He mentions £1bn – perhaps the total economic impact



01 The National Automotive Innovation Centre will research automotive technologies



02 Artist's impression of the inside of the National Automotive Innovation Centre

03 Lord Bhattacharyya welcomes the UK's new prime minister to the Warwick Manufacturing Group premises

Biography

Lord Kumar Bhattacharyya
Chairman, Warwick Manufacturing Group

Prof Lord Bhattacharyya was born in Dhaka and after graduating from the Indian Institute of Technology, Kharagpur, one of India's premier technological research institutes, he was invited to become a graduate apprentice at Lucas Industries in the UK. After completing his graduate apprenticeship, he was offered the Lucas Fellowship and entered the University of Birmingham where he attained an MSc in Engineering Production and Management and a PhD in Engineering Production. Before completing his PhD at Birmingham, he was appointed as a lecturer and began the process of establishing a manufacturing education programme for industry there. The UK first ever professor of manufacturing, Lord Bhattacharyya is an advisor to many companies and organisations around the world, and has advised the UK government on manufacturing, innovation and technology, including former prime ministers Margaret Thatcher and Tony Blair.

of the combined auto centres. "It is the single biggest privately funded investment by any university in the UK," said Bhattacharyya. The 33,000m^2 centre will research new automotive technologies and build prototype cars. NAIC is about taking design and research through to manufacturing.

The central theme for NAIC is low carbon and electric propulsion, about which Bhattacharyya is evangelical. "The design of new cars is the future. They have to be very, very lightweight. The car has changed very little over the years. Another big change now is vehicle autonomy – to assist the driver – low carbon and batteries."

As well as major investors, including Jaguar Land Rover (JLR), which has put £50m into the building, NAIC works with several automotive tier-one suppliers, including Bosch, Continental and ZF, and it is attracting more. "We work with Nissan, battery companies; we have been approached by German companies because suddenly they are excited about what we are doing. What we are doing is being monitored by the competitors of JLR. If they can come in and benefit from it, they will."

How does that sit with JLR? "There are two levels, one is commercial competitiveness – that will remain with JLR. The fundamental science, that can be transferred without any problem," he said. "And sometimes JLR will also ask if it can work with XYZ, so that both companies can benefit, even a rival OEM. And with these new technologies, not everyone will build a battery factory."

To complement the flagship NAIC, WMG built the Energy Innovation Centre, which includes a £13m battery materials scale-up Pilot Line that develops new battery chemistries from concept to proven traction batteries, and a battery characterisation laboratory. Then there is the Advanced Propulsion Centre, a 10-year, £1bn industry- and government-funded project for developing low-carbon propulsion systems. In July 2014, the University of Warwick was chosen as the site for its hub location. "To design and manufacture low-carbon engines, do we look at a combination of propulsion types or just a single propulsion? How do you make that efficient?," said Bhattacharyya. "Irrespective of whether it's electric or not, you want lightweighting. So the APC works as part of a lightweighting research centre but in a different way to working with internal combustion engines or with electric motors. How do you design electric motors that are part of the total system, rather than in isolation? There is no point in us having an energy [storage] centre if we don't have a propulsion centre. It is so coupled. Materials, electric motors, batteries and new means of energy transfer in the powertrain."

> "I am sure that when the deals are done with the EU, it won't be as black and white as people think, because all countries have got bilateral relationships"

Bhattacharyya is a government advisor on engineering and manufacturing. What does he make of the new-look Department for Business, Energy and Industrial Strategy (BEIS) given the trail of underwhelming manufacturing strategies of the past decade? "The new prime minister bought in the Industrial Strategy at the heart of policies on day one [of the new administration]. We have to be sure that production is as good as the world's best. Concepts such as the Northern Powerhouse and the Midlands Engine, they are piecemeal. I am confident that the government will deliver on a national industry strategy."

Bhattacharyya has campaigned indirectly or directly for the UK to invest in engineering skills since his PhD at the University of Birmingham in the 1960s. Since the main drive for creating a 'technical class' began at the end of New Labour in 2009, has Britain got closer to filling the skills gap? "No, it is just as bad," he said. "It's easy for politicians to talk, somebody writes a speech and they talk. To implement it is a huge task. You have to have the infrastructure to implement it. That is why I am so keen on the Industrial Strategy." Meanwhile WMG is, unsurprisingly, doing its bit on skills. It now has both a University Technical College, the WMG Academy for Young Engineers, and an apprentice school, which has nearly 400 starts and aims to have 1,000 by 2020. "We are spending £20m on a brand-new building and we are helping SMEs with the Apprenticeship Levy, in effect paying part of the levy for them and we develop the curriculum and how it should be taught."

Heading for new destinations

Novelist Jon Wallace considers the science fiction implications of engineering stories that have caught his eye. This month, the future pros and cons of driverless cars

Since Mr Benz unveiled his patented motor-wagen, the car has helped define the way we imagine our future, as the most intimate expression of man's relationship with engineering. Where bridges, dams and canals remain the boast of nations, automobiles are the boast of individuals. Where air and sea transport remain stubbornly mass transit (private ownership the domain of the few) automobiles empower us all, making each of us captains of our own little craft. Cars help define our position in society: our first car is a passage to adulthood. Our choice of car projects our status where we choose to roam.

It makes sense that scifi writers have so often used the car as a defining element in their future worlds. From *Back to the Future 2*'s flying DeLorean to *Mad Max 2*'s 'Pursuit Special', the state of the car has helped define the state of the future and, more importantly, provided the means for adventure on a broad, dazzling canvas.

Still, when we observe the car's progress in the 21st century, those of a scifi disposition can't help but feel a pang of regret. Visions of flying cars, once contemplated as an inevitable evolution, have become a sort of punchline. Worse, the car's core appeal, that of a liberating symbiosis between man and machine, is under threat. As engineers confront the challenges of climate change, overwhelmed networks and our own safety demands, the driver is increasingly made merely another passenger. As the passing of steam ripped the romance from rail, could the end of petrol wipe out the wonder of wheels?

This month, *The Engineer* reported on a joint venture between Volvo and Uber to create a fleet of driverless taxis. Such automated traffic indicates a dreary future indeed: hardly what we've been led to expect by the chaotic cabs of *The Fifth Element*, or *Red Dwarf*'s 'Hoppers'. Where automation has raised its head in scifi taxis, such as *Total Recall*'s 'Johnny Cab', our heroes have impatiently ripped it from its housing.

It's here that we begin to see possibilities for stories. For the driverless car 'revolution' seems above all the fascination of giant corporations – the Googles and Apples of this world. Will individuals of the future submit so meekly to a chauffeured existence, drained of passion? We love our cars, and a forced transition to automation may be a rocky road indeed – particularly in the world of taxis.

A story could follow a band of black-cab drivers left destitute by the Uber hordes. Raging against the dying of their profession's light, they wage a guerilla war on the automaton fleet; a hit-and-run campaign, where their unique knowledge of London's streets allows them to evade capture. Peace talks get nowhere, until Uber officials consent to sit not across the table from their cabbie foes, but on seats behind them, communicating through a glass partition – that famously helpless position that gives cabbies the upper hand in any negotiation.

London's black-cab drivers of the future could respond in a militant fashion to the massed ranks of Uber taxis

> "Perhaps parents, freed of the unique stress of the family drive, may enjoy a much increased lifespan"
>
> Jon Wallace

The conflict may spread. If we abdicate control of our cars' performance, will we happily relinquish the status of speed? A story could take place in a world of totally regimented, creepingly slow traffic. Wealthy boy racers, denied the satisfaction of aggressive fast-lane antics, move from speed to height. Taking inspiration from recent Chinese bus designs, they commission towering bling mobiles carried on wheeled stilts – gold-leaf gondolas that sail above the obliging mass of homogenised epod vehicles. But their elation only lasts for so long: motorway pirates emerge at street level, bands of former white van men and truckers, who abandon their pods, scale the stilts, and plunder the new tall ships for their treasure.

It may not all be doom and gloom. Perhaps parents, freed of the unique stress of the family drive, may enjoy a much increased lifespan? Perhaps the traffic jam, rather than a source of frustration, may become a centre for entirely new forms of human interaction. Start-up company 'Drive.ai' is already testing automated cars with digital signage mounted on their roofs, using emojis to convey their intentions to other drivers. How might the use of such light shows evolve? Might the cars of the future, made of new meta materials, change shape and colour at our command, display becoming as much a part of human communication as the Peacock's or the Frigate Bird's?

We could follow the tale of two lovers, stuck in a crawling, endless traffic jam, drawn by each others' intricate automotive displays. Deciding that they cannot leave each other, they programme their vehicles to reshape into a single new form, allowing not only their coupling, but that of the vehicles too – binding systems and engines into new 'married' forms.

When it comes to cars, anything is possible. JG Ballard said "the ultimate concept car will move so fast, even at rest, as to be invisible", but it's a fair bet we won't see cars disappear just yet. Cars are too bound up with defining how we see the world, how the world sees us – and where we all are headed. ◉

Jon Wallace is a science fiction author living and working in England. His new novel, *Rig*, came out in paperbook and ebook in June

Getting the measure of the astronomers

Advanced metrology systems are helping astrophysicists and machine builders get to grips with their day-to-day tasks. Stuart Nathan reports

Astronomers could deal with the largest measurement units available to mankind, but to be sure their observations are accurate, their equipment needs to be measured down to the finest tolerances. A new astronomical facility in Teruel, Spain, turned to 3D measurement specialist Faro to ensure that its equipment was calibrated correctly.

The Javalambre Astrophysical Observatory is part of the Astrophysics and Cosmology Research Centre of Aragón (CEFCA), and houses two telescopes with wide fields of view to carry out sky-mapping projects, aimed at determining the speed of the universe's expansion. This requires accurate large-volume dimensional control, particularly for aligning the telescopes' optical elements; a task that will first be carried out after the mirrors are aluminised to provide their perfect reflective surfaces and then must be repeated periodically to verify the telescopes' stability. Due to the optical requirements of the telescopic scientific projects, mechanical positioning tolerances of less than 50µm and angular deviances of less than 10 arc seconds are required. The observatory decided to use the Faro Vantage system, which is specifically designed to measure large volumes accurately.

The mass and volume of the equipment at the observatory are both large: one of the telescopes has a primary mirror of 2.55m in diameter and a secondary one of 1,183m, separated by 2.2m, and the other a primary mirror of 0.83m diameter. The entire set of structures and systems has a total volume of around 12.5m and weighs approximately 45 tonnes; moreover it can support instruments weighing up to 1,000kg in themselves. Combined with the fine tolerances needed, this meant that a dimensional control tool that could handle a large workload was required, so that projects could be run effectively and efficiently.

> "The metrology system is a powerful piece of equipment that allows us to meet the requirements of astrophysical research"
>
> Guillermo López Alegre

"The versatility of the Faro Vantage, its large volume of work and high positioning accuracy allow us to meet the technical specifications," said Axel Yanes, head of engineering at CEFCA.

The Vantage system is claimed to be the most comprehensive laser tracker solution available on the market. Prior to its introduction, according to its manufacturer there was no single system that provided portability, extreme accuracy and durability in all conditions; users had to make concessions when specifying equipment. Vantage, however, meets all these requirements, Faro claimed, and offers a maximum operating range of 160m and a volumetric accuracy of 0.049mm at 10m. Moreover, it has an IP52 rating, meaning that it is resistant to dust and water, and also has integrated WLAN, so it can connect to a laptop via cable.

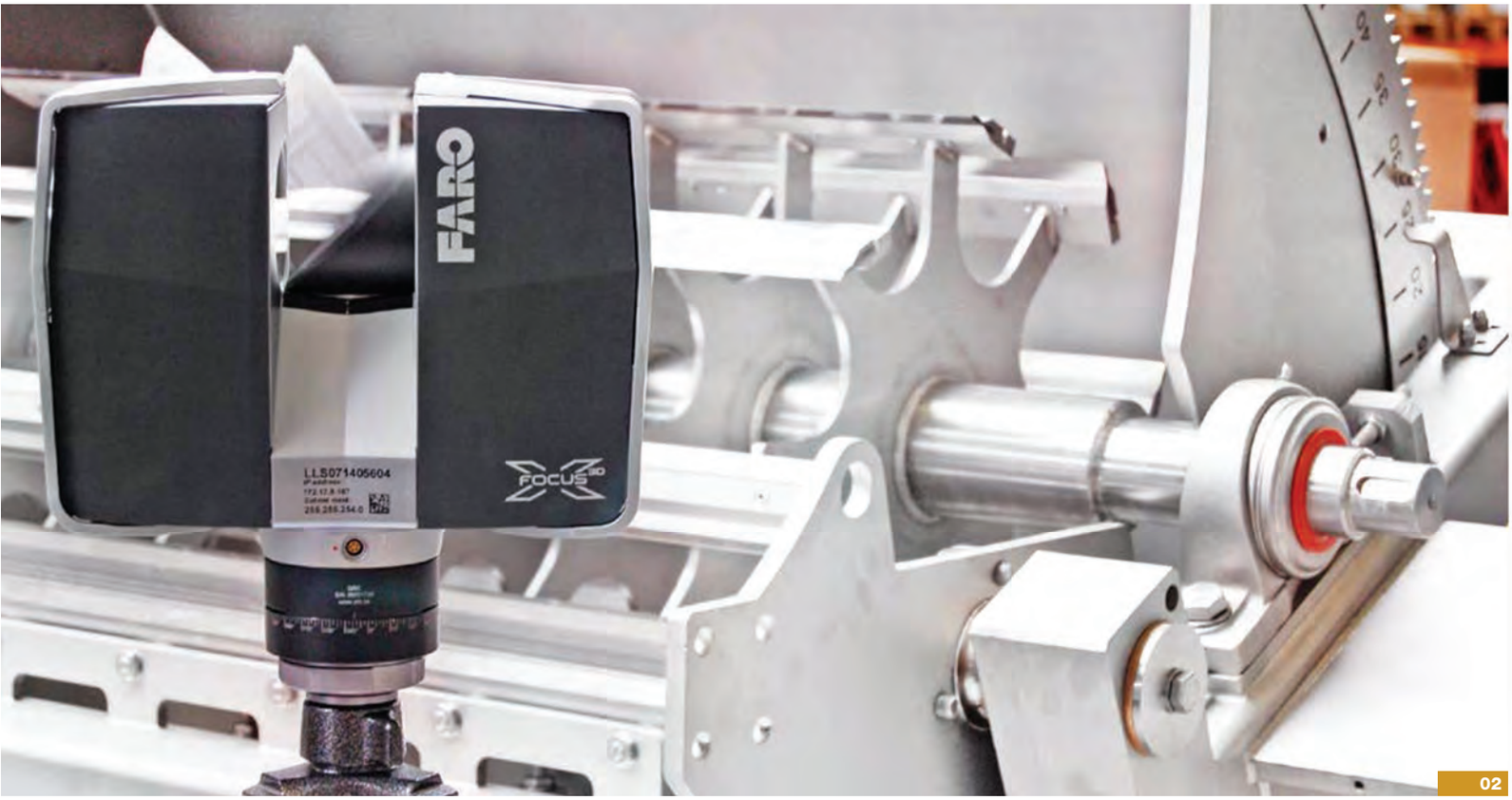
01 The telescopes in the Javalambre Observatory weigh 45 tonnes

02 Faro Focus in action at Westerhof

"As well as fulfilling the objectives for which it was initially intended, Faro's metrology system allows us to resolve new technological challenges stemming from research work carried out at CEFCA," said chief mechanical engineer Guillermo López Alegre. "It's a powerful piece of equipment that allows us to simply and easily meet the strict requirements dictated by a field such as astrophysical research."

It has also helped to save the research centre money. According to Alegre, the system "has already allowed the engineering staff at CEFCA to be independent and self-sufficient in their tasks specified for the present and future,

01



02

as they don't have to resort to specialist companies – with the resultant cost saving."

The observatory staff's success with this equipment is leading it to outline future objectives with regards to Faro's technology. These objectives include metrology to integrate new instruments into the telescopes and verify dimensions of the assemblies; preventative maintenance for the observatory's equipment and installations; and reverse engineering to improve the observatory's components.

Accurate measurement is becoming increasingly important in machine factories; one reason for this is that the constant requirement for new machinery in specialised sectors requires new equipment to be integrated into existing production lines. Dutch engineering company Westerhof has recently started using two tools from Faro to streamline its workflows and improve accuracy.

Precise 3D measurement is crucial for Westerhof, because 3D models of machines are necessary for precise integration. In the past, all of the company's measurements were done manually, which could cause problems if inaccuracies occurred. "If that happens, we have to re-engineer the entire machine, causing a large financial cost to us and the client," said commercial technical advisor Thijs Lenferink. "Because of this, we looked for a solution that gave us perfect accuracy, to avoid these mistakes.

"We did some market research, and eventually chose the Faro Focus X130 and the Faro Gage for the creation of 3D models and gauge of existing machinery, due to the accuracy, high quality and user friendliness," said Lenferink. The focus is a compact laser scanner. "Everybody can use it, with even minimal training," he added. "It weighs barely 5kg and measures just 24 × 20 × 10cm. Our engineers can carry it around wherever and whenever it is needed. In comparison to other products, the Focus X series was the most accurate with its measurements. This is necessary in our line of work, as the more accurate you are, the more accurate the machine will be eventually."

Westerhof uses the laser scanner to create a full 3D model of the location where its clients are planning to place a new machine. A full scan takes around two hours, whereas previously it would take a whole day to measure manually. Measurement accuracy is up to 2mm. "This offers us a new standard of accuracy in our models," said Lenferink. Moreover, the measurement software that comes with the system allows Westerhof compatibility with existing CAD programs, which saves time when creating 3D models. "Now we can simply transfer the Faro Scene software files to the computer and immediately start working on a 3D model of the machines in this environment," Lenferink said. "The concepts are then developed into detailed designs with CAD software. During this phase, we select the required materials, production methods and assembly together with the client as we can send him the file for feedback."

The company also uses the Faro Gage to check whether the created machinery accurately corresponds to the measurements of the 3D model. Previously this was also done manually, but the new system allows the company to eliminate all possible errors early in the process, while also providing a detailed measurement report of the machinery for the client.

Failure analysis deals with crankshaft problem

Problem is traced to minute cracks in crankshaft journals. Supplier: Axiom Engineering Associates

Insight provided by failure-analysis expert Axiom Engineering Associates helped solve a crankshaft engine problem for a car manufacturer. Axiom was called in by Shoreham-based Ricardo Engineering, an automotive consultancy, which was working on behalf of a major car company that had appointed Ricardo to discover why crankshafts were failing in one of its engine ranges.

The problem was traced to minute cracks in the crankshaft journals and Axiom was tasked with determining the cause.

Metallurgist Dr Rene Hoyle, who founded Axiom with fellow engineer Adam Potter in 2003, explained: "The design and production of automotive components is driven by the need for low cost, low weight and better efficiency.

"Designs that use higher-strength materials, smaller diameters/sizes and lighter weight deliver lower frictional losses, greater efficiency, smoother running and lower operational costs. However, such developments don't come without their own issues. Higher-strength materials tend to be more notch-sensitive and susceptible to fatigue cracking issues. In the case of crankshafts, the change of section at the edges of journals are a prime site for fatigue to initiate."

Axiom worked closely with automotive engineers to investigate the failures and understand why the cracks were appearing.

The company sectioned the broken crankshafts so it could examine the actual machined radius profiles of the journals, which can be a factor in the initiation of fatigue issues.

As a result of Axiom's analysis, the problem was pinpointed and changes made to the manufacturing process – ensuring many miles of stress-free driving enjoyment for the company's customers.

Although full details of Ricardo's client are a closely guarded secret, Dr Hoyle said this was not the first time Axiom has worked in the automotive sector. "Axiom has worked with a number of multinational automotive design and manufacturing organisations to improve and optimise their designs," he revealed. "Our expertise has helped them understand how and why failures occur. No one wants to suffer a catastrophic engine failure, such as a snapped crankshaft, in the outside lane of the M1."

Measuring up to the task of quality for key fob trims

Validating suspect parts after visual checking. Supplier: Bowers

Carbon composite designer Reverie recently enlisted measurement specialist Bowers group to help ensure the quality of a prestige product it was manufacturing for a luxury car manufacturer. Reverie has been commissioned to make key fob trims for the car company, and needed to ensure the precise consistency to tolerances of plus or minus 0.1mm.

Normally, it would use a Faro Fusion arm for such applications but, in this case, touching the part with the arm caused composite to flex, leading to inaccurate measurement.

Instead, Bowers used a Baty R14 FT2-E Profile Projector for the measurement. "The Baty R14 unit is perfect for checking any suspect parts that are identified during visual checking, or for checking and validating any client returns for fit errors. It works excellently for these particular applications," said design and manufacturing engineer Peter Farndell.

The key fobs were a particular quality challenge because they are cut and trimmed by hand. There is therefore naturally the possibility of some variation. The Baty unit helps ensure quality and minimise rejection, thereby reducing cost. Bowers also uses it to check diameter wear on its CNC cutters to improve the accuracy, as tools can tend to dent and chip.

World water speed record is a matter of positional data

Metrology is being used to capture data from surfaces of prototype boats. Supplier: Manchester Metrology

With a well-deserved and fearsome reputation as the most dangerous of all the speed records, the world water speed record has stood since 1978, making it also the most enduring speed record.

It currently stands at 317.6mph and is held by Australian Ken Warby who built the boat *Spirit of Australia* in his backyard. A surprisingly low-tech affair, *Spirit of Australia* is made of wood and is powered by a jet engine.

But no record stands forever, and Warby's mark is set to be challenged in the near future by a British boat called *Quicksilver*.

The team working on *Quicksilver* has turned to Manchester Metrology to assist in the building of its boat. Manchester Metrology has provided a Faro Edge Arm ScanArm HD to the team, which the team is using in order to capture accurate positional data from the surface of its prototype boats.

The system combines the advantages in flexibility and functionality of a scanning arm with a high-definition Laser Line Probe HD creating a powerful contact/non-contact portable measurement system, which can be used for applications such as in-process inspection.

Video measuring determines length of irregular shape

Spring manufacturer uses highly accurate, automated procedure. Supplier: Nikon Metrology

Redditch-based seal energising spring manufacturer Clifford Springs is using a new, highly accurate, automated procedure on a Nikon Metrology iNexiv VMA-4540 CNC video measuring machine to determine the length of an irregularly shaped loop of welded coil. The result is equivalent to the circumference of the spring when it eventually strengthens a circular seal.

The iNexiv is more accurate than the former hard gauges. Up to 1,000 successive coordinates around the loop are recorded automatically and subsequently linked to create a series of small, straight lines that are added together to find the length. To correct for the fact that it is the arcs between the points that should really be totalled, Nikon Metrology's engineers calculated a small correction factor running to eight decimal places that increases the measured length to arrive at the true circumference.

The new process has the added advantage that the number of coils per unit length of spring can be counted automatically, which predicts its load deflection characteristics. Compared with the present method of manually counting the number of coils in a given length and using a formula to extrapolate the total number for the whole spring, the optical method will be more precise. Furthermore, measuring the angle between successive coils in a spring and their distance apart will be more accurate and reliable, as well as much faster than current manual procedures on a shadowgraph from a profile projector.

Managing director John Clifford said: "Customers are increasingly asking for reports with numerical values from inspection of the springs we manufacture. The Nikon Metrology machine has allowed us to print off actual readouts of spring diameter and soon coil count and geometry will be included. It has enhanced the perception of our metrology expertise among our customers and increased the confidence they have in the reports we produce."

EQUATOR™
the versatile gauge™

RENISHAW
apply innovation™

Shop floor process control with the flexible Equator gauging system

See us at:
Northern Manufacturing
Stand D14

Join hundreds of automotive part suppliers who use the low cost Equator as a manually loaded system or in fully automated cells

Equator provides fast data capture, highly repeatable results and easy operation, at a low purchase price and with low cost of ownership.

- Operators or robots can switch between different parts in seconds
- Automated cells can be easily configured with EZ-IO software
- Unique ability for repeatable gauging in widely varying thermal conditions combined with flexibility

Process Monitor is built into both manual and automated systems. It allows users to view the gauging history of a part, an invaluable function for controlling a manufacturing process, along with an instant graphical view of the status of each feature tolerance.

Process Monitor also enables management of the mastering process according to temperature, time or number of parts gauged.

For more information visit www.renishaw.com/equator

Renishaw plc New Mills, Wotton-under-Edge, Gloucestershire GL12 8JR United Kingdom
T +44 (0)1453 524524 F +44 (0)1453 524901 E uk@renishaw.com
www.renishaw.com

A world away from wiring

A new data-transfer technology could eliminate the need for additional wires and fibre-optic cables in aircraft. Helen Knight reports

Aircraft manufacturers are constantly searching for ways to reduce the weight of their airframes, in a bid to improve energy efficiency and reduce emissions.

But as the use of lighter materials such as carbon-fibre composites increases, manufacturers are being forced to look elsewhere.

One target for manufacturers is to reduce the amount of wiring within aircraft, particularly with the increasing use of electric motors and actuators in aircraft and drones.

Now a new data-transfer technology has been developed that can be built into the structure of an aircraft, eliminating the need for additional wiring or fibre-optic cables.

The technology, known as SurFlow, is being developed by engineers at TWI, based in Great Abingdon, Cambridge. It can be incorporated into different types of composite materials, including carbon fibre and glass fibre, allowing them to transmit electromagnetic waves without the need for wires or fibre optics.

Companies have been investigating ways to reduce the wiring in modern aircraft, according to TWI defence programme manager Paul Burling, SurFlow's inventor. These efforts have typically focused on embedding wires within the composite, or the use of exotic materials such as carbon nanotubes. Embedding wires into a composite during manufacturing can result in voids within the material that could cause it to fail, while new materials can take around seven years to be approved for use in aircraft.

So Burling began searching for a technology that would allow electromagnetic waves to travel around the airframe itself. "I came up with the idea of using a coating that we produce here to protect composite aircraft from lightning strike, to place that on the surface," said Burling.

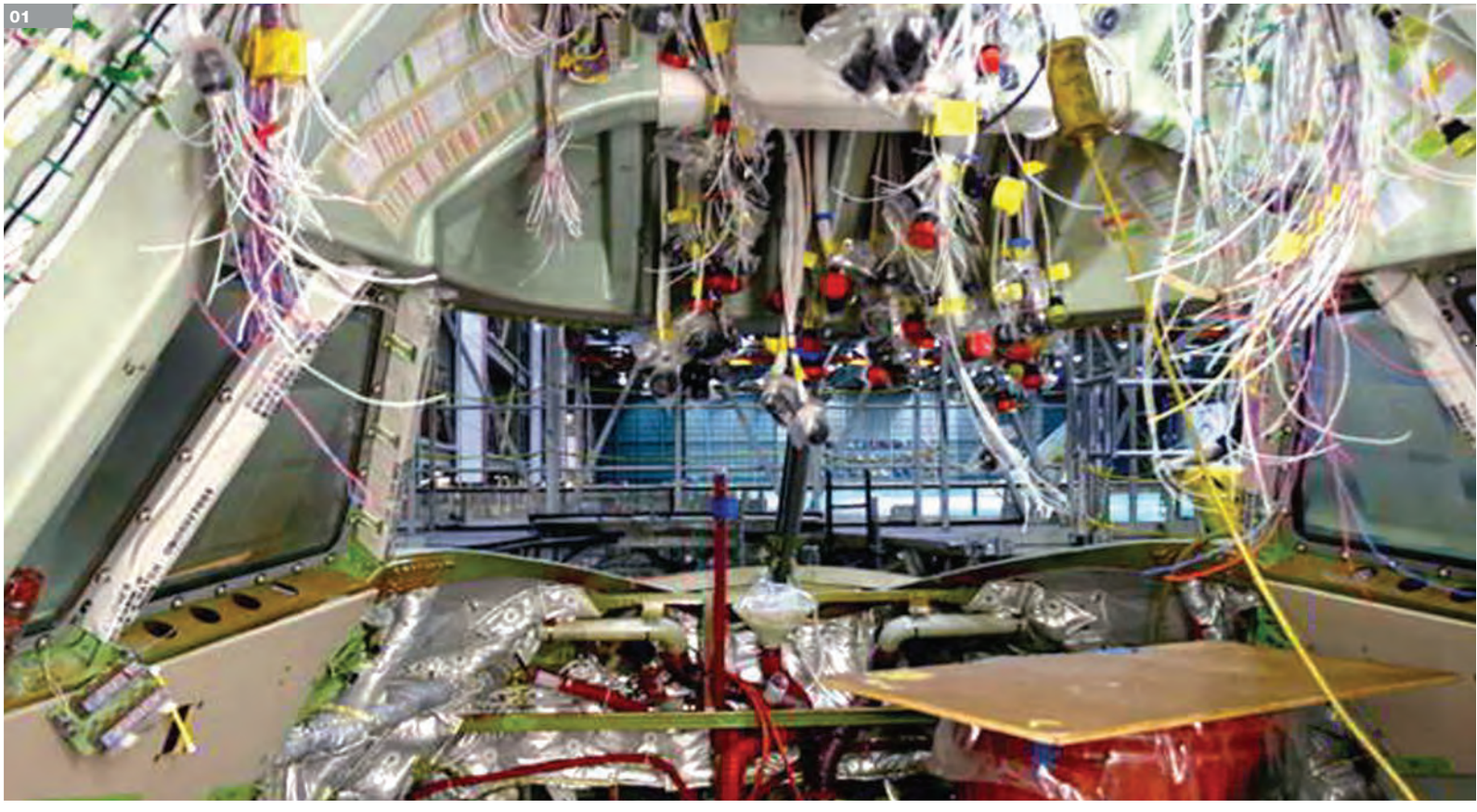
The material consists of a composite containing a layer of resin that acts as a dielectric, which is then topped with a metallic coating to act as the conductive layer.

By combining both dielectric and conductive materials, the SurFlow technology allows electromagnetic waves to be transmitted through the composite structure.

The technology uses surface waves, a type of electromagnetic wave that propagates along the interface between two media with different properties.

These surface waves travel along the inside of the laminate, on the surface of the non-metallic layer, said Burling. "If you cut through the material, you would have a metallic surface on the outside, then you have a resin-rich layer, then you have your carbon-fibre reinforcing, and then on the inside you have another layer of resin."

Transducers placed at any point along the composite can transmit and receive these waves. >>


01

Integrating additive manufacturing with standard CNC machining

Hybrid Manufacturing Technologies has developed a unique CNC-based hybrid tool control solution that enables virtually any CNC machine or robotic platform to deploy both metal-cutting and metal-adding heads in the spindle and conveniently change between them.

Hybrids system uses Beckhoff controls to integrate additive manufacturing with standard CNC machining

Founded as a commercial entity in 2012 by Dr. Jason Jones and Peter Coates, Hybrid Manufacturing Technologies actually began life in 2007 when the active use of a high-speed milling machine was initiated at De Montfort University's Additive Manufacturing (AM) and 3D printing research laboratory. The cross-pollination of additive and subtractive technologies led to a four year, UK-based research project named RECLAIM (REmanufacture of high-value products using a Combined LAser cladding, Inspection and Machining system) with support from the Technology Strategy Board and a number of industrial collaborators.

ADDITIVE MANUFACTURING

Key to the technology is its ability to provide both metal adding and metal removal tools on the same spindle; operations normally undertaken by discrete machines and requiring lengthy additional changeovers and programming steps. This also means that the majority of metal parts made by additive manufacturing can have post-processing operations, such as polishing, milling and surface blasting, performed without having to locate to another manufacturing cell, resulting in fabrication and surface finishing being achieved in a single setup. The hybrid approach also allows different compositions of materials to be used in the same component, while in-process inspection can assure quality levels otherwise impractical or impossible to evaluate.

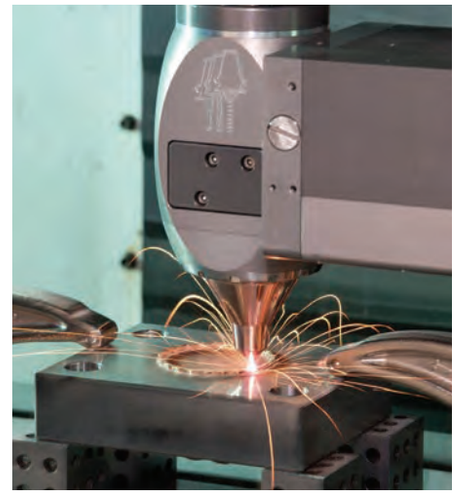
The company initially had issues – relating to both the Ethernet communications and the HMI – with its original control solution, which lead to the first contact with Beckhoff Automation in 2014. The result of this collaboration was a control solution that not only addressed the communication and HMI issues, but also facilitated easier connection at customer sites and offered greater capability to expand the solution as the technology and the customers' needs evolve.

The technology is compatible with most CNC machine configurations and robotic platforms and can be supplied in collaboration with an OEM as an option on a new machine or added as a retrofit to new or used machines already in the field. A machine tool builder adopting Hybrid's system can use it to add additive manufacturing to the capabilities of a standard machine. Hamuel, for example, first introduced an additive-capable model to a line of their machine tools in 2013 and several other machine tool builders have followed suit.

The current Hybrid system supports a range of AMBIT™ processing heads with different geometries, laser profiles, powder delivery configurations and de-focused energy beams to support tasks including 3D deposition, cladding, marking, cutting, drilling, pre-heating, annealing/stress relieving, surface re-melting and cleaning among others. The default setup accommodates up to 15 processing heads, but it can be expanded indefinitely, subject to space in the tool changer and controller capacity.

Beckhoff's motion control solution comprised a number of elements from its industry-leading portfolio. These included the EK1100 EtherCAT Coupler and other EtherCAT terminals and a Beckhoff CP2218 panel PC running Microsoft Windows 7 and TwinCAT 3 software for programming and control. Hybrid Manufacturing Technologies were particularly impressed by the Beckhoff HMI solution and the ability to deploy EtherCAT in the machine head.

Peter Coates, Co-founder of Hybrid Manufacturing Technologies elaborates on the technology and its capabilities: "We can make bespoke heads for customers, depending on their precise application needs, and these heads can be attached to virtually any machine tool. Looking beyond the machine, Beckhoff's use of EtherCAT means that connection to other cells is straightforward, and being based on a Window platform makes interfacing with Enterprise Systems far simpler from a protocol perspective and can leverage existing communication backbones. We will be looking to deploy Beckhoff systems in our standard product offerings as we expand worldwide, in step with the granting of foundational patents and intellectual property rights around the globe."



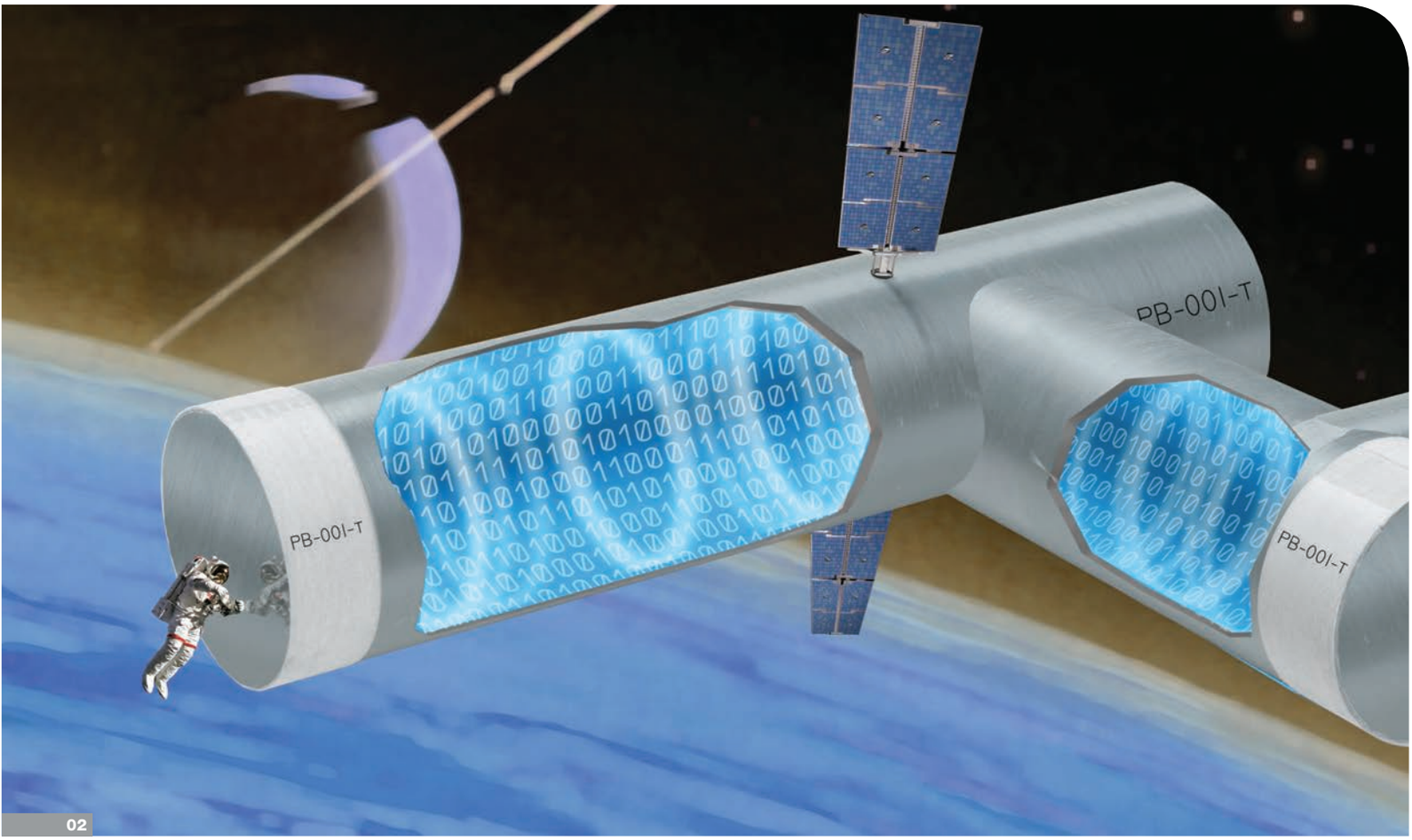
The unique head is controlled using Beckhoff's motion control solution

EASY TO USE

Commenting on the move to a new control solution, Peter Coates, explains: "It was a bit of a culture shock, as we were used to working with software and hardware from another supplier, but we were able to do all the programming using the TwinCAT 3 software with minimal training. We found it incredibly easy to use and will exploit further training opportunities to improve our knowledge of the system's capabilities. The beauty of the structured text programming is that we don't have to change the platform, this also allows us to expand it seamlessly by simply adding new PLC code and all of the controls run the same code, which is unbelievably useful. The connectivity will also allow us to license the software in a way that allows users to deploy it on a pay-per-use basis."

By offering an open architecture running on off-the-shelf software solutions, Beckhoff products can be used as separate components or integrated into a complete and seamless control system. This open approach also facilitates integration into customer sites, especially in relation to the deployment of Ethernet-based control and ERP solutions.

www.beckhoff.co.uk



02

02 SurFlow represents a new way to transmit data

"You could use it as a very smart parking sensor, across the whole surface of the bumper, rather than just particular areas"

Paul Burling, SurFlow

>> The metallic coating can be applied directly to the composite, using a range of different techniques, including spraying or rolling, according to TWI project leader Jasmin Stein.

However, the team typically uses a process known as High Velocity Oxy-Fuel (HVOF), in which a gun is used to deposit a metal in a very fine form onto a surface.

"This conforms to very complex geometric shapes in a very uniform way, and adheres very well," said Burling.

Since the SurFlow technology is a coating process, it can be used alongside existing composite manufacturing equipment that has already been accepted for use in aircraft component production, eliminating the need for a lengthy approval process.

The technology is capable of transmitting data at up to 6Gbps, and unlike systems based on wires will continue to operate even if the composite component is damaged.

"As long as you don't have catastrophic failure within the structure, the system will find its path around, and get the data from A to B," said Burling.

And since the team knows the time of flight of the electromagnetic signal through the material, they may ultimately be able to use the technology to carry out non-destructive testing, he added.

"If there is something in the way, you can see the reflection coming back off the obstacle, so you should be able to work out where those holes are in relation to the structure."

Even tiny changes in the waveform would allow damage to the composite to be detected.

What's more, unlike wireless communication systems the signal cannot be intercepted remotely, creating a secure, high-capacity data-transfer network.

Alongside aircraft, the technology could also be used in the automotive industry. Carbon-fibre composites are already widely used in luxury cars, and their use is now extending beyond this to lower cost vehicles.

Incorporating the SurFlow technology into the carbon-fibre structure could significantly reduce the complexity of a vehicle's internal communications network.

It could also be used as a proximity sensor, said Burling. "If we take a car bumper at the moment, parking sensors have to be placed and wired into the bumper, which can be quite fiddly, and adds more complexity within the wiring harness," he added.

If the material is tailored with the right dielectric, fibre and coating, it can be made to be very thin and flexible, said Burling. When this material is then bent, any obstacle that comes close to it will start to affect the surface waveform.

"So you could use it as a very smart parking sensor, across the whole surface of the bumper, rather than just in particular areas."

The technology could also be used in robotics, to enable communication throughout a system without the need for wires. It could also be used in consumer electronics, where it could allow devices to connect to a network by making contact with the composites surface, without the use of plugs, or having to detect a wireless network.

The technology can also be retrofitted to existing structures, by applying the conductive coating to composite components. Since the surface waves are confined to the surface, they will follow the contours of the material, meaning the transducers do not need to be in a line-of-sight arrangement, increasing the flexibility of the system.

TWI is planning further tests of the technology, including exploring its use in advanced aerospace applications and real-time composite monitoring.

The company is now working with customers across different industries to develop particular commercial applications for the technology, according to their individual needs. The technology can be adapted and used in any application and industry where composites are used and require data transmission, said Stein.

Facing up to the prosthetic mix

Automating the process of mixing silicone. Supplier: Intertronics

The silicone used in prosthetics for the face and body requires delicate mixing, with even highly skilled professionals often needing time to correctly match colours and ensure consistency of the material. However, using Intertronics' Thinky ARE-250, University Hospital Coventry has been able to automate this process.

Originally, mixing at the hospital was carried out by hand using a palette knife in two stages – mixing and then flattening on a glass plate to squeeze out the air. It was arduous work, especially for the larger quantities needed for hands, breasts, and facial components. It also usually required use of fillers for changing consistency, and small quantities of intense colour pigment being mixed with clear silicones to suit the individual patient.

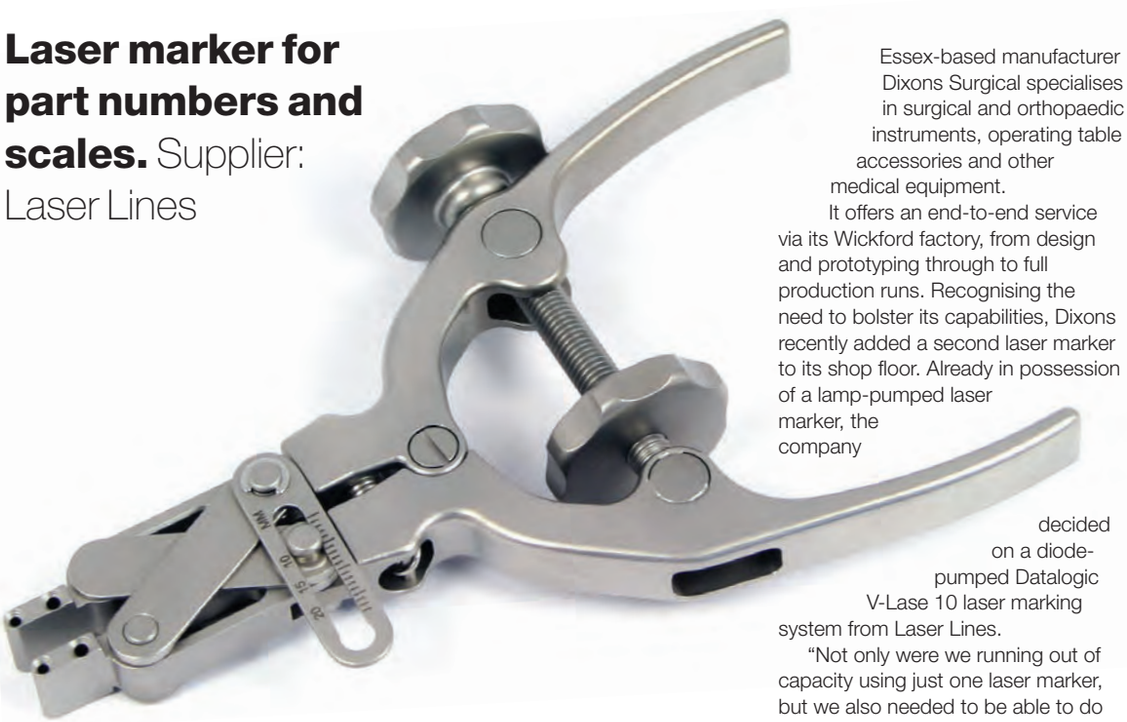
In an effort to streamline the process, the hospital got in touch with Intertronics to trial the Thinky ARE-250 non-contact planetary mixer. Using both rotation and revolution, it mixes and degasses the silicone at the same time. The constituents are simply measured into a container that goes straight into the machine, saving time while reducing material waste.

"I have been doing this work for about 12 years and for the past 12 months have used the Thinky a great deal," said Jim Dimond, consultant clinical maxillofacial prosthetist at University Hospital Coventry.

"It has allowed us to quickly produce homogenous silicone in large quantities that is free of air, transforming a time consuming, physical task into an automated effortless one."

Working on a set of smaller, intricate marks for surgical

Laser marker for part numbers and scales. Supplier: Laser Lines



Essex-based manufacturer Dixons Surgical specialises in surgical and orthopaedic instruments, operating table accessories and other medical equipment.

It offers an end-to-end service via its Wickford factory, from design and prototyping through to full production runs. Recognising the need to bolster its capabilities, Dixons recently added a second laser marker to its shop floor. Already in possession of a lamp-pumped laser marker, the company decided on a diode-pumped Datalogic V-Lase 10 laser marking system from Laser Lines.

"Not only were we running out of capacity using just one laser marker, but we also needed to be able to do smaller, more intricate marks, particularly when it came to part numbers and scales on orthopaedic instruments, something that a diode-pumped laser is particularly suited to," said managing director Jay Dixon.

"As well as the accuracy of the mark, one of the things that Laser Lines could offer was a bigger enclosure. For the type of work we do, we need the flexibility to mark larger items. Other brands at similar price points offered similar products with smaller enclosures of around 500mm wide, as opposed to the 870mm-wide enclosure with the Datalogic system."

When it came to finding a new welder, the intricate nature of its work meant Dixons was searching for devices more commonly associated with the jewellery market. However, most welders aimed at that segment come with small cabinets, as the space requirements of jewellery are significantly less than those needed to produce medical equipment.

"We chose to invest in a laser welding system from OR Laser: the ECO 3300, which is a 120W 'open' device that gives us the ability to weld parts as large as necessary," said Dixon.

Seismic levels of approval

Fasteners used to strengthen LA building. Supplier: Lindapter

Lindapter's Hollo-Bolt fasteners have received seismic-type approval to be used in the construction of the Wilshire Grand Centre, set to be the tallest tower in the western US.

Due to open in downtown Los Angeles in 2017, the 73-floor tower will include a hotel, offices, retail space and a rooftop sky lobby that will provide guests with sweeping views of the city that extend to Santa Monica. As tragic events in Italy have reminded us, buildings in high-risk seismic areas must be built to exacting standards, and with LA being particularly prone to earthquakes, the specifications for the new tower are rigorous.

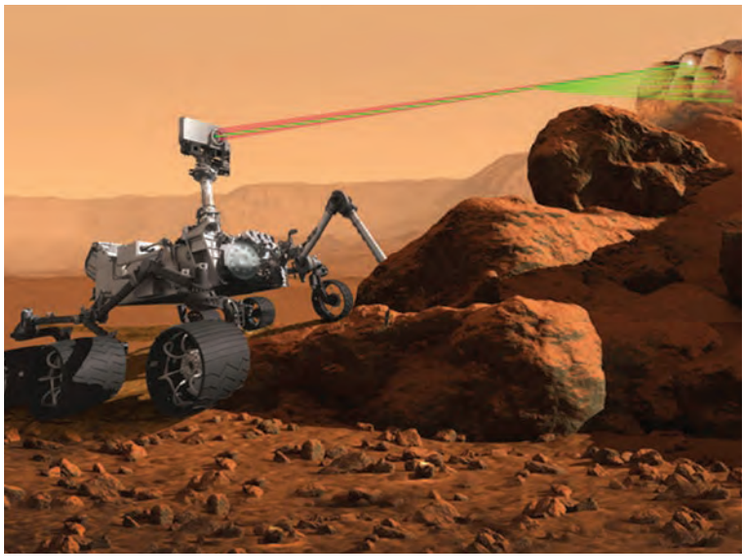
A prominent feature of the AC Martin design will be a swooping glass canopy that creates an atrium with an exposed steel design. Lindapter's seismic-approved Hollo-Bolt was specified for connecting circular sections throughout the curved atrium structure. Following the structural engineer's recommendation, steelwork contractors used over 3,000 M20 Hollo-Bolts to secure the structural hollow sections that form the swooping atrium framework.

The fasteners were installed from just one side, rapidly achieving discreet splice connections without the need for drilling or welding. According to Lindapter, the cost-effective installation did not require specialist equipment or specialist labour, and dramatically reduced the amount of work at height in comparison to traditional welding or through-bolting methods.

The design also eradicated the possibility of tube deformation that can be associated with through-bolting if the bolts are over-tightened.

Picturing the surface of Mars

Rivets and tools for Radar Imager. Supplier: TR Fastenings



TR Fastenings Norway, part of Trifast PLC, has been asked to supply essential rivets and tools for a Radar Imager for the new NASA Mars Exploration Rover, which launches in 2020.

The Norwegian Defence Research Establishment (FFI), which is designing and developing the Radar Imager on behalf of NASA, required components that were robust enough to withstand the extreme conditions of the atmosphere, where temperatures can plummet to -125˚C.

Drawing on its experience of working within the telecommunications and energy sector, TR Fastenings was able to tap into its network of suppliers and deliver the components to FFI within the required timeframe.

The Radar Imager will be used in the Mars subsurface experiment, known as RIMFAX. It will add a new dimension to the Rover's toolset by providing the capability to image the shallow subsurface beneath the Rover in unprecedented detail. It will explore the ancient habitability of its field area and select a set of promising samples.

The radar antenna itself is an aluminium sheet-metal construction assembled from several complex-shaped parts.

The harsh environment during launch, landing and operation on the Mars surface necessitates strict mechanical requirements to the antenna. Furthermore, the integration with the Rover is demanding with respect to the very precise tolerances. The antenna is assembled with CherryMax aerospace-certified blind rivets and the assembly process is aided by dedicated guiding tools, all delivered by TR Fastenings.

NASA's Mars Exploration Rover Mission is a robotic space project that began in 2003 with the sending of two solar-powered rovers, Spirit and Opportunity, to explore the Martian surface and geology.

One of the mission's key goals is to search for a wide range of rocks and soils that hold clues to past water activity on Mars. The new Mars Exploration Rover will build on the work of the other rovers in its scientific goals of searching for evidence of ancient life on Mars.

"It is incredible to think that our fasteners will be used in outer space and is a testament to the high regard our products have with such a prestigious customer as FFI," commented Jan-Erik Storsve of TR Fastenings Norway.

Making electric plans around sea conditions

A whole new way of installing cables for a wind farm.
Supplier: Harting Customised Solutions

Harting Customised Solutions has worked with Siemens to create a new way of installing the cabling and switchgear for the Dudgeon Offshore Wind Farm.

Led by Statoil, Statkraft, and Masdar, the £1.5bn Dudgeon Offshore Wind Farm is located about 24 miles off the North Norfolk coast and rated at 402MW.

Installing the wind farm meant planning around sea conditions, which limits construction to between late spring and early autumn.

Scott Williams, project manager for Siemens, said: "The transition pieces with integrated switchgear are installed offshore as soon as the monopole supports have been installed. This is approximately 12 months before the turbines will be installed. We therefore needed a simple way to connect the transition piece switchgear at the bottom of the tower with the turbine switchgear at the top."

The task for Harting was to create connecting cables and a cabinet to house the switchgear, and package them so they could be protected through the winter.

Siemens also wanted to reduce the time taken to make the connection because on similar projects, a team of two-to-four engineers rig the cables and connect each individually – top and bottom – taking one to two days per turbine. What started as a job of providing cabinets and components grew into a larger work because there are 67 turbines to connect.

Each turbine required Harting to connect the two pieces of switchgear, including control cabling with an input/output of 24 wires, a 24vDC cable, and cabling for the 230vAC supply. A total of 67 control cabinets was required, each with one suite of cables (I/O; 24vdc; and 230vac).

The Harting Han M housing range was selected due to its environmental characteristics. The IP65 rating and aluminium die-cast material ensured it met Siemens' environmental requirements. These were kitted out with protected modules ensuring finger-safe connection.

Getting to grips with project planning

Connectivity for efficient planning, installation and preparation. Supplier: Weidmüller

The new Klippon Connect series from Weidmüller delivers innovative connectivity for efficient planning, installation and operation.

Whether engaged with project planning, construction in line with planning specifications, documentation, cost calculations or the ordering process, Klippon Connect can help make the planning process as efficient as possible, such as with the Weidmüller Configurator step-by-step software support for selecting and assembling terminal block strips and accessories.

The installation stage includes preparatory work, component assembly, wiring and testing. Using Push In connection technology, a high wiring density with maximum ease of use is achieved with distinctly faster installation. The leaf spring connection system incorporated in the WDU 70/95 and WDU 120/150 feed-through terminals allows users to insert conductors with large cross-sections into the opened contact point from above with very little effort.

The operation stage not only involves panel transport, but also panel installation, commissioning, maintenance and subsequent disposal. Weidmüller offers a complete marking system comprising software, markers and printers that ensure the processes carried out are quick and consistent.

While panels are configured individually, various recurring application fields within the panel are a permanent fixture in virtually all areas of use. Weidmüller has developed special solutions for these application fields, including power feed-in, power distribution, control voltage distribution, current and voltage transformer distribution, signal distribution and DCS marshalling, as well as shielding and earthing.

Similarly, Klippon Connect always offers the right connection system because it gives complete freedom of choice. Both screw connection technology and spring connection technology can be used.

Best delivery service I have experienced.

Anthony Marwick,
Natsales Advertising PTY Ltd.

The website is extremely easy to use... all in all, 100% happy.

Ian Dargusch,
Installation and Service Engineer.

The first place that I go to when looking for parts & tools.

Alison Waygood,
Medical Disinfectors Ltd.

I find RS customer services & technical help to be excellent, I can't fault them!

Mrs. Maddie Rabhi,
Heath Scientific Co.

Satisfaction speaks volumes

Right products. Right service. Right time.

At RS, customer satisfaction is our No.1 priority. So we work hard to make it easy to get what you need, when you need it – saving you valuable time to get on with the job at hand.

Experience the RS difference for yourself at uk.rs-online.com

Precision displacement measurement – key facts

Selecting a non-contact displacement measurement sensor. Supplier: Micro-Epsilon

The terminology applied to sensors can be confusing but is critical when selecting the right measuring instruments for an application – especially for displacement and distance sensors.

If engineers get this part wrong, they could end up paying more than they need to for over-specified sensors. Conversely, a control system or product may lack critical performance if the displacement sensor does not meet with the required specification.

Resolution

The issue of resolution is often one of the most frequently misunderstood and poorly defined descriptions of performance.

The resolution of a sensor is defined as the smallest possible change it can detect in the quantity that it is measuring. Resolution is not accuracy. An inaccurate sensor could have high resolution, and a low-resolution sensor may be accurate in some applications.

In practice, the resolution is determined by the signal-to-noise ratio, taking into account the acquired frequency range. Often in a digital display, the least significant digit will fluctuate, indicating that changes of that magnitude are only just resolved. The resolution is related to the precision with which the measurement is made.

The electrical noise in a sensor's output is the primary factor limiting its smallest possible measurement. For example, a measurement of a 5µm displacement will be lost if the sensor has a 10µm of noise in the output. It is therefore essential that the resolution of the selected sensor is significantly lower than the smallest measurement that is required.

Accuracy

The accuracy of a displacement sensor describes the maximum measuring error taking into account all the factors that affect the real measurement value. These factors include the linearity, resolution, temperature stability, long-term stability and a statistical error (which can be removed by calculation).

Repeatability

Repeatability is a quantitative specification of the deviation of mutually independent measurements, which are determined under the same conditions. It defines how good the electrical output is for the same input if tried again and again under the same conditions. In terms of displacement sensors, repeatability is a measure of the sensor's stability over time.

Typically, sample-to-sample repeatability will be lower for very fast sample rates, since less time is used to average the measurement. As the sample rate is lowered, repeatability will improve, but this does not continue indefinitely. Beyond some slower sample rate, repeatability will start to worsen as long-term drift in the components and temperature changes cause changes in the sensor's output.

Signal-to-noise ratio

The quality of a transmitted useful signal can be stated by its signal-to-noise ratio (SNR). The SNR often limits the accuracy with which some measurements can be performed. Noise arises with any data transmission. The higher the separation between noise and useful signal, the more stable the transmitted data can be reconstructed from the signal. If, during digital sampling, the noise power and the useful signal power become too close, an incorrect value may be detected and the information corrupted.

The SNR is calculated by dividing the mean useful power by the Mean Noise power. SNR is generally understood to be the ratio of the detected powers (not amplitudes) and is often expressed in decibels. Usually, the definition refers to electrical powers in the output of a sensor or detector.

Linearity/non-linearity

The maximum deviation between an ideal straight-line characteristic and the real characteristic is known as the non-linearity or linearity of the sensor. The figure is normally provided as a percentage of the measuring range or percentage of full-scale output.

In many applications, the sensor non-linearity will play a large part in determining the actual measurement accuracy. It is very common for users to use the resolution value of a device when actually the linearity figure is required. Quite often the linearity figure will be 10 or 20 times greater than the resolution. Therefore, if incorrectly specified, the measurement sensor will dramatically under perform.

Long-term stability

Despite the use of high-quality components, the stability of sensors or measurement systems can change over the course of time i.e. with unchanged input quantity and ambient conditions, the possible change of the output signal over a certain time period is acquired.

Temperature stability

You may find that most suppliers of low-cost laser sensors do not state the 'temperature stability' of their sensors. So how do you know the actual measurement error or how to correct your results to account for this? Typically, measurement errors can be as high as 400ppm/K, which can significantly affect the measurement accuracy. On the other hand, a supplier of high-performance laser sensors is much more likely to state the temperature stability of a sensor on the data sheet.

Measuring range

The measuring range describes the space of a sensor in which the object to be measured must be situated so that the specified technical data are satisfied. The extreme regions of this space are termed the start and end of the measuring range. Some sensors exhibit a free space between the front of the sensor and measuring range and the sensor. With contact sensors, the measuring range is the distance between the mechanical minimum and maximum possible distance of the sensor mounting to the object.

Offset distance

The offset distance of a sensor is defined differently from supplier to supplier and from sensor principle to sensor principle. The offset distance corresponds to the distance between the sensor edge and the centre of the measuring range or the start of the measuring range.

Response time

Response time is the period from the time of the event to the signal output. The response time is often deemed to be achieved when 90 per cent of the signal output is achieved. Many sensor specifications do not state response time and it is assumed this is equal to the stated measurement speed or measurement frequency. This is incorrect. Quite often the response time will vary depending on the position of the measurement object.

The Airbus A350XWB has already pushed the boundaries in terms of technological advancements in aircraft design and engineering. Airlines and passengers are reaping the benefits of using advanced materials and advanced manufacturing methods which have led to reduced fuel burn and a quieter and more pleasant environment inside and out.

But after such giant strides, where next for aircraft design?

Airbus is working on answering that, mindful that air passenger numbers double every 15 years or so and with the majority of the world's population are still yet to experience air travel, the demand will continue to increase. So further improving efficiency of aircraft to avoid adverse environmental impact will be a mandatory element in sustaining a thriving aerospace sector.

An aircraft's wings are a key contributor to aerodynamic performance improvements and Airbus in the UK is a global leader in wing design and integration.

Through the **Aerospace Technology Institute** (ATI), Airbus is working with the UK government and others in the aerospace sector on new and innovative designs to transform the way we fly in the years and decades to come.

There are a number of projects underway including the **Wing of the Future**, which will develop advanced modelling techniques and rapid wing integration capabilities aimed at streamlining the early phases of an aircraft's development.

The engineer in charge of the **Wing of the Future** is **Tim Galsworthy** who previously head of wing structures engineering for A350-900 and so is no stranger to cutting edge technology.

"We are an open book when it comes to the wing of the future." he said, "There are many questions we will be answering in the next decade, but there are some things that are certain. We do know that air passenger numbers are increasing and the air travel is here to stay, so our customers will expect the next generation of airliner to be even more efficient and have even less of an environmental impact than the brand new aircraft of today."

Tim's team is diverse in expertise as it is in experience, with representatives from multiple engineering functions, flight physics, wing architecture, structures and systems design and landing gear, plus manufacturing engineering, wing assembly, business development and research and technology.

"Our approach is about improving the integration of the wing design with other sections of the aircraft, including the centre wingbox, pylons and engines. Obviously we can't work in in isolation. But not only do we need to design the wing of the future, we need to ensure we can sustain high assembly rates when it eventually goes into production.

"So it's not an insignificant task. We are developing multiple technologies so there are mature options available to Airbus when the aircraft of the future finally goes into production. We can't say when that will be at this stage, but we want to make significant inroads in the next decade and maturity is vital."

Earlier this year, Airbus launched "**Fly Your Ideas**", a unique global student competition aimed at inspiring today's generation to build tomorrow's sustainable aviation. Every two years, the competition offers a unique opportunity for students from across the globe to co-innovate with Airbus on real challenges facing the aviation industry and to develop valuable skills for their future careers.

New in this latest competition, students are asked to submit solutions to genuine industry challenges that are either innovations for '**Now**' or innovations for the '**Future**'; guaranteeing a cross section of ideas that are both applicable today and deliver blue sky thinking for tomorrow.

More information can be found at:

www.airbus-fyi.com

info:

- In the last **40 years** the aviation industry has **cut fuel burn and CO_2** emissions by more than **70%**, **NOx** emissions by **90%** and **noise** by **75%**. This has been achieved through the aircraft and operational improvements, and innovation.
- In the same time, **flying has become 60% cheaper** (in real terms) than it was in the 1970s.
- **62.7 million** jobs supported by aviation worldwide
- **50.5 million tons** of freight carried each year
- **3.5 billion passengers** in 2015
- By 2026, it is forecast that aviation will contribute **1$ trillion to world GDP**

AIRBUS

Greener horizons

A host of technologies are set to reduce civil aviation's environmental impact. Stephen Harris reports

Aircraft pollution is in some ways a relatively small problem compared to that from cars. The aviation industry is responsible for just 2 per cent of global man-made carbon emissions whereas road transport contributes about 16 per cent. Yet the low-carbon revolution has already begun on the roads with the launch of fully electric cars and hydrogen-powered buses. A battery-powered jumbo jet, however, remains a fantasy and aviation emissions are rising thanks to rapid industry growth.

So what technologies could the civil aerospace sector use to help improve its environmental outlook? Greener propulsion systems are obviously essential for reducing carbon emissions, but there are also big potential changes in the design of aircraft and, crucially, how they are manufactured, that the industry believes hold significant promise.

In particular, it's not just the technologies themselves but how they are integrated on the aircraft that will make a difference, according to Iain Gray, director of aerospace at Cranfield University and former managing director of Airbus UK. "We continue to make aerodynamic gains through things such as new wing architectures, and lots of people forget the inefficiencies that are still associated with aircraft design at low speed with the landing gear down, for example," he said. "But the biggest thing we can do is look at the integration of the power plant and the airframe itself."

This idea that engines could be built into the wings of an aircraft rather than hanging below them in order to create a more aerodynamic shape (and so require less fuel) is on the long-term horizon of major companies such as Airbus and Rolls-Royce. The two firms are collaborating on a concept study known as E-Thrust to design a set of electric fans distributed in clusters along the wing span. Energy would then be generated from an advanced gas power unit that also charges the aircraft's batteries. On descent, the fans could even be used as wind turbines to harvest more energy.

"If it becomes unfeasible to put the engine under the wing you can go for a different wing design or eventually distribute more fans around the vehicle," said Phil Curnock, chief engineer for future programmes in Rolls-Royce's civil large engines business. "Battery technology weight has to come a long way before you can get to fully electric aircraft," he added. "This makes it easier to go down a hybrid or electric route."

Such a concept is still several decades away from being seen on production aircraft. In the meantime, Rolls-Royce is focusing on its Advance engine design, which will introduce a carbon titanium composite fan to reduce weight and change where most of the work is done in the engine to make it more efficient. After this will come the UltraFan, which, with its power gearbox and variable pitch blades, Rolls-Royce hopes will deliver a 25 per cent improvement in emissions compared to the first generation of its Trent XWB engine by 2025.

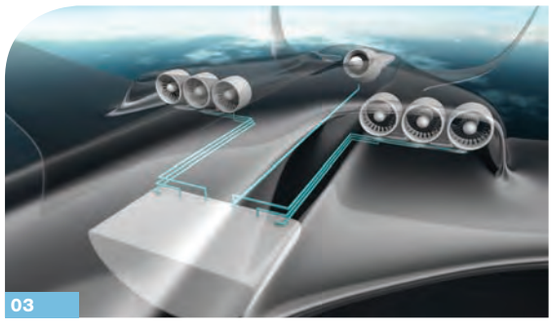
There's another key technology that's set to have a major impact on the environmental footprint of aircraft and that's additive manufacturing or 3D printing. Although still in its early stages as a production tool, the technology can already help reduce the weight an aircraft carries by enabling components to be designed in a way that could never be manufactured with traditional techniques, for example, built from a lattice or honeycomb structure.

"We can make components significantly lighter but with the same performance," said Billy Wu, leader of the additive manufacturing research network at Imperial College London. "By reducing weight you get fuel savings over the life of the plane. So even though the capital costs are higher you save money in the long term." **>>**

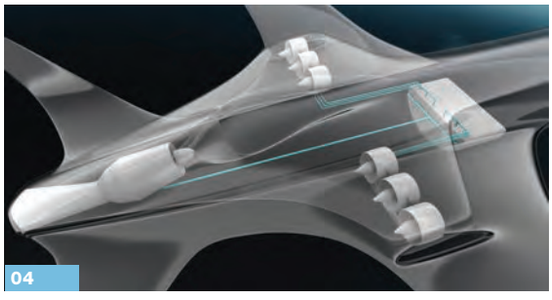
> "By reducing weight you get fuel savings over the life of the plane. So even though the capital costs are higher you save money in the long term"
>
> Billy Wu, Imperial College London

01 NASA's N3-X concept plane uses a blended-wing body to improve aerodynamics

02



03



04

02 Rolls-Royce's Advance concept features carbon titanium blades

03/04 Airbus' E-Thrust concept

"We start with powder and turn some into a product. The rest goes back into the machine"

Nick Jones, Renishaw

>> Every gram of weight reduced contributes to fuel savings, so even being able to reduce the weight of a belt buckle from over 100g to around 70g using 3D printing is important. The Airbus A350 XWB contains more than 1,000 3D-printed parts, many contributing a small but important weight reduction.

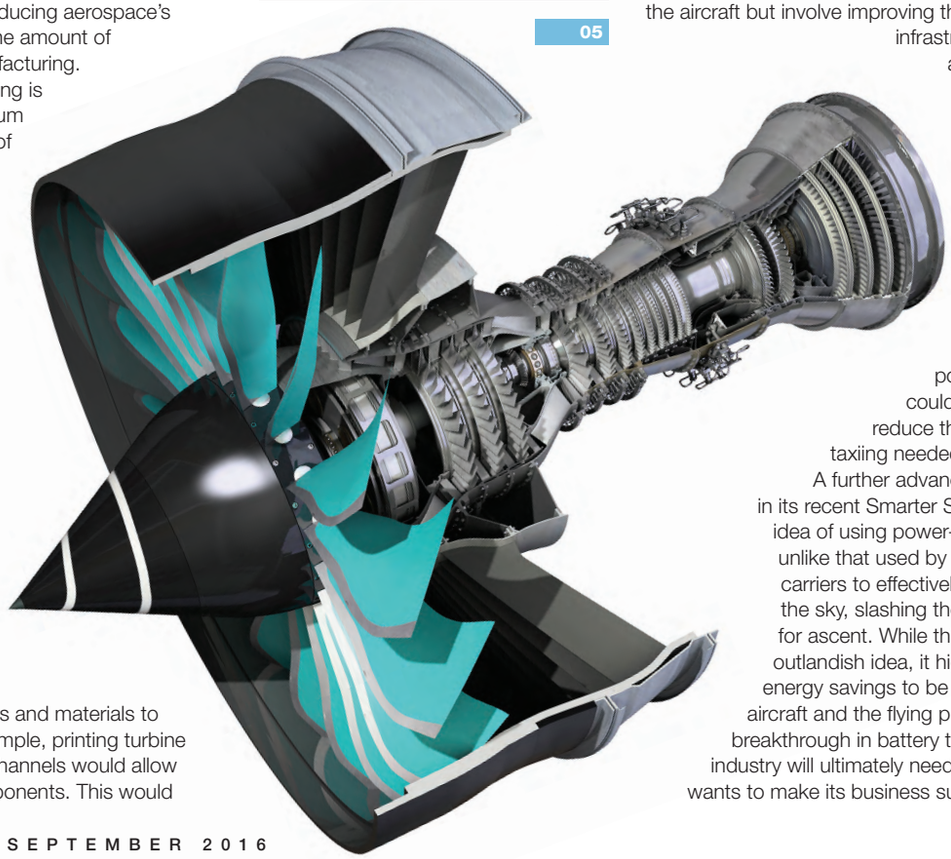
Additive manufacturing is also reducing aerospace's environmental impact by reducing the amount of material that is wasted during manufacturing. "So much of aerospace manufacturing is about buying large lumps of aluminium or titanium and turning 95 per cent of them into swarf," said Nick Jones, technical manager at 3D printer manufacturer Renishaw. "With additive manufacturing, we start with a powder, turn what we need into the product and the rest can go back into the machine." The company recently joined an Airbus-led project known as WINDY to develop expertise in 3D printing wind components.

This kind of research will enable the next step in aerospace additive manufacturing: to start using 3D printing for safety-critical components. This has the opportunity not just to make these parts lighter but could also enable manufacturers to program greater functionality into components and materials to improve the way they work. For example, printing turbine blades that contain tiny ventilation channels would allow more air to be run through the components. This would increase the protective cooling effect you get from passing a film of air across the blades and so raise the temperature at which the engine can safely operate, meaning greater efficiency and more fuel savings.

There's a final set of technologies that could reduce aviation's environmental impact that aren't even located on the aircraft but involve improving the airspace and airport infrastructure. Using greater autonomous guiding and planning technology could enable air-traffic control to schedule aircraft landings and take-offs much more efficiently, reducing the time aircraft spend circling an airport wasting fuel. An aircraft's landing position and location could even be optimised to reduce the amount of runway taxiing needed.

A further advance considered by Airbus in its recent Smarter Skies concept study is the idea of using power-assisted take-off not unlike that used by some aircraft on naval carriers to effectively catapult the aircraft into the sky, slashing the amount of fuel needed for ascent. While this is perhaps a more outlandish idea, it highlights how there are energy savings to be made in every part of the aircraft and the flying process. In lieu of a huge breakthrough in battery technology, the aerospace industry will ultimately need to look at all of them if it wants to make its business sustainable.

05 Rolls-Royce's Ultraform concept offers a 25 per cent reduction in fuel burn



05

AIRBUS

UNESCO
United Nations
Educational, Scientific and
Cultural Organization

A passion for aviation and innovation

fly your ideas

Kickstart your dreams

Airbus challenges students worldwide to innovate for the future of aviation

At Airbus, we're constantly looking for new, better ways to fly and that's what Fly Your Ideas is all about.

Our teams have identified **five key challenges** for aviation in the 21st Century.

Now we invite students of all disciplines to submit ideas that address one of the **5 challenges.**

Challenges

- Business Models
- Flight Operations
- Passenger Experience
- Design Engineering
- Manufacturing

Teams can register and submit their ideas until **25 November 2016.**

The live final will take place in **May 2017,** when the top selected teams will prototype and visualise their ideas before presenting them to a panel of Airbus and industry experts.

The winners of Fly Your Ideas 2017 will share the top prize of **€30,000;** the runners-up **€15,000.**

Find out more at **www.airbus-fyi.com**

3D SYSTEMS

Advanced prototyping and manufacturing solutions

From the originator of 3D printing and shaper of future 3D solutions.

3D Systems On Demand Parts Manufacturing, Quickparts, providing advanced prototyping and manufacturing solutions, using traditional and additive manufacturing technologies, materials and finishing options. Bring your prototypes to life and create real functional end-use parts. With instant online quoting from anywhere in the world and a global team of 3D printing experts committed to customer success, 3D Systems connects designers, engineers and manufacturers, delivering quality, innovation and responsiveness while providing the most advanced and comprehensive 3D digital design and fabrication solutions available today, including 3D printers, print materials and custom parts manufacturing services.

When you're designing, developing, testing and manufacturing products, speed is important. The faster you can reach the consumer, the better. Powered by industry-tested 3D printing technology, 3D Systems' rapid prototyping services produce your parts quickly with the accuracy and unlimited complexity of 3D printing. Whether it's a robust assembly component prototype or a full-colour presentation model, you can choose from a variety of 3D printing technologies and materials to ensure that each part meets your exact specifications.

Sometimes metal parts can't be made using subtractive or casting methods, and you shouldn't have to alter your design to fit a production process. That's where Direct Metal Printing (DMP) comes in. DMP blends industrial metal production with the speed and unlimited part complexity of 3D printing. Especially useful for challenging geometries, DMP produces everything from one-off prototypes to mould tooling to series of end-use parts from a variety of alloys and metals. These are real industrial parts—fully dense, ready to use, and fit for post-production machining—produced with 3D printing's signature speed.

CNC machining doesn't have to drag down your timeline. QuickCutCNC® streamlines the inefficiencies of the traditional CNC machining process while maintaining its high-quality results. So you can move faster through production or prototyping of parts that require a specific metal or plastic material, and still enjoy the high dimensional accuracy and surface finish that makes CNC a go-to production method.

Injection mould tooling involves a complex time and economic commitment. We can help you ensure that your commitment pays off so you can get quality parts to your customers faster. 3D Systems' project managers know tooling inside out, and they use that knowledge to help you identify design issues, by use of Design For Manufacture (DFM), determine tool specifications and ensure timely delivery of parts only.

3D Systems is the UK's foremost provider of 3D printing and rapid prototyping services for industries including automotive, aerospace, medical and defence. We specialise in delivering high quality components for prototype, pre-production and full production requirements, from our bespoke 22,250 square foot facility in High Wycombe, backed up by more than 30 years of experience in rapid prototyping and tooling industries.

We offer complete and tailored end-to-end solutions, from design to manufacturing. To learn more, visit us online at uk.3dsystems.com/quickparts.

Software is in the fine print

Cloud-based software is helping 3D printing realise its true potential.

Evelyn Adams reports

From fashion designers to aerospace engineers, 3D printing is transforming the way products are designed, tested and created. The technology was invented in the 1980s, but largely used to create prototypes from weaker materials. It wasn't until the expiration of a crucial patent seven years ago that 3D printing really started to emerge as a tool that could transform manufacturing. Today, many are hailing it as a key component of a new industrial revolution. But experts claim another change could still transform the industry.

That change is being driven by cloud-based software.

By building up complex shapes, layer by layer, 3D printing is able to create intricate, bespoke designs far easier and at a much lower cost than traditional manufacturing techniques. By its very nature, it offers a collaborative approach to creating product designs. With the help of the cloud, anyone with an internet connection can create, adjust store and stream designs to 3D printers anywhere in the world. Many believe the technology could help open up 3D printing for the wider population.

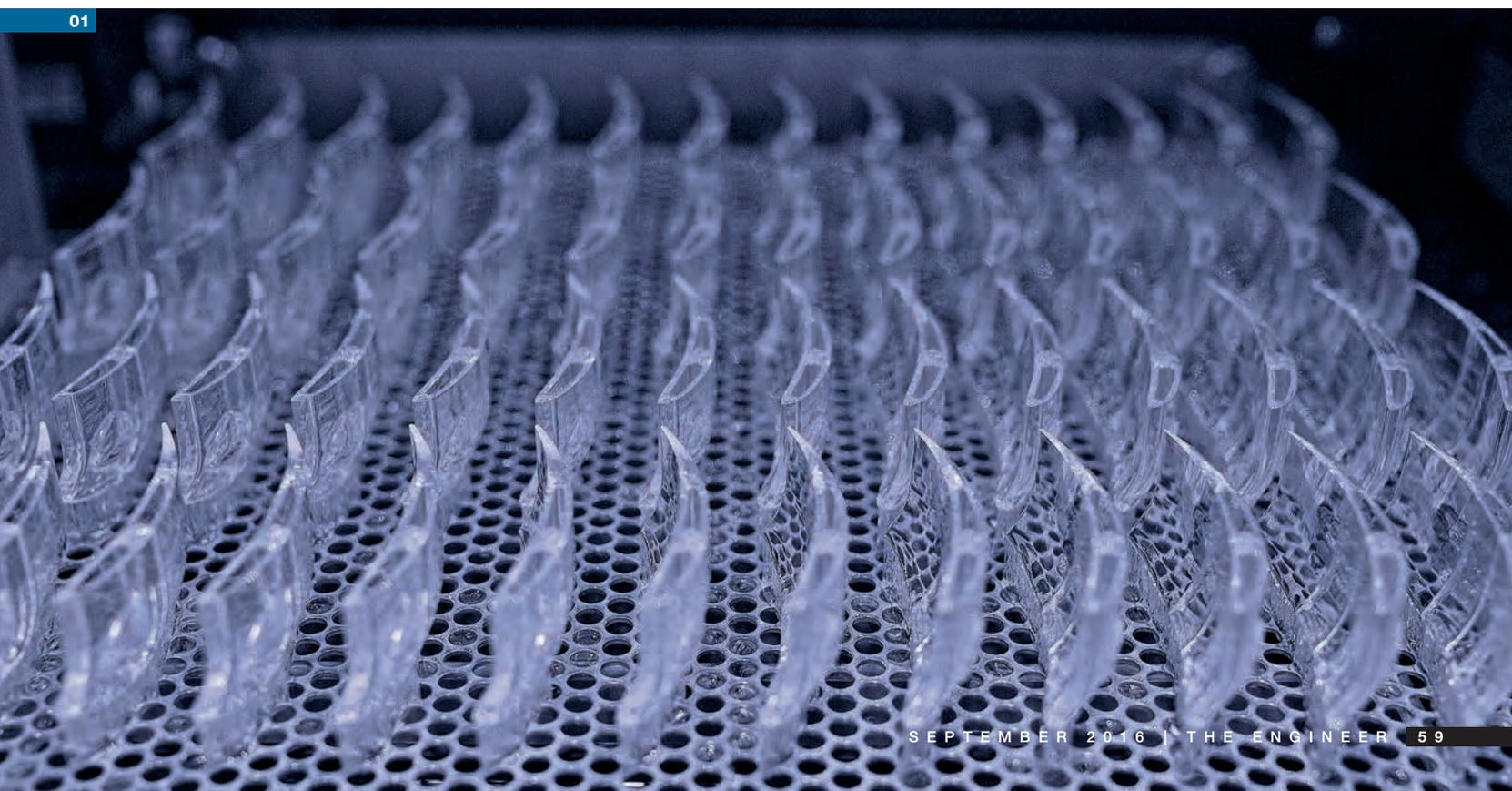
Belgium-based Materialise was one of the first companies to provide cloud-based services for 3D printing. "We noticed that more and more consumers are looking for technology to 3D print their applications," said Kirsten Van Praet, marketing coordinator at Materialise. "The companies offering this technology can only do so when they have access to data preparation software. Connecting to our cloud services to have access to this technology is a logical step. In general, the customers of our cloud-based services are software providers, 3D model databases, 3D printing services and desktop machine manufacturers."

Materialise said it has an inventory of patented 3D printing technology at hand and it makes parts of that technology available via cloud. Other companies can also integrate their cloud offerings into this workflow to build up a larger database. "In that way they don't have to develop the software themselves and can focus on their core activities," said Van Praet.

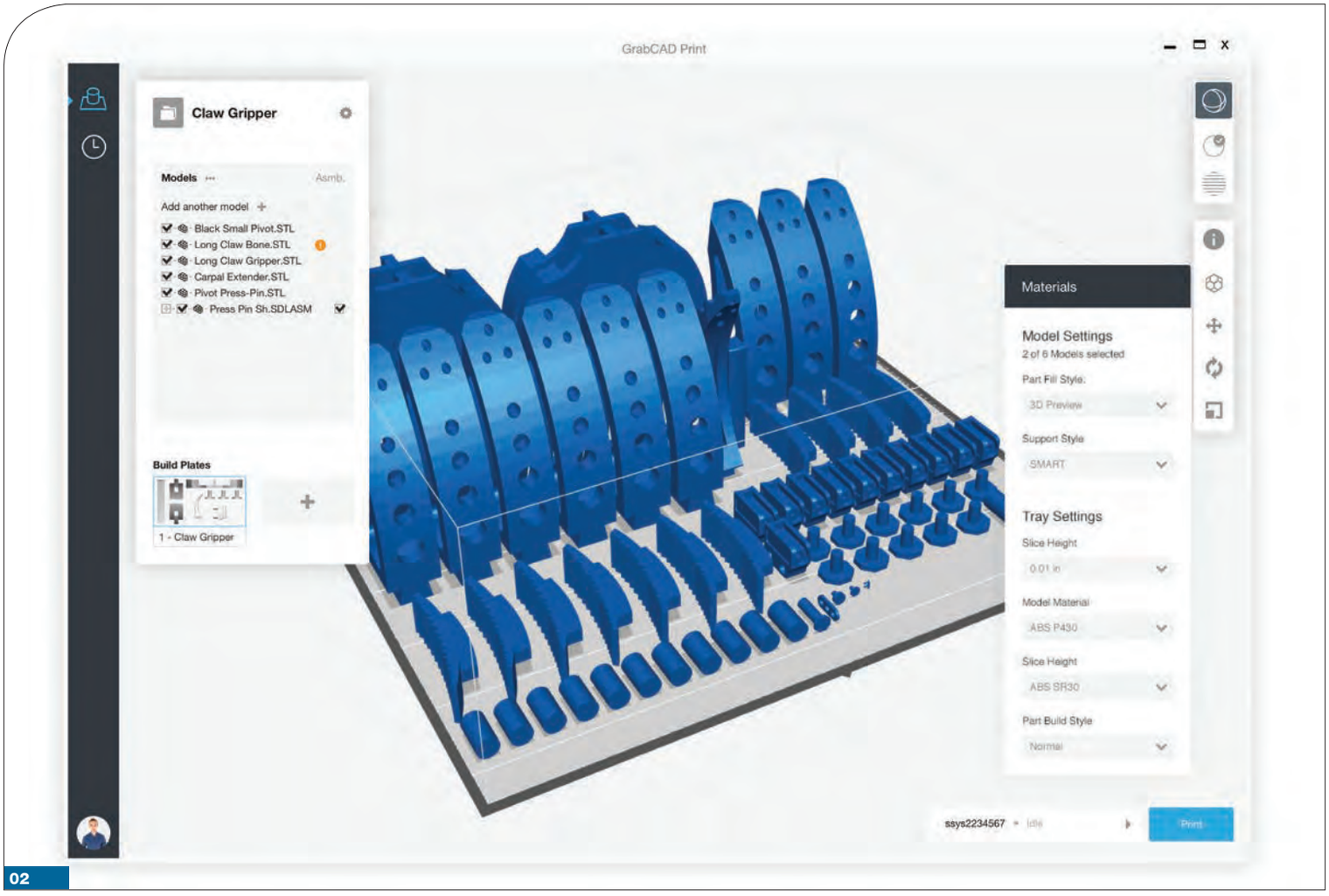
"It is mainly data preparation technology that is offered in the cloud. Is the file ready to go to a 3D printer? Is it in the right file format? Is it watertight? Is wall thickness sufficient everywhere? These are a couple of questions that pop up when someone wants to print a part. That's why we decided to put some of our Materialise Magics software in the cloud and enable other companies to connect to our cloud API [application programming interface]. Users can nowadays worry less about whether or not their design will successfully print, giving them more time to make great things that truly matter."

A number of other major players in the 3D printing sector have also been working on cloud-based 3D printing services. 3D Systems, for instance, has been using cloud-based software to customise a product **>>**

> "Users can nowadays worry less about whether or not their design will successfully print, giving them more time to make great things that truly matter"
>
> Kirsten Van Praet, Materialise



01 More and more companies are using 3D-printing technology



02

"In the past when a build had to be switched to a different 3D printer I'd have to do a clean restart"

Jimmy Callaway, Joe Gibbs Racing

>> known as Bespoke Braces. This is a personalised, 3D-printed brace for children and young adults with scoliosis. In the Bespoke Braces process, a patient's arm is scanned and data is transmitted to cloud-based servers where a brace design, customised by the patient and clinician, is created to match the shape of the patient's individual anatomy.

One of its cloud-based tools is a system known as 3DSprint. This lets anyone, according to the company, "break down historic design and manufacturing barriers to 3D printing". The software was used by Zetroz to create the world's smallest ultrasound therapy system. The team would convert the CAD file into STL format and load it into 3D Systems' 3DSprint software to lay out the parts on the ProJet 5500X build plate. 3DSprint meant that the design of the complex device was a collaborative effort between several team members.

"With 3DSprint we are giving engineers and designers the ultimate streamlined shared cloud and desktop platform experience that makes the design-to-manufacturing workflow faster, simpler and ubiquitously connected," said Avi Reichental, president and CEO of 3D Systems.

Another major 3D printing firm, Stratasys, announced in May that it would be pursuing a new cloud-based software strategy designed to make 3D printing significantly easier and more intuitive. The approach is powered by a new, open architecture 'design-to-3D print' workflow application, known as GrabCAD Print. The partnership means product designers, engineers, and 3D printer operators can now send CAD files to a Stratasys 3D Printer from their familiar CAD environments. The system also helps with data sharing related to job scheduling, print queue status and the amount of material used. It can be accessed via standard browsers, mobile apps or through the GrabCAD Platform.

02 Stratasys GrabCAD system helps designers print on the cloud

"When keeping up with fast-paced development, frequently things will change in the last minute. In the past when a build had to be switched to a different 3D printer I'd have to do a clean restart – redo all of that file preparation work. With GrabCAD Print it's easy to switch between 3D printers within a single app. That's a huge step forward in improving the workflow," said Jimmy Callaway, design engineer, Joe Gibbs Racing.

According to Wohlers Report, the 3D printing industry is expected to grow by more than 31 per cent per year until 2020. In just four years, it will generate over £16bn ($21bn) in worldwide revenue. This year alone, it is expected to generate £5.4bn ($7.1bn) globally. These figures seem impressive, but many experts are arguing that more needs to be done to improve the technology before manufacturers can really reap the benefits. But it seems, using cloud-based software could help make this happen.

"[We have] different companies that are interested in providing cloud-based 3D printing services, from AM platforms such as Grow to desktop machine manufacturers such as Leapfrog," said Van Praet. "It always comes down to the same thing: making 3D printing as simple as possible to a wide audience."

3D SYSTEMS

On Demand Manufacturing

Stereolithography (SLA) • Full Colour Printing • Direct Metal Printing • Vacuum Casting
CNC Machined Plastics & Metals • Injection Mould Tooling & Parts

3D Printed Prototypes & End-Use Parts in Plastics & Metals

FROM THE ORIGINATOR OF 3D PRINTING & SHAPER OF FUTURE 3D SOLUTIONS

3D Systems is the UK's foremost provider of 3D printing and rapid prototyping services for industries including automotive, aerospace, medical and defence. We specialise in delivering high quality components for prototype, pre-production and full production requirements, from our bespoke 22,250 square foot facility, backed up by more than 30 years of experience in rapid prototyping and tooling industries.

Visit us online at www.3dsystems.com/uk/quote

Wycombe Sands, Lane End Road, High Wycombe HP12 4HH UK
quickparts.uk@3dsystems.com | 08450 514 900

Additive at the turn of the tide

Visitors to this year's TCT Show + Personalise will look upon expertise from all areas of the additive manufacturing and 3D printing industry

TCT Show + Personalise, the UK's showcase for 3D design and manufacturing technologies, returns to the NEC Birmingham on 28–29 September 2016.

While the move of additive technologies towards true manufacturing has been a somewhat stilted affair, visitors to the TCT show floor will see first-hand that the tide is truly turning. This year's show will cover a range of sectors, and promises to bring expertise from all areas of the additive manufacturing and 3D printing industry, along with upstream, downstream, competing and complementary technologies.

This year, around 220 companies, including Trumpf, Stratasys and Olympus, are expected to use TCT to showcase a range of products and technologies.

Stratasys will showcase the J750 3D Printer, a full-colour, multi-material 3D printer. According to the company, this exceptionally versatile system is able to produce prototypes, as well as tooling, moulds, jigs and fixtures, and enables product designers, manufacturers and service bureaus to accelerate product development by making near-instantaneous decisions.

Also on display will be the Stratasys Fortus 3D Printer, which is claimed to reduce production costs, slash lead times and streamline supply-chain workflows. Visitors will be able to see The University of Warwick's 3D-printed submarine on the stand, which features significant FDM production parts.

Concluding the line-up, Stratasys will premiere the world's largest, fastest, and most complex 3D-printed UAV. Consisting of 80 per cent 3D-printed parts, Aurora Flight Sciences was able to produce a lightweight structure without the common restrictions of traditional manufacturing methods, while developing a customised vehicle to overcome the financial implications typical with low-volume production.

Trumpf will introduce the TruPrint 1000 3D, a compact, easy-to-install, true plug-and-play metal printing machine, suitable for the production of small metal components by LMF (laser metal fusion). It only requires 240V of power and an inert gas connection, and the system features a coating system.

The TruPrint 1000 builds components layer by layer from a wide range of fine metal powders, including steel, aluminium and titanium, using a build space of 100 x 100mm. This technology is especially suitable for parts with a complex geometry – such as those with internal channels and hollow spaces, and for economical manufacture of individual parts, prototypes or short production runs.

> The conference will educate on the technology that will change industry in the years ahead

Proposed application areas for the machines include everything from tool and mould-making, through to dental applications for the production of crowns and dental bridges.

Elsewhere on the exhibition floor, Olympus will exhibit the Olympus LEXT OLS4100, which is claimed to be the industry's first laser scanning compound microscope. Offering accuracy and repeatability, and with non-contact 3D observations, this microscope effortlessly delivers measurements of surface features at 10 nanometre resolutions.

Other leading companies bringing new tech to the TCT Show include Added Scientific, which will be launching its new software Flatt Pack; Photocentric, which will display a Liquid Crystal 3D printer using a 40in screen; and Sodick, which will be showcasing the OPM250L metal 3D printer and high-speed machining centre combination.

Meanwhile, running alongside the exhibition, a packed conference schedule, featuring a diverse range of speakers, will educate visitors about everything from the latest applications of 3D technologies, to the disruptive technologies that will change industry in the years ahead. **>>**

01/02 This year, around 220 companies are expected to use TCT to showcase a range of products, technologies and applications

02


03

02/03 This year's show will cover a range of sectors

Over the course of the show, delegates will be able to access a range of useful presentations over at the Tech Stage

>> Among the keynote presentations, Richard Trimlett, consultant adult cardiac surgeon, Royal Brompton Hospital, and Alex Berry, founder, Sutrue, will look at how additive manufacturing has increased cross-discipline collaboration between product designers and surgeons.

In other key sessions, Caterpillar engineer Austin Schmidt will give some valuable insight into how additive technologies can be deployed in large organisations, while Jan Vandenbrande, program manager, defence science office, DARPA, will look at how additive technology has been used to create shapes and materials properties that were previously thought impossible. Other presenters include representatives from Alstom, AP Works, Siemens and 3M, as well as a number of leading research institutions from across the globe.

Over the course of the show, delegates will also be able to access a range of useful presentations over at the Tech Stage – a special forum for learning and education.

Sessions taking place here include an update on the latest thinking on software for design, prototyping and visualisation and a beginners' guide to additive manufacturing.

The Tech Stage will also feature a Start Up Pitch Competition, where exhibitors from the exhibition's start-up zone will present a short, sharp five-minute presentation of their product or service to a panel of industry experts.

For more information on the event visit www.tctshow.com


zortrax M300
make something
BIG.
zortrax
zortrax
M300
Zortrax M300
the most reliable 3D printer for engineers.
large build volume
the Zortrax Ecosystem
acclaimed reliability
zortrax.com/m300

Offshore ambitions

A demand for a raft of technical skills mean that it is a pretty good moment to consider a career in the renewables sector. Jon Excell reports

While the nuclear sector remains clouded by indecision, and other areas of industry are still reeling from the decision to leave the EU, the extraordinary ambition of the UK offshore sector is relatively undimmed.

Offshore wind already contributes 5 per cent of the UK's electricity and supports around 15,000 jobs. Here in the UK, the aim is to source 15 per cent of our energy from renewables by 2020 and by the end of this decade the UK's offshore wind sector is expected to have doubled in size.

Unsurprisingly, according to those close to the industry, all of this growth and optimism, and consequent demand for a raft of technical skills, mean that it's a pretty good moment to consider a career in the sector.

Bessie Lau-Norris is a senior recruitment specialist at Denmark's Dong Energy, whose Hornsea Project One wind farm, currently in construction just off the Yorkshire coast, will be the world's first offshore facility of its kind to exceed 1GW in capacity.

"As a company we are investing billions of pounds in new UK wind projects that we'll need to recruit for so it's a great time to join if you're looking for a long-term career," she told *The Engineer*.

And as Dong continues to expand its offshore wind operations in the UK (earlier this summer, ministers gave the go-ahead for Hornsea Project 2 – an 1,800MW extension to the Hornsea scheme), Lau-Norris said that the firm's demand for engineers of all kinds will only increase. "We cover most aspects of offshore wind energy generation, including planning and design where we might need geotechnical or environmental engineers, right through to operations and maintenance where we need technicians and operations managers. We're always on the lookout for qualified electrical engineers as there's a lot of high voltage and cabling work in the design process, but we're growing at such a fast rate we're recruiting for lots of different disciplines."

> "We are investing billions of pounds in new UK wind projects that we'll need to recruit for"
>
> Bessie Lau-Norris, Dong Energy

01

Chris Rawley, divisional manager for renewable energy at engineering recruitment specialist Matchtech, confirmed that a wide range of skills are currently in demand across the sector. "The majority of job opportunities are within operations – wind-turbine technicians and blade technicians continue to be in high demand," he said. "However, with an influx of large projects on the horizon there are, and will be an increasing number of opportunities available for civil, mechanical and electrical engineers, as well as architects and planners." Rawley added that with wind projects becoming larger in size companies are particularly keen to find people with experience on the newer, larger, wind-turbine models.

Employers are also increasingly keen to hear from engineers from other sectors. "There are lots of roles that require skills that can be transferred from other industries," said Lau-Norris. "We take on electricians and mechanics from a whole range of sectors. As long as candidates have the right experience, attitude and are suitably qualified for the role, then it doesn't matter if they've worked in renewables before."

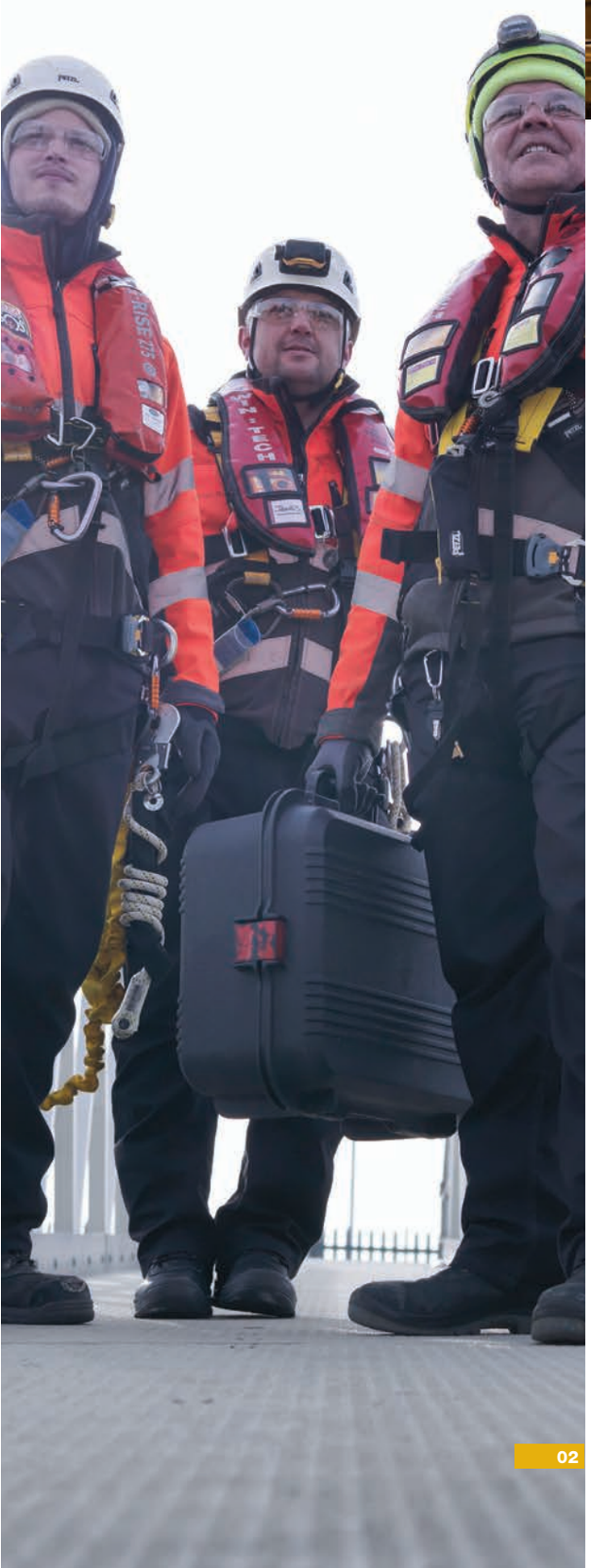
Unsurprisingly – given the similarities in the working environments – skilled engineers from the oil and gas sector are particularly in demand. "We've seen a lot of people come across from the oil and gas sector as their experience working offshore can help," said Lau-Norris.

Indeed, given the current downturn in the oil and gas sector, industry body RenewableUK is putting pressure on government to look at ways of making the transition from hydrocarbons to renewables as easy as possible. "The UK is perfectly placed to take advantage of its 40 years of offshore expertise by easing the transition for workers from fossil fuels into renewables" said Maf Smith, deputy chief executive of RenewableUK.

As well as Dong's Hornsea activity, key offshore wind projects in the UK at the moment include Scottish Power's £2bn East Anglia One project; Dong's

"The UK is perfectly placed to take advantage of its 40 years of offshore expertise"

Maf Smith, RenewableUK



02

03

04

01/02/03/04 Offshore wind already contributes 5 per cent of the UK's electricity and supports around 15,000 jobs. By the end of the decade, the UK's offshore wind sector is expected to have doubled in size

Walney Extension windfarm in Cumbria; the Dudgeon Offshore wind farm (off the coast of Norfolk); Suffolk's £1.5bn Galloper windfarm; and RWE NPower's Triton Knoll project.

As well as this, a number of large onshore projects are also being developed, particularly north of the border. These include: Dorenell (approximately 200MW and now owned by EDF), Kype Muir (89MW) and Middle Muir (51MW).

All of these projects are creating a demand for engineers. For instance, according to Lau-Norris, Hornsea Project One has the potential to create around 2,000 jobs during its construction phase with up to 300 additional jobs supported directly and indirectly throughout its operational phase.

Looking further into the future, Hornsea Project 2 (HP2), which is awaiting a final investment decision from Dong, and Hornsea Project 3, which is also in the pipeline, look set to create even more demand. "If these projects go ahead we'll need lots more engineers to develop, operate and maintain them, but it's too early to say how many at this stage," said Lau-Norris.

Interestingly, unlike many other sectors, which have reported a post-Brexit slowdown in recruitment following the UK's EU referendum, offshore wind has thus far been relatively unaffected. "Brexit has not changed our long-term commitment to the UK," said Lau-Norris. "As a company we've already invested £6bn in the UK and plan to double that by 2020. So in terms of our recruitment activity, this will continue as we develop new wind-farm projects. We've got engineering vacancies at the moment and we will continue to need qualified engineers to help us deliver clean, sustainable energy to the UK."

Chris Rawley, divisional manager for renewable energy at engineering recruitment specialist Matchtech, echoed this, although warned that an end to free movement of EU nationals – one possible outcome of Brexit negotiations – could hit the sector in the years ahead. "Should EU nationals need to obtain visas to work in the UK in the future, we could face an increase in skill shortages," he said.

As well as offering good solid career prospects, Lau-Norris said the sector has some other major attractions, not least the opportunity to do something considered worthwhile and interesting. "If you're looking for an interesting job in a growing industry, where you can go to work every day knowing you're doing something good for the planet then go for it. Our wind-farm projects have a life of 25 years, then there's the decommissioning phase so working in this industry could give you a job for life. Also there are some really exciting and unique roles, for example, our technicians get to work via boat, occasionally via helicopter, and then climb huge turbines, so there are plenty of options for engineers that don't want to be office based. Equally, if you'd rather not be climbing a 195m high turbine – we've got lots of office-based roles too."


CBSbutler
Precision Resourcing
cbsbutler.com
01737 822 000
where others fail
sured delivery
Proven skills
THE SUNDAY TIMES
100
BEST SMALL COMPANIES TO WORK FOR
2016
best company
2016
safecontractor
APPROVED
CERTIFIED
ISO
9001:2008
COMPANY

WORKSHOP AND DEVELOPMENT MANAGER
£35,000–£42,000
Bristol

This new role has been created to give our Workshop team structured and dedicated support to develop their skills. This is a truly challenging and rewarding position, focused on enabling the business to advance and compete in world-class manufacturing.

TRAINING AND DEVELOPMENT ENGINEER
Up to £30,000
Bristol

You know what it's like to be an apprentice with its challenges, successes and hard work. This is your chance to mentor future Engineers and Maintenance Assistants. In this practical role, you'll be able to pass on your skills and knowledge while supervising our apprentices. What could be more rewarding?

PROJECT ENGINEER
Up to £38,000
Bristol, with some travel to West Yorkshire

On a plant the size of 25 football pitches, the sheer scope and financial value of our projects will keep you engaged and challenged. You'll get your teeth into a range of projects, whether from concept to completion or in a support function on larger projects; building your career whilst making a significant impact.

MAINTAINER SHIFT TEAM MANAGER
£35,000–£40,000
Bristol

We've created this senior engineering role (working days) to manage the shift engineering teams. You'll make a big impact on the smooth running of the plant by proactively supporting each team member – greater efficiency here means we can better utilise our resources, increase plant reliability and provide dependable support for both preventative and unplanned maintenance.

CONDITION MONITORING TECHNICIAN
Up to £37,000
Bristol

This newly created engineer role is your chance to make a big impact on the reliability of our 32-acre Bristol site by ensuring planned condition monitoring techniques and maintenance activities are sustained.

ENGINEERING TECHNICAL MANAGER (MANUFACTURING, CONSTRUCTION)
Up to £45,000
Bristol

In this critical, collaborative role, your versatile management skills will ensure we make the best use of all available resources and use informed understanding to prepare for future growth and investment. In return, you'll be fully supported to make an impact in our business, and drive forward your career.

SHIFT TEAM MANAGERS X 2 (ENGINEERING & PRODUCTION)
Up to £32,000 + 38% shift premium
Bristol

These hands-on roles focus on engaging and supporting shift teams to ensure quality of work, whilst mentoring employees to grow and achieve results. The impact you make in either role will be visible across Siniat and set you on a path to achieve your career goals within an innovative and successful business.

PRODUCTION ENGINEER

We are looking to recruit an experienced Production Engineer to join our busy engineering department within manufacturing. The successful candidate will have an Engineering based Degree, or equivalent vocational based qualification. This could be as a Time Served Engineer with ONC, HNC, and HND level qualifications. The role will include all aspects of Production Engineering, but knowledge of SPC, Six Sigma, OEE, and in particular Lean Systems training and experience.

JOB OVERVIEW To provide production engineering support to the Technical and Development Teams on projects that they are involved in. This will include the, identification of the most cost effective means of developing the production processes for those projects. This will include purchasing capital equipment or assisting with the design and building of equipment using internal resources.

RESPONSIBILITIES To advise the Technical and Development Teams on all projects that are being undertaken to enable facilitate their smooth and efficient transition into Production, making sure that this is carried out meeting all the requirements of the Intersurgical Internal Quality System.

In achieving the above, to comply with cost benefit requirements of the Company. This also must meet all current Regulatory needs.

To make sure that all projects are regularly reviewed and assist in projects that require production engineering involvement, including estimated costings, production outputs, tooling requirements.

To be involved in the sourcing and specification of selected assembly and test equipment for all required Technical and Development projects, this could be by utilizing internal or external resource, and making sure that they meet all of the Regulatory, Quality and Commercial needs of the Company.

This will include monitoring and reporting on those projects transferred to production to ensure they meet the agreed performance specifications, in terms of, cost, validation, delivery date, including the recommendation and assistance with corrective actions, as required.

To work to provide stronger and more effective cross-functional links and communication between Technical, Production, Tool Room, and Quality.

To research new process ideas that will lead into the continuous improvement in functionality; capacity; cost and quality of the existing range of products.

Any other reasonable duties required by the company.

If you feel you have the appropriate skills and experience please apply online at
www.intersurgical.co.uk/careers

INTERSURGICAL®
COMPLETE RESPIRATORY SYSTEMS

Molly Millars Lane, Wokingham, Berkshire,
RG41 2RZ T: 0118 9656 300 F: 0118 9656356

Regenerated.

The new and improved Engineer Jobs website brings you quality jobs across 45 sectors within the engineering industry.

With special functions allowing you to easily apply to jobs you're interested in, whether you are using your mobile, tablet or a desktop computer.

ON THE MOVE?

Get the jobs you're interested sent directly to your inbox.

FLAG IT UP

Flag jobs you're interested in as 'Favourites' and apply to them later at your leisure.

EASY CV UPLOAD

Use our nifty File Chooser that allows you to easily upload your CV from your computer, Dropbox, Google Drive and more.

ONE-CLICK APPLY

Easily apply to jobs you're interested in with just one click! Job done.

EXPERT INFORMATION

Get quality career related news, advice and insight for our expert Careers Insight section.

Search and apply today at theengineer.co.uk/jobs

In partnership with MATCHTECH

Sept 1946

Winged bullet

The story behind a supersonic aircraft that never quite came to fruition in post-war Britain

The story of the Miles M52 aircraft is an intriguing tale of what might have been. In September 1946, *The Engineer* published a feature based on details that had recently been released by the Ministry of Defence. Just a few months earlier, the British government had cancelled the programme due to budget constraints, despite the design of the supersonic research aircraft being almost complete, and the construction of the first of three prototypes well underway.

Miles Aircraft of Reading had been tasked with building the turbojet-powered M52, which was intended to fly at 1,000 mph and reach a height of 36,000ft within 90 seconds. To achieve this, the engineers at Miles came up with a radical design more reminiscent of a piece of weaponry.

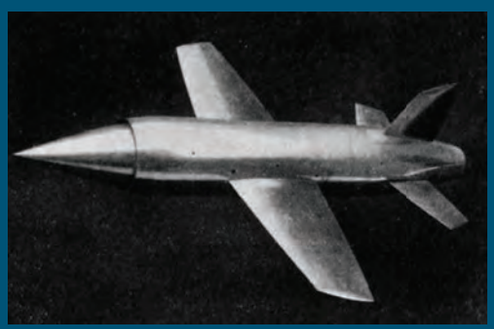
"Resembling a winged bullet, the overall dimensions were to have been 33ft long and 27ft wing span, the wings being somewhat shorter than those of aircraft of similar length," *The Engineer* wrote 70 years ago.

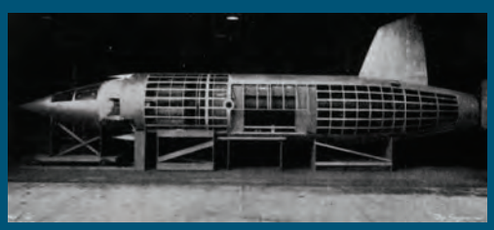
"As a step towards producing a wing shape which has a low drag in the supersonic speed range and yet permits low speed flight with good control, Miles Aircraft Ltd designed a bi-convex wing, with very sharp leading and trailing edges."

This bi-convex wing was tested on a standard Miles Falcon and then later in combination with a moving tailplane, proving the design's stability at low speeds. The power plant, which would have produced 17,000 horsepower at full-speed flight, was to be supplied by Power Jets (Research and Development) Ltd. Alongside the fuel tank and flight controls, the engine would have taken up almost the entire fuselage.

"It can be described as a three-stage unit, the first stage consisting of an ordinary jet engine with centrifugal blower," our predecessors wrote. "Gases from this engine pass through a turbine, which also serves as a ducted fan, bringing in an additional supply of air, which is mixed into the main stream.

"The mixture then passes through an 'athodyd' (aero-thermo-dynamic duct), into which fuel is injected and burnt, thereby increasing still further the speed of the gases, which are finally ejected by a nozzle in the tail. The power plant is 3.5ft in diameter and 23ft long."





The engineers at Miles came up with a radical design more reminiscent of weaponry

"For the M52 undercarriage, tyres and wheels had to be designed for a touch-down speed of 170mph"

The Engineer

With all that power just inches from the pilot, as well as the extreme heights the M52 would be operating at, it's no surprise that an ejection system was in place. The pressurised cockpit was designed to be completely jettisoned by detonating charges of plastic explosive in the tubular structures that connected the cabin to the fuselage. In theory, the air pressure would force the cockpit clear of the aircraft, and a parachute would help it descend gradually.

Once the cabin had slowed to a reasonable speed and descended to a designated height, the pilot would then bale out using a parachute of his own. If you were lucky enough to make it back to Earth in a fully intact aircraft, landing sounds like it could have been almost as terrifying as a bale-out.

"For the undercarriage special tyres and wheels had to be designed, as the touch-down speed was likely to have been about 170mph, with a two-mile run before stopping. The designed all-up weight is about 8,200lb at take-off, giving a wing loading of 58lb per square foot."

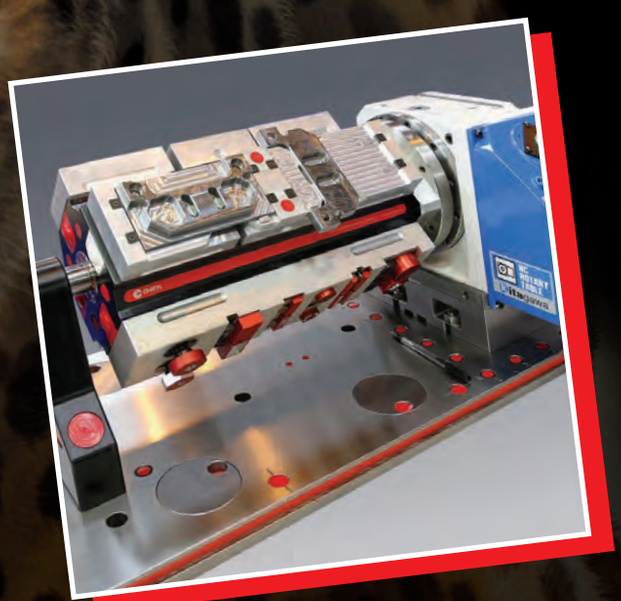
Although a piloted M52 never took to the skies, an unmanned version roughly 30 per cent the original scale did. It launched from a modified de Havilland Mosquito on 8 October 1947, but its rocket exploded shortly after release. Six days later Chuck Yeager broke the sound barrier for the first time in the Bell X-1, an aircraft that shared many similarities with the British design. In October 1948, an unmanned M52 reached Mach 1.38 in stable level flight.

Dennis Bancroft, chief aerodynamicist at Miles, later claimed Bell Aircraft was given access to the drawings and research on the M52, but that the US reneged on its side of a knowledge-sharing agreement made in 1944, and that no US data came back in return. At this point, the X-1 was supposedly struggling with conventional tail designs, and the variable incidence tail used on the M52 is said to have inspired a similar device on the record-breaking US craft.

Unsurprisingly, claims of British influence on the iconic Bell X-1 are widely disputed in the US, and history is generally written by the victors. But perhaps with a little more funding on this side of the Atlantic, the M52 just might have given Chuck Yeager and the X-1 a run for their money. **AW**

Fast and precise component workholding?

The answer's YES



Chick from 1st MTA. The UK's leading machining accessory supplier.

Email: enquiries@1mta.com Freephone: 0800 783 0510
Fax: 0800 783 0517 www.1mta.com

1st MTA MACHINE TOOL ACCESSORIES

Word of the issue

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

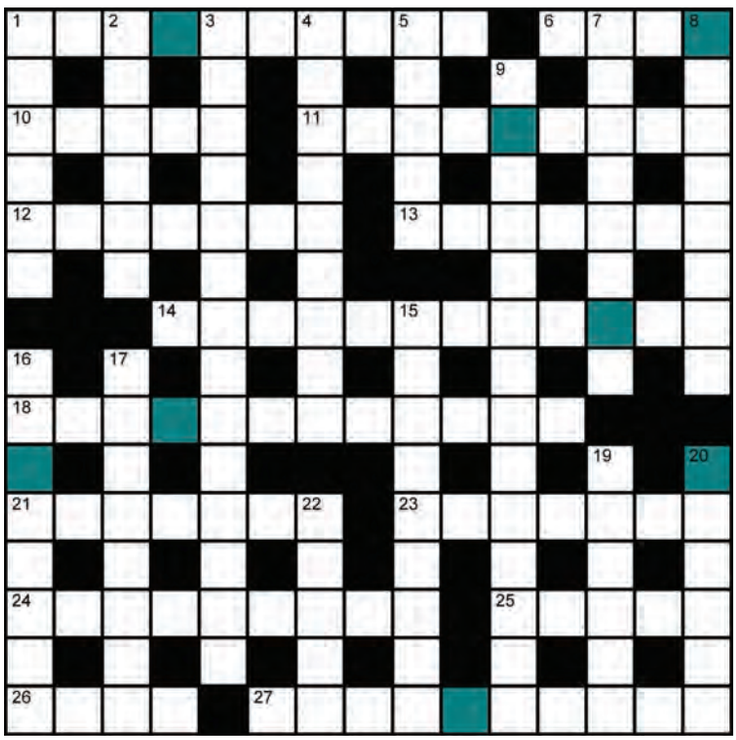
Visiting a heritage railway recently, a guide spoke of how virtually every replacement part had to be made by hand in the modern era. The vast majority are turned on a lathe, a process also used when wooden items were produced and a skill hardly changed for centuries, save for the motive power.

The word 'turn' came to English from Old French where tour is derived from Latin tornus. Here the reference is not simply to revolve one's position, for that came from the real meaning of 'turned as on a lathe'. We can trace this as coming from the Latin tornare meaning 'to polish, round off', all suggesting an idea of a circular motion.

This comes from the Proto-Indo-European root tere, also meaning 'to rub, turn, or twist'. Intriguingly this is also the root of the verb 'to throw'. Hence the original meaning is clearly from the action used in both processes rather than effects that are clearly very different.

Big picture

Supacat's Recovery HMT (High Mobility Transporter) is one of a number of variants emanating from the company's Jackal and Coyote vehicle range. HMT variants – including Logistic Support and Gun Towing – were just two of the vehicles on show at this month's DVD event at Millbrook.



Prize crossword

When completed rearrange the highlighted squares to spell out an impelling force. The first correct answer received will win a £20 Amazon voucher. Email your answer to **jon.excell@centaurmedia.com**

Across

1 Showing indifference or disregard (10)
6 Front part of a vessel or aircraft (4)
10 Form by pouring into a cast (5)
11 Payments imposed on property (4,5)
12 A cutting tooth (7)
13 Cause to fall in drops (7)
14 A major highway (8,4)
18 Municipal home (7,5)
21 Exceptional interest in yourself (7)
23 Amount lost needlessly (7)
24 Control that maintains a steady speed in a machine (9)
25 Third planet from the sun (5)
26 Selects as an alternative (4)
27 Diplomatic buildings (10)

Down

1 Land governed by a ruler (6)
2 Channel carrying water (6)
3 Not easily destroyed (14)
4 Small photovoltaic structure (5,4)
5 Equipped with feathers, like an arrow (5)
7 Educational reading material (8)
8 Gives false information to (8)
9 Metal made resistant to corrosion (9,5)
15 Place where metal is smelted (9)
16 Postulated sequence of possible events (8)
17 To correct (3,5)
19 Open space at the top of a house (6)
20 Open fabrics of string or wire (6)
22 French underground (5)

Collaborate to Innovate Conference: 17th November 2016

the ENGINEER collaborate to innovate

In association with Mazak Your Partner for Innovation, FRAZER-NASH CONSULTANCY

THE WINNERS HAVE BEEN ANNOUNCED...

ENERGY, EFFICIENCY & SUSTAINABILITY

ABB

Atmospheric Sampling over Ascension Island using UAVs

University of Bristol with Royal Holloway; University of London; University of Birmingham

SAFETY & SECURITY

QinetiQ

The Queen Elizabeth Class Aircraft Carriers

The Aircraft Carrier Alliance with BAE Systems Naval Ships; Thales; Babcock; Ministry of Defence

HEALTH & WELLBEING

GE

ADEPT - Additive manufacture for Design-led Efficient Patient Treatment

Renishaw PLC with PDR (Cardiff Metropolitan University); Abertawe Bro Morgannwg University Health Board (Maxillofacial Unit); LPW Technology Ltd

THE BUILT ENVIRONMENT

BECHTEL

SPECIFIC Innovation and Knowledge Centre

Swansea University with Tata Steel; NSG; BASF; Cardiff University

INFORMATION, DATA & CONNECTIVITY

BOSCH Invented for life

ORCHID: The Science of Human-Agent Collectives

University of Southampton with University of Oxford; University of Nottingham; University of Southampton; BAE Systems; Rescue Global; Secure Meters

TRANSPORTATION

AIRBUS

Materials Strategic Partnership

EPSRC / Rolls-Royce plc with University of Cambridge; University of Swansea; University of Birmingham

YOUNG INNOVATOR FOR PRACTICAL APPLICATION

RENISHAW apply innovation™

Nuclear Crane Zoning System

Future Tech Studio with Sellafield

YOUNG INNOVATOR DESIGN

RENISHAW apply innovation™

Nine Elms to Pimlico Bridge Design Project

Watford Grammar School for Boys with Hyder Consulting

Hear from the winning teams at the Collaborate to Innovate Conference

BOOK YOUR PLACE NOW!

£249 Student / Academia Rate	£399 Early Bird Rate (Usually £499)

Book Your Place Now: **conferences.theengineer.co.uk**

Brought to you by the ENGINEER

In association with FRAZER-NASH CONSULTANCY, Mazak Your Partner for Innovation

Energy, Efficiency & Sustainability Category Sponsor: ABB

Safety & Security Category Sponsor: QinetiQ

Health & Wellbeing Category Sponsor: GE

Built Environment Category Sponsor: BECHTEL

Information, Data & Connectivity Category Sponsor: BOSCH Invented for life

Transportation Category Sponsor: AIRBUS

Advanced Technology Sponsor: CATAPULT High Value Manufacturing

Young Innovator Category Sponsor: RENISHAW

In Partnership with: EPSRC Engineering and Physical Sciences Research Council, EngineeringUK, The Big Bang UK Young Scientists & Engineers Fair

DCA

GOOD DESIGN

Helping our clients achieve success through great product design

www.dca-design.com